TRANSACTIONS

of

the Wisconsin Academy of Sciences, Arts & Letters

Volume 71
Part 1
1983

TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

Volume 71, Part I, 1983

Co-editors
PHILIP WHITFORD
KATHRYN WHITFORD

TRANSACTIONS OF THE WISCONSIN ACADEMY

Established 1870
Volume 71
Part I, 1983

WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

The Wisconsin Academy of Sciences, Arts and Letters was chartered by the State Legislature on March 16, 1870 as an incorporated society serving the people of the State of Wisconsin by encouraging investigation and dissemination of knowledge in the sciences, arts and letters.

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The TRANSACTIONS of the Wisconsin Academy of Sciences, Arts and Letters is an annual publication devoted to original papers, preference being given to the works of Academy members. Sound manuscripts dealing with features of the State of Wisconsin and its people are especially welcome; papers on more general topics are occasionally published. Subject matter experts review each manuscript submitted.

Contributors are asked to submit *two* copies of their manuscripts. Manuscripts should be typed double-spaced on 8½ x 11 inch bond paper. The title of the paper should be centered at the top of the first page. The author's name and brief address should appear below the title. Each page of the manuscript beyond the first should bear the page number and author's name for identification, e.g. Brown-2, Brown-3, etc. Identify on a separate page, the author with his institution, if appropriate, or with his personal address to be used in Authors' Addresses at the end of the printed volume.

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Papers received after July 1 will be considered for the next annual volume. Manuscripts should be sent to:

Philip & Kathryn Whitford
Co-Editors: TRANSACTIONS

2647 Booth St.
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DEDICATION

This memorial volume presents the results of a paleontological symposium sponsored by colleagues, alumni and students of The University of Wisconsin-Milwaukee, Department of Geological and Geophysical Sciences as a tribute to the productive life of Dr. Katherine Greacen Nelson. This symposium was held on the old Milwaukee Downer Campus in Milwaukee on January 1, 1983, and all participants were Katherine's students.

It is appropriate that this memorial volume, sponsored by contributions from former students and industries that employ her students, be published in the *Transactions* of the Wisconsin Academy of Sciences, Arts, and Letters. She worked for many years in a variety of capacities for the Academy, and was the first woman elected as President.

To Katherine Greacen Nelson, geologist, educator, and friend, we dedicate this volume with love for enriching the lives of so many people.

Katherine Greacen Nelson

KATHERINE GREACEN NELSON

Katherine Greacen was born in Sierra Madre, California on December 9, 1913. She was married to Attorney Frank H. Nelson of Milwaukee, Wisconsin. She died on December 29, 1982 in Milwaukee after a short but valiant fight against cancer.

After receiving the first Ph.D. in geology from Rutgers University in 1938, Katherine began her distinguished career of service at Milwaukee Downer College. After World War II duty in the oil fields of Texas, she returned to Milwaukee and made contributions at Milwaukee Downer Seminary, the Y.W.C.A., and Wisconsin State College before joining The University of Wisconsin-Milwaukee Faculty in 1956.

Although Katherine's professional accomplishments include numerous scholarly papers, she is best known for her devotion to teaching others about the earth. Most university professors restrict their teaching to college-level courses and the supervision of graduate students, but not Katherine. She was always generous in her educational endeavors, and was equally available to, and comfortable with, a bus load of school children visiting the Greene Museum or congressmen contemplating the potential for the Ice Age Scientific Reserve. She never undertook any assignment with thought of personal reward or recognition. All she ever cared about was helping an individual, a group, or an organization. Such selfless people are rare in our society.

In addition to being the first chairperson of the Department of Geological and Geophysical Sciences at UWM, Katherine found time to serve the University on dozens of committees, including two terms on the Faculty Senate. She was a Fellow of the Geological Society of America, and a member of the Paleontological Society and the American Association of Petroleum Geologists.

Katherine held offices in a score of service-oriented organizations. For special contributions toward the establishment of a Sigma Xi Club at UWM, she was elected President. In recognition of assistance to the Milwaukee Public Museum, she was appointed an Honorary Curator. For long-term service to the Wisconsin Geological Society, including a term as President, she was appointed an Honorary Member. She was President of Phi Kappa Phi, and was a nominee for President of the Earth Science Section of the American Association for the Advancement of Science at the time of her death. The Midwest Federation of Mineralogical and Geological Societies honored Katherine as Educator of the Year in 1982. She was an active contributor to programs of the National Association of Geology Teachers, and served as President of the Central Section. In 1978, this organization selected her as the first woman recipient of the prestigious Neil Miner Award for distinguished contributions to earth science education.

There is much more one could record about Katherine the doer, but what about Katherine the person? She was tranquil and energetic with a kind word and helping hand to all; and always with a beautiful smile. To her, the earth was a remarkable place—to be understood, appreciated and enjoyed. She labored tirelessly for this belief while imparting warmth, enthusiasm and joy to everyone with whom she came in contact.

ACKNOWLEDGMENTS

The Katherine G. Nelson Symposium and Memorial Program presented at The University of Wisconsin-Milwaukee on January 15, 1983 was coordinated by Richard A. Paull, and arrangements were facilitated by Frank J. Charnon, Gregory Mursky, Rachel K. Paull and Robert W. Taylor; all of the Department of Geological and Geophysical Sciences at The University of Wisconsin-Milwaukee. The other faculty, staff, and students in the department generously assisted in many aspects of the program. Dennis D. Bollmann, Marmik Oil Company, Denver, Colorado and Charles W. Gartmann, Placid Oil Company, New Orleans, Louisiana acted as session chairpersons.

The memorial program was conducted by L. Joseph Lukowicz, Ladd & Lukowicz, Denver, Colorado; Frank E. Horton, Chancellor, The University of Wisconsin-Milwaukee; Douglas S. Cherkauer, The University of Wisconsin-Milwaukee; Robert E. Behling, West Virginia University; and Rachel K. Paull, The University of Wisconsin-Milwaukee.

Rachel K. and Richard A. Paull directed the preparation and critical review of the manuscripts contained in this volume. However, the encouragement and assistance of LeRoy R. Lee, Executive Director of the Wisconsin Academy of Science, Arts and Letters; and Philip B. and Kathryn D. Whitford, Co-Editors of the *Transactions* were critical factors in making this publication possible.

The papers included in this volume were critically reviewed by: Dr. Timothy R. Carr, Arco Oil and Gas Company (Texas); Dr. James W. Collinson, The Ohio State University; Dr. Robert E. Gernant, The University of Wisconsin-Milwaukee; Dr. Markes E. Johnson, Williams College (Massachusetts); Dr. Bradford Macurda, Jr., The Energists (Texas); Dr. Rachel K. Paull, The University of Wisconsin-Milwaukee; Dr. Dietmar Schumacher, Pennzoil Exploration and Producing Company (Texas); Dr. Peter M. Sheehan, Milwaukee Public Museum and The University of Wisconsin-Milwaukee; and Dr. Dale R. Sparling, Southwest State University (Minnesota).

Financial support for publication of this memorial volume of the Transactions dedicated to Katherine Greacen Nelson was provided by The Amoco Foundation through the efforts of many geologists and geophysicists employed by Amoco Production Company; Richard W. and Julie S. Behling, Tulsa, Oklahoma; Conoco Incorporated through the efforts of William E. Laing; Cotton Petroleum Corporation through the efforts of Arthur L. Paquette and Donald E. Paull; Exploration Logging U.S.A. through the efforts of Robert J. Rose and Howard Greene; Exxon Company USA through the efforts of Robert L. Sunde; Jeffrey C. Gruetzmacher, Leaf River Group, Houston, Texas; The InterNorth Foundation through the efforts of Julie S. Behling; Dietmar Schumacher, Pennzoil Exploration and Production Company, Houston, Texas; Sohio Alaska Petroleum Company through the efforts of M. J. Marfleet and Edward A. Frankovic; Robert L. Sunde, Kingsville, Texas; Union Oil Company of California through the efforts of Charles W. King, Larry H. Smith and David E. Willis.

The generosity of the individuals and organizations listed above is gratefully acknowledged by all of Katherine's students, friends and colleagues.

In addition, thanks are offered to present and future contributors to the Katherine G. Nelson Scholarship fund established by the Department of Geological and Geophysical Sciences at The University of Wisconsin-Milwaukee.

MILWAUKEE'S GENTLEMEN PALEONTOLOGISTS

Donald G. Mikulic
Illinois State Geological Survey, Champaign, IL 61820

Abstract

During the last half of the nineteenth century several large fossil collections were assembled from Silurian and Devonian rocks quarried in the vicinity of Milwaukee, Wisconsin. Conditions for collecting were favorable at that time because the quarries were small, low volume, hand-operated and more numerous compared to present-day operations. Low paid quarry workers were able to significantly supplement their incomes by selling fossils which insured a continual supply of specimens.

These collections were assembled by a few moderately wealthy, self-educated naturalists, who had the time, money and interest to secure large numbers of specimens. The most prominent of these gentlemen paleontologists were Increase A. Lapham (collection destroyed by fire in 1884), Fisk Holbrook Day (collection now at Harvard's Museum of Comparative Zoology), Thomas A. Greene (collection at The University of Wisconsin-Milwaukee), and Edgar E. Teller (collection at the National Museum of Natural History).

By assembling collections and publishing a few papers, these individuals stimulated paleontologic and stratigraphic research in the area by such notable geologists as James Hall, Robert Whitfield, Stuart Weller, and many others. Since most quarries in the area are abandoned, and because of the mechanized nature of large-scale quarrying at those remaining, it is impossible to assemble comparable collections of new material. These old collections, therefore, are of critical importance to future geologic work in the area, particularly in the fields of taxonomy, biogeography, biostratigraphy, taphonomy, paleoecology, and stratigraphy.

Introduction

During the last half of the nineteenth century, several important collections of Silurian and Devonian fossils were made in the vicinity of Milwaukee, Wisconsin by local naturalists, including I. A. Lapham, F. H. Day, T. A. Greene, E. E. Teller, and C. E. Monroe. These collections, which represented a great expenditure of time and money, stimulated the interest of many prominent scientists in the geology and paleontology of southeastern Wisconsin. The most important result of the subsequent research was the discovery and correct interpretation of Silurian reefs in the area—the first Paleozoic reefs to be identified in North America (Fig. 1).

Two primary factors influenced the assembly of these collections. Most important was the availability of fossil specimens, due to the methods and intensity of quarrying for lime and building stone. Also important, however, was the role of the naturalist in nineteenth century science and his motivation for an interest in natural history. Both of these factors have changed greatly, and the decline of the local stone industry has made it impossible to assemble comparable material. Because the older collections are irreplaceable, they remain a key element in geological research of the Milwaukee area and in Silurian and Devonian paleontology in general.

This paper discusses the conditions under

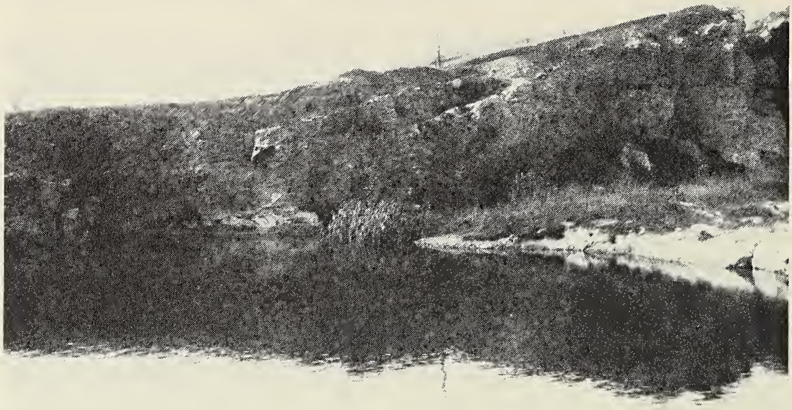

Fig. 1. Reef structure in the west wall of the Schoonmaker quarry, Wauwatosa, Wisconsin, 1899. This Silurian reef was the first Paleozoic reef described in North America (Hall, 1862). This quarry was also the locality from which Day, Greene, and Teller, as well as others, made extensive fossil collections. The area illustrated is near the present intersection of 68th and State Streets in Wauwatosa. Photo by W. C. Alden, Photo No. 115, U.S. Geological Survey Photo Library, Denver.

Fig. 2. Lithograph demonstrating typical nineteenth century quarrying methods. Quarry depicted was in Devonian rocks at Mill No. 1 of the Milwaukee Cement Company shortly after the company began operations, ca. 1876. The area shown in the lithograph is on the east bank of the Milwaukee River, near the old swimming beach in Estabrook Park, Milwaukee. From Chamberlin (1877); drawn from a photo taken by J. C. Miller.

which the collections were made, the prominent individuals who assembled them, and the way in which this collecting activity has contributed to geological research of southeastern Wisconsin.

Milwaukee's Stone Industry

Silurian and Devonian dolomite underlies much of southeastern Wisconsin and was an important source of building materials throughout the 1800s. The development of the local stone industry and the methods of operation were important factors in the formation of the nineteenth century Milwaukee area fossil collections. Because a fairly thick cover of Pleistocene and Recent sediments limits natural bedrock exposures in southeastern Wisconsin, quarries were critical to extensive collecting and the rate of fossil discoveries was closely related to the growth of the stone industry. Local quarrying reached its peak in the late 1800s with the development of the natural cement industy, which utilized Devonian rock (Fig. 2).

Nineteenth century quarries were quite different from the large mechanized operations of today. Most were small, shallow, and the rate of rock extraction was slow. Due to the lack of mechanization, large numbers of low-paid laborers were employed. After blasting, blocks too big to be handled were broken with sledge hammers. All rock was picked up by hand and placed in carts or wagons, and building stone was trimmed with hammer and chisel (Fig. 2).

Probably most quarry workers had little desire to start personal fossil collections during their ten hour workdays. However, the opportunity to supplement their incomes was a compelling reason to develop an interest in paleontology. Milwaukee's gentlemen paleontologists supplied the financial incentive by regularly purchasing fossils from the workers. A single good specimen could fetch a dollar or two, a sum which doubled the daily wages of most quarry employees. Thus, the methods of quarrying and the active fossil market insured that few important fossils would escape the notice of the quarrymen.

Since the later 1800s, the number of quarries in the Milwaukee area has decreased from over thirty sites to only one. Most of the former sites are completely filled and covered, and the active quarries are unfavorable for collecting because of high vertical walls and large-scale operations. Also, quarry workers are no longer a dependable source of specimens since they have little direct contact with the rock and to double their daily wages through fossil purchases would be prohibitive. These changes have all contributed to a significant decrease in the availability of fossils, as well as rock exposures, which severely limits modern geological and paleontological research in southeastern Wisconsin.

Gentlemen Paleontologists

Fossil collecting was greatly influenced by the presence of several well motivated and competent naturalists who lived in the Milwaukee area during the time that quarrying activities were at their peak. These individuals were typical of the self-educated and self-supported researchers who were responsible for much of the advancement of science throughout the nineteenth century.

In the 1800s, scientific research and education took place sporadically and the quality was irregular. It was difficult to obtain advanced education in new specialized scientific areas such as geology, and it was even more difficult to find employment in these fields. However, these constraints did not prevent an increase in the popularity of all aspects of natural history throughout the nineteenth century.

Studying and collecting natural history specimens for one's "cabinet" became a socially acceptable and popular pastime. The quality of naturalist activities ranged from mindless collecting of everything and anything to some of the best research of the time. Milwaukee's gentlemen paleontologists fit into the middle of this range. While

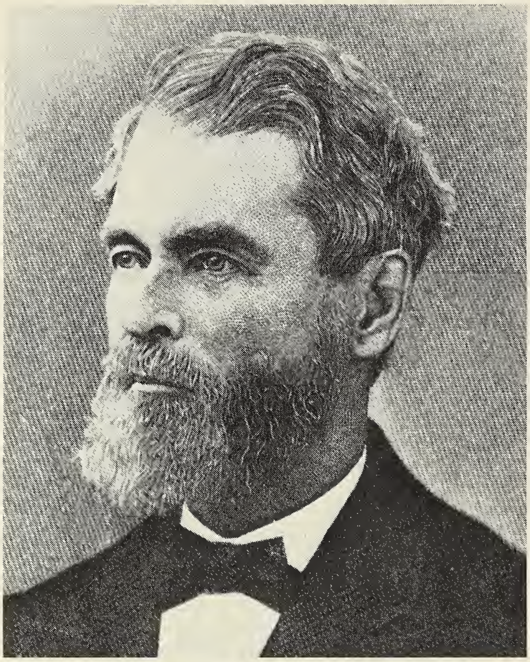

Fig. 3. Portrait of Increase A. Lapham (from Sherman, 1876).

men like I. A. Lapham did make substantial contributions to many fields of natural history, others were not as diversified in their interests nor did they publish as many scholarly papers. All were interested in several different branches of natural history, and these lifelong interests developed early. None of these individuals had advanced training in geology or other science, and were generally self-taught. They all enjoyed fairly high social standing and were successful enough in their chosen careers to have the time and money to devote to paleontological pursuits. The major contributions of these naturalists were the professional interest they stimulated in others and the comprehensive collections they diligently assembled. The following biographical sketches describe Milwaukee's best known gentlemen paleontologists and their activities.

Increase Allen Lapham

Increase Allen Lapham is well known as Wisconsin's first scientist and one of the state's most distinguished early citizens (Fig. 3). His numerous accomplishments in other fields of natural history may overshadow his paleontological contributions. However, he was the first to collect fossils in the Milwaukee area, and undoubtedly influenced the activities of his contemporaries.

Lapham was born at Palmyra, New York, on March 7, 1811. As a youth he worked as a stone cutter during construction of the Erie Canal at Lockport, New York (Sherman, 1876), and this work with fossiliferous Silurian rocks stimulated a lifelong interest in geology. He wrote his first scientific article at the age of 17, a short paper published in the American Journal of Science dealing with the geology around Louisville, Kentucky (Lapham, 1828). After spending several years as an engineer in Ohio, he moved to Milwaukee in 1836 at the request of Byron Kilbourn, and became chief engineer and secretary of the Milwaukee and Rock River Canal Company (Sherman, 1876). Soon after his arrival, he and Kilbourn began to seach the area for economically important rock and mineral deposits. Lapham also began to make observations on a variety of natural history subjects, which he continued to do throughout his life.

In 1846 Lapham sent a collection of Milwaukee area fossils to James Hall for identification. With the help of Hall's fossil identifications, Lapham determined the correct stratigraphic succession of rock units in Milwaukee. By the time his 1851 paper was published, he had defined the general Paleozoic stratigraphic section for eastern Wisconsin, established correlation with the New York section, and recognized the eastward dip of the rocks into the Michigan Basin.

In 1853 Lapham sent a manuscript entitled "American Paleontology" containing over 2000 fossil descriptions to Hall for completion and co-authorship (Winchell, 1894). Collaboration with Hall would have greatly elevated Lapham's stature as a geologist and paleontologist. Although Hall agreed to complete the project, he apparently did nothing with it and it was returned in 1860 at Lapham's request (Bean, 1936).

In 1873 Lapham was appointed head of the new state geological survey, and in this capacity he assembled a noteworthy group of young geological assistants, including T. C. Chamberlin (Beloit College) and Roland Irving (The University of Wisconsin). In 1875 he was replaced by a political crony of the new governor, but his early planning was in no small way responsible for the later success of the survey. He died on September 14, 1875, a few months after his removal from office.

Lapham's natural history collection, which included "10,000 fossils, minerals, shells, meteorites, and Indian relics" (*State Journal,* Dec. 16, 1884) was purchased by the state for The University of Wisconsin. Unfortunately, his entire collection was destroyed in the Science Hall fire of December 1, 1884 (*Milwaukee Sentinel,* Dec. 2, 1884). Only a partial list of Lapham's material exists in the published catalogue of the Wisconsin state mineral exhibit from the Centennial Exposition at Philadelphia in 1876, which consisted predominantly of specimens from his collection (Sweet, 1876). Lapham was generous with his specimens and many were given to, or exchanged with, other scientists. Some of James Hall's type specimens from Wisconsin, now in the American Museum of Natural History, are probably Lapham's specimens, although they are not so labelled. The Worthen Collection at the Illinois State Geological Survey contains at least one Lapham specimen and others are reported to be located at the Milwaukee Public Museum (Teller, 1912) and in the Greene Museum at The University of Wisconsin-Milwaukee.

Fisk Holbrook Day

Fisk Holbrook Day, the son of Reverend Warren Day and Lydia Holbrook Day, was born at Richmond, New York, on March 11, 1826 (Fig. 4). He attended Jefferson Medical College in Philadelphia, graduating in 1849

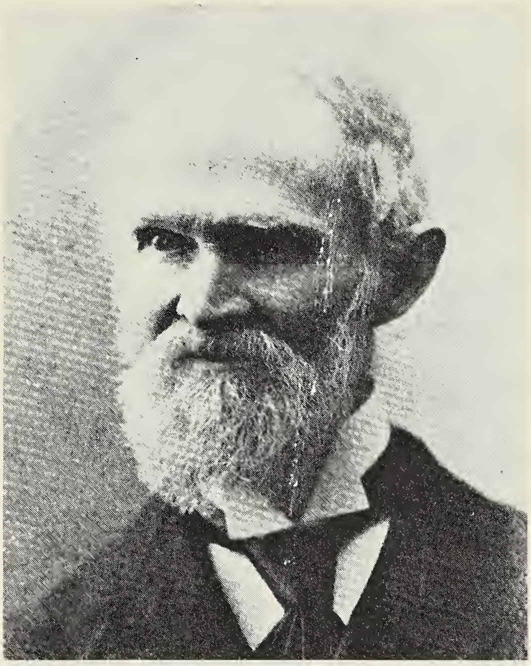

Fig. 4. Portrait of Fisk Holbrook Day (from Zimmermann, 1979).

(*Lansing Journal,* 1903). Day moved to Wauwatosa, Wisconsin, in 1854, and was a prominent physician in Milwaukee County for almost 40 years. Besides having a private practice, Day was a physician for Milwaukee County hospital and poor farm for many years (Zimmermann, 1979).

Day was a naturalist with a wide variety of interests, including geology, botany, and archeology (Fig. 5). His paleontologic interests probably stemmed from his father's acquaintance with James Hall while in New York. Reverend Day had collected fossils and occasionally corresponded with Hall during the 1840s, and Hall visited the Day household to examine his collections. Hall later made several visits to Wauwatosa to study the fossils in F. H. Day's cabinet, and a few specimens figured by Hall in 1867 and 1870 were from the Day collection.

Day published one paper on Milwaukee area geology in 1877. This paper demonstrates that Day was very observant and an original thinker, confident enough in his

Fig. 5. F. H. Day in his study, ca. 1870s. Photo courtesy of Mary Dawson.

observations to dispute established geological authorities such as James Hall and Charles Doolittle Walcott. Day (1877) mentioned working on another paper about the general characteristics of trilobites that apparently was never published. However, he did supply a detailed faunal list from local quarries to T. C. Chamberlin, which was published in Volume 2 of *The Geology of Wisconsin.*

Day specialized in collecting local Silurian fossils, and by 1880 he had assembled a collection of the best quality ever made in southeastern Wisconsin. His cabinet contained may spectacular specimens, primarily from the Schoonmaker quarry. These included an orthoconic cephalopod over seven feet long, and a spectacular specimen of the trilobite *Bumastus dayi* (named in his honor) (Fig. 6).

In 1880 Day decided to sell his collection, and offered it to The University of Wisconsin (through T. C. Chamberlin) and to Harvard University. Most of the collection, including the best specimens, was purchased by Alexander Agassiz and donated to the Museum of Comparative Zoology at Harvard in 1881 (Raymond, 1916). While it may seem unfortunate that Day's collection was

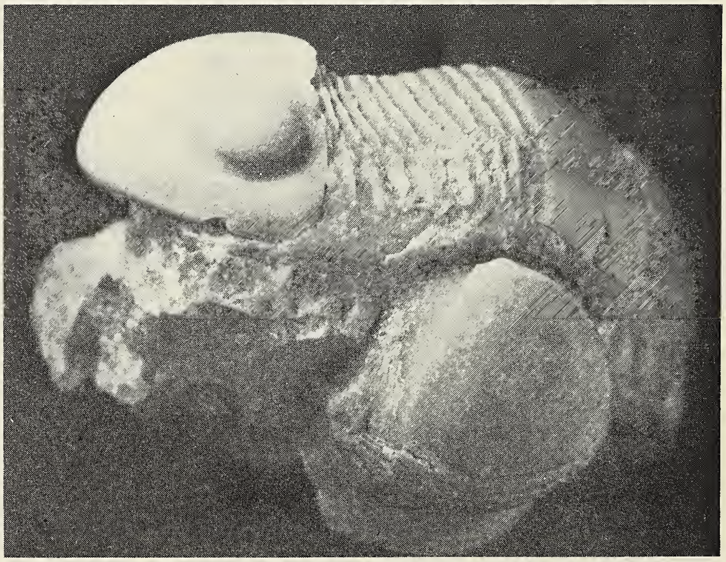

Fig. 6. Two specimens of the trilobite *Bumastus dayi* collected from the Silurian reef at the Schoonmaker quarry by Day, named in his honor by Raymond (1916). This was Day's most valued specimen, for which he was offered $100. This specimen is now No. 647 in the Museum of Comparative Zoology at Harvard.

sent out of the state, had it been sold to The University of Wisconsin probably it too would have been destroyed in the 1884 Science Hall fire. Even after Day shipped 8265 pounds of material to Harvard (*Milwaukee Sentinel,* Jan. 9, 1881), he still retained over 5000 fossils. In 1884 he sold a large number of the remaining specimens to Thomas Greene and much of his library to Edgar Teller. Day retired in 1893 and moved to Lansing, Michigan, where he died on May 31, 1904. At the time of his death he had several thousand specimens in his possession, which were later sold to The University of Michigan.

Day's material at Harvard was placed in the general collections and cannot be studied as a comprehensive unit. Much of it has not been catalogued, but it is in reasonably good shape. Besides containing most of Day's best specimens, the Harvard collection has material from Milwaukee area localities that is not represented elsewhere. Day's material in the Greene collection cannot be identified, but, based on the purchase price, it probably represents a large part of Greene's Wauwatosa material. The labels for many of Day's specimens at The University of Michigan have been lost, and little of his collection has been unpacked.

Thomas Arnold Greene

Thanks to the foresight of his family, T. A. Greene's correspondence, library, and, more importantly, his collections have been preserved in Milwaukee. This material, including several biographical studies (Buck, 1884; Conrad, 1895; Nehrling, 1895; Greacen and Ball, 1946a, b; Thomas, 1928) provides the most detailed information available for any of Milwaukee's gentlemen paleontologists.

Greene was born on November 2, 1827 in Providence, Rhode Island (Conrad, 1895) (Fig. 7). At the age of 16 he began training in a drug store, and five years later he moved to Milwaukee. Greene purchased a retail drug store, and shortly afterward went into partnership with Henry H. Button. Their firm became one of the largest wholesale drug businesses in the city, making Greene a wealthy man (Greacen and Ball, 1946a).

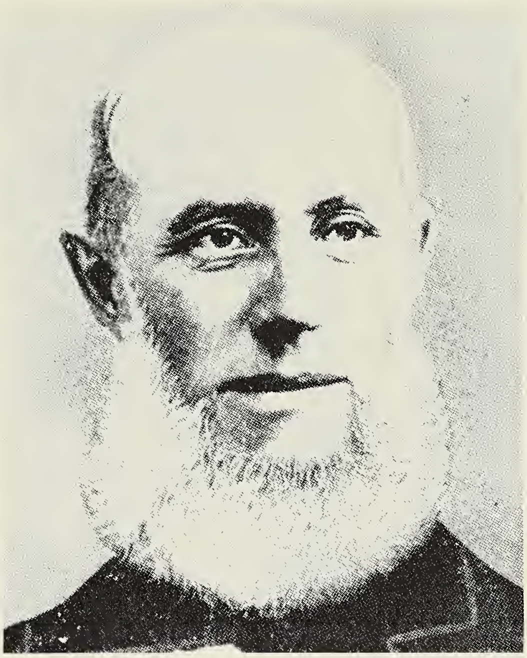

Fig. 7. Portrait of Thomas A. Greene (from Thomas, 1928).

Greene was very interested in botany and geology in his youth, and brought a collection of Rhode Island minerals with him to Milwaukee (Nehrling, 1895). During his first thirty years in Milwaukee, Greene devoted a little time to collecting and purchasing minerals, but there was no apparent interest in fossils. While he sustained an interest in botany and mineralogy, in subsequent years paleontology became his major concern. Because of poor health in 1878, he was advised by his physician to seek relief from the pressures of business. As a means of relaxing he began to collect and purchase fossils, and continued to do so until his death in the fall of 1893. Greene collected primarily at the cement quarries, the 26th Street quarry, and quarries at Racine and Wauwatosa. He corresponded with fossil collectors around the country to arrange exchanges or purchases. He also corresponded with many scientists and loaned specimens to them. James Hall, C. Wachsmuth, and J. Newberry all illustrated a number of Greene's specimens.

Although Greene acquired a thorough knowledge of Silurian and Devonian fossil identification, he apparently had no interest in writing scientific papers. His correspondence does reveal some geological data, and it also contains information on how he assembled his collection and gives insight into his personality.

Greene was quite serious and methodical in his efforts (Buck, 1884), and his goal was to obtain a comprehensive collection of both minerals and Silurian and Devonian fossils. Although he wanted the best possible specimens for his collection, he also purchased as many common specimens as possible. He was aggressive in his quest for specimens, and collecting soon became an obsession—certainly not the type of relaxation his doctor had prescribed. Greene's persistence in trying to convince other collectors to trade or sell specimens to him often resulted in their complete disinterest in further dealings with him. Greene seldom revealed information on the availability of fossils to other collectors, and in most letters he states that collecting had been better a few years before at all of his localities.

In addition to the large number of fossils purchased from quarry workers in Wisconsin, Greene also dealt with collectors and quarrymen in the Chicago area, and obtained Waldron (Indiana) fossils from J. Doty. His main supplier of Chicago area fossils from 1884 to 1893 was A. G. Warner. Warner appears to have earned a fair income by selling fossils to a small group of wealthy collectors, including Dr. J. Kennicott and W. Van Horne of Chicago. When Greene purchased Kennicott's collection in 1885 he also became Warner's main, and possibly only, customer. For the remainder of his life Greene purchased specimens from Warner on a regular basis, often receiving several boxes of fossils a month during the summer. It is interesting to note that Greene invariably paid Warner less than his asking price for the fossils. There was seldom any bargaining over the price, and it is difficult to determine whether Greene was always underpaying or Warner was always overcharging. As a result of these transactions

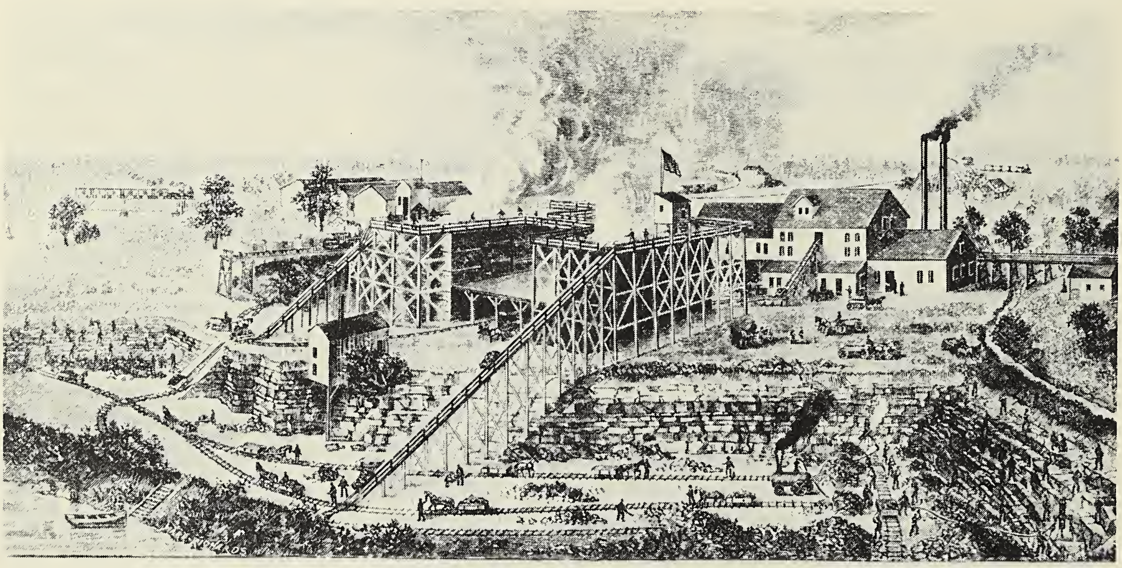

Fig. 8. Mill No. 1 of the Milwaukee Cement Company, ca. 1885 (from Barton, 1886).

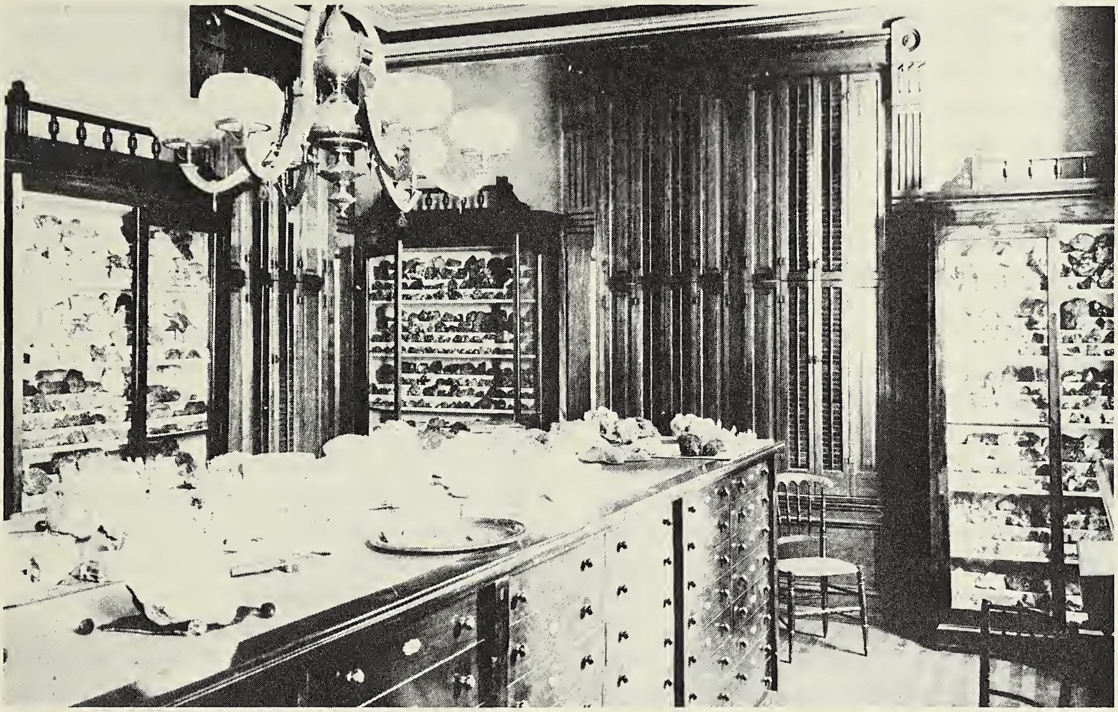

Fig. 9. Thomas Greene's collection at his home, probably taken after his death in 1894 and before the dedication of the Greene Museum in 1913. Photos courtesy of the late Katherine G. Nelson.

Fig. 10. Another view of Thomas Greene's collection at his home. Photo courtesy of the late Katherine G. Nelson.

with Warner, Greene acquired the best collection of Chicago area Silurian reef fossils.

Greene's interest in Devonian fossils led him to purchase stock in the Milwaukee Cement Company (Fig. 8). Greene possibly made this investment more to insure a constant supply of fossils than to realize financial gains, but he later became a member of the board of directors and vice president of the company (Greene and Berthelet, 1949).

He also had interesting and unusual dealings with the Horlick Lime and Stone Company in Racine. At most quarries he arranged to have workers and owners save fossils for him to purchase, but at this quarry he also paid to have workers break rocks for him while he was on the premises. He eventually arranged to have charges set in specific parts of the quarry ready to go off when he arrived. Anyone who has collected fossils in recent years knows this type of cooperation is unheard of in modern quarries, even if one could afford it.

Greene was a member of the Board of Trustees of the Milwaukee Public Museum from 1883 until his death in 1894. He arranged fossil purchases for the museum while on the board, but he also outbid the museum for specimens he wanted in his own collection (Greacen and Ball, 1946a).

Greene spent over $16,000 on his entire collection, including many of the wooden cases in which it is still housed. Of that amount, over $5000 was spent on fossils between 1878 and 1893. Greene's collection (Figs. 9 and 10) was kept by his family until 1911 when it was donated to Milwaukee-Downer College (Greacen and Ball, 1946a). The family also provided a fireproof building for the collection. In 1964 the collection was sold to The University of Wisconsin-Milwaukee for the bargain price of $20,000, and is now worth more than ten times that amount.

The Greene collection is the sole major nineteenth century Milwaukee area fossil collection to remain intact and in the area. Not only is it the largest collection of local Silurian and Devonian fossils, but it is also the largest single collection of Silurian reef fossils from the Chicago area. Although the Greene collection is undoubtedly the most important paleontologic research collection in the state, it has been only partially examined by specialists. However, it will remain a key element in any future geologic research in the area.

Edgar Eugene Teller

Edgar E. Teller was born on August 3, 1845 in Buffalo, New York (Fig. 11). In 1875 he moved to Milwaukee where he worked as a buyer for Plankinton and Armour (and its successor firms) until his retirement (Teller, 1924). He became interested in paleontology by stopping in at the Moody quarry (26th Street quarry) on his way to and from work in the early 1880s. Teller devoted most of his time to collecting Devonian fossils from the Milwaukee Cement Company quarries, but he also collected a large amount of Silurian

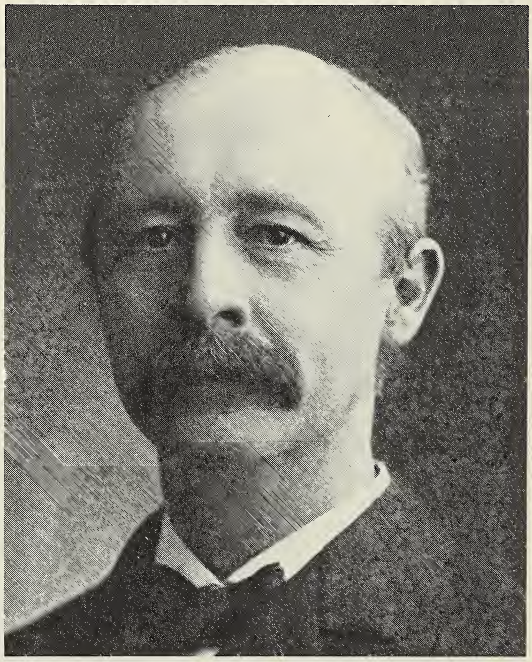

Fig. 11. Portrait of Edgar E. Teller, ca. 1895. Photo courtesy of Kathryn Teller.

material from the Moody quarry and lesser amounts from the Schoonmaker quarry and the Horlick quarry in Racine (Fig. 12), as well as some of the few complete trilobites known from the Cambrian Lodi Shale of Wisconsin.

Teller corresponded with, and loaned specimens to, a number of professional paleontologists, including James Hall, Robert Whitfield, Stuart Weller, Charles Eastman, Charles Walcott, and H. F. Cleland. Because of these associations, his collection contained, or supplied, more figured specimens than any other local naturalist's. He also wrote more scientific papers than other local collectors (Teller, 1900; 1906; 1910; 1912; Monroe and Teller, 1899), providing some of the most detailed descriptions of Wisconsin Devonian geology ever published (also see discussion about Monroe).

Teller was a major participant in the Wisconsin Natural History Society. He joined the society in 1885, serving as its president on several occasions, and as an editor and director until he returned to Buffalo in 1915. The demise of the society at this time was probably due in part to his departure. Teller was also interested in archaeology, and helped to establish the Wisconsin Archaeological Society as a separate organization from the Wisconsin Natural History Society in 1901 (Teller, 1924).

In 1908 Teller gave a large part of his collection to the Walker Museum at The University of Chicago (now part of the present-day Field Museum). Few of these specimens can now be identified as collected by Teller, but many of the Wisconsin Silurian and Devonian fossils in this collection undoubtedly were his.

Teller died in Buffalo on July 19, 1923. Both the National Museum of Natural History and Yale University were interested

Fig. 12. Main quarry of the Horlick Lime and Stone Company located along the Root River near Racine, Wisconsin, ca. 1888. The Silurian reef rock at this quarry supplied most of the fossils collected in the Racine area (from Art Publishing Co., 1888).

in his collection, and on April 3, 1924 his wife, Marie, gave the entire collection of 100,000 specimens and a library of several thousand volumes to the National Museum. This donation included nearly all of the type specimens described from his collection. Teller's material was assimilated into the National Museum's general collections and can no longer be examined intact. Several drawers of his Silurian specimens remain unsorted and uncatalogued. His books were incorporated into the museum library.

Charles Edwin Monroe

Charles Monroe was born in 1857, and later graduated from Oberlin College and The University of Michigan Law School (*Milwaukee Journal,* May 13, 1931) (Fig. 13). He moved to Milwaukee in 1884, and began a long career as a prominent attorney. He was apparently interested in several fields of natural history, of which botany was foremost.

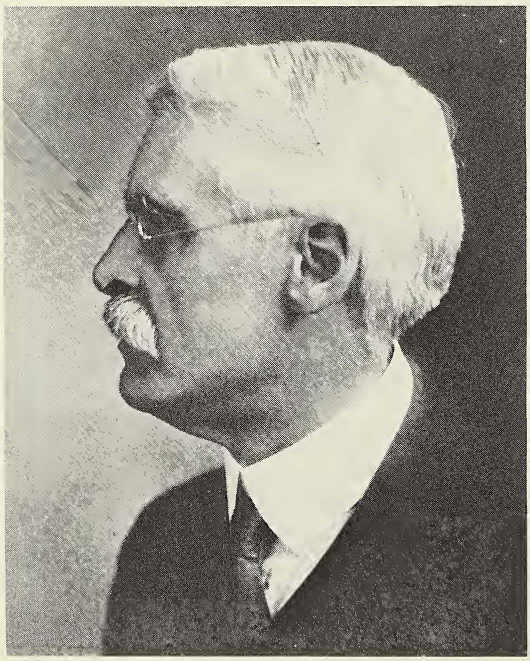

Fig. 13. Portrait of Charles E. Monroe, ca. 1920s. Photo courtesy of the Milwaukee Public Museum, Neg. No. 417133.

In the 1890s and early 1900s, Monroe spent a considerable amount of time collecting and studying the Devonian fossils of Wisconsin. He was a close friend of Edgar Teller, and the two of them share credit for stimulating research on the Devonian rocks of the area. Together they made comprehensive collections of all the localities and stratigraphic units of the Wisconsin Devonian. They were the first to publish detailed descriptions of the stratigraphic occurrence of Devonian fossils and to subdivide Devonian strata. They published an important report on Devonian rocks and fossils encountered during excavation for water intake tunnels at North Point in Milwaukee. They also discovered the phyllocarid bed in the Silurian Waubakee Dolomite and supplied the phyllocarid specimens described by Whitfield (1896). In 1900 Monroe published a description of the Devonian rocks, which he discovered, at what is now Harrington Beach State Park near Lake Church, Ozaukee County, Wisconsin. He contacted several individuals, including Charles Schuchert and Stuart Weller, in an attempt to have this new fauna described, and it was probably a result of his efforts that one of Schuchert's students, H. F. Cleland, began his work on the Wisconsin Devonian.

Monroe was associated with the Milwaukee Public Museum for many years. He held the position of honorary curator of paleontology from 1897 until at least 1922, and was the only person to work on the museum's fossil collections until Ira Edwards was hired in 1916. A generous donor to the museum, he gave nearly all of his Wisconsin Devonian fossil collection to the museum between 1898 and 1900, including the spectacular jaw of *Eastmanosteus* figured by Eastman (1900) and Cleland (1911) (Fig. 14). Other fossils he collected became type and figured specimens in papers by Cleland, Pohl, Penhallow, and others.

After 1905 Monroe devoted almost all of his spare time to botany, and he made

Fig. 14. Jaw of the Devonian fish *Eastmanosteus pustulosus* collected in 1899 by C. E. Monroe in the Milwaukee Cement Company quarries. The specimen is approximately 10 inches long and is now in the collection of the Milwaukee Public Museum (from Cleland, 1911).

several donations of botanical material to the Milwaukee Public Museum, including a collection of over 15,000 specimens in 1924. He moved to Oberlin, Ohio, in 1929, where he died in May, 1931, at the age of 74.

Other Local Collectors

Several other individuals are known to have made fossil collections in southeastern Wisconsin during the nineteenth century, but little specific information is known about their activities. For the most part, these collections have disappeared.

Professor Samuel S. Sherman, who taught at Milwaukee Female College in the 1860s and 1870s, collected and purchased fossils from quarrymen in the 1860s. Sherman moved to Chicago in 1879 where he worked for Sherman Brothers, a family business.

Walter Rankin of Carroll College collected fossils in the Waukesha area and some of his specimens are thought to be in the Day and Greene collections.

Philo Romayne Hoy was a general naturalist like Lapham, who confined his studies to the Racine area. Hoy was born in Mansfield, Ohio, in 1816, and was trained as a medical doctor. In 1846 Hoy moved to Racine (McMynn, 1893) and later that same year he and Lapham collected fossils together in the quarries north of Racine. Hoy also knew Day and Greene and accompanied them to Racine area quarries on many occasions. James Hall also received specimens from Hoy. Hoy's collection was divided between Day and the now defunct Racine College (Teller, 1912). Ornithology and botany are the fields of natural history for which Hoy is most often remembered.

F. L. Horneffer collected fossils from the cement quarries and the 26th Street quarry in Milwaukee during the 1890s (Teller, 1912). His fossils became part of Teller's collection, and included some of the type material in that collection. Horneffer continued collecting into the early 1900s, and accompanied Gilbert Raasch into the field on occasion (G. Raasch, 1973, pers. comm.).

After the turn of the century, quarrying activity in the area declined, and methods of operation changed. Social values, education, and employment opportunities also changed, and the gentlemen paleontologists faded from the scene. The only important local collections made since that time were assembled by Gilbert Raasch and Joseph Emielity. Both these men are Milwaukee natives who started collecting fossils as children, and went on to become professional geologists. Nearly all of their collections are now located in the Milwaukee Public Museum.

The Collections

Research Value

The four major surviving collections are of primary importance to paleontological research on the Paleozoic geology of southeastern Wisconsin. The Day, Greene, Teller, and Monroe collections are a source of unique and unstudied fossils and contain many type specimens. They cannot be duplicated in quantity, quality, or comprehensiveness, because most of the bedrock outcrops and quarries have disappeared and quarrying methods have changed. In addition, they are the only source of fossils and rock samples for many of the vanished localities. The later collections made by Raasch and Emielity supplement the older collections by covering more recent exposures, but do not replace them.

Although many of the fossils were collected more than one hundred years ago, they have not lost their usefulness for paleontologic research. Locality information accompanies most specimens, and by studying old geologic reports and the lithology of the specimens, it is possible to determine the exact geographic location and stratigraphic horizon in which the fossils were collected. It is also possible to determine reef or interreef origins for most of the Silurian material.

These collections are invaluable for taxonomic studies because they include many type specimens and numerous individuals of single taxa which are necessary for population studies. While the Day, Teller, and Monroe collections are no longer readily available for comprehensive faunal studies of specific localities, the Greene collection is ideal. It contains the most complete collection of North American Silurian reef fossils found in any museum. These historic collections are also important for research in biogeography, paleoecology, biostratigraphy, taphonomy, rates of evolution, and for general and local stratigraphic studies.

Preservation of the Collections

Many other nineteenth century fossil collections in the state, and throughout the country, have virtually disappeared through accident or neglect. Over 20,000 fossils were collected by the Wisconsin Geological Survey during the 1870s, and were equally divided among twelve different educational institutions in the state (Chamberlin, 1880). Approximately 1200 specimens were destroyed along with Lapham's collection in the Science Hall fire in 1884, but the fate of most of the others has not yet been determined. Only a few hundred of these specimens are known to exist.

Even in recent years, important collections have been seriously damaged by neglect. The W. C. Egan collection of Chicago area fossils in the Chicago Academy of Science is a good example. This collection was well organized as late as 1946 (Ball and Greacen, 1946), but by 1967 it was in disarray and many specimens, including types, cannot be located. The University of Wisconsin-Madison Geology Museum has also suffered long periods of neglect during which fossils disappeared and uncatalogued material was rendered useless because of missing locality information.

The Greene, Day, and Teller collections are all vulnerable in varying degrees to the same problems. Above all, a collection must be completely catalogued to prevent the loss of locality data. Once this is accomplished, the Day and Teller collections will be in little danger (although the Museum of Comparative Zoology is not exactly fireproof). Greene's collection is, and probably always will be, vulnerable to the type of neglect that small university collections often face. As long as a dedicated individual, like the late Dr. Katherine G. Nelson, took care of the collection there was a little danger of this happening. However, with her passing, the awareness of the importance of the Greene collection may fade. The University of Wisconsin-Milwaukee faces an important obligation in preserving the Greene collection and insuring its usefulness in the future.

Summary

The collecting activity of Milwaukee's gentlemen paleontologists continues to be a major factor in geological research in the Milwaukee area. They made important observations, published papers, distributed specimens, and assembled comprehensive collections, all of which stimulated interest in the geology and paleontology of the area. They spent more time and money assembling their collections than would have been possible for any professional geologists of that time. Their fossils were studied by some of the most prominent paleontologists of the nineteenth century, including James Hall, F. B. Meek, J. S. Newberry, C. D. Walcott, C. Wachsmuth, R. P. Whitfield, P. E. Ray-

mond, H. F. Cleland, C. R. Eastman, J. M. Clarke, Stuart Weller, A. F. Foerste, E. O. Ulrich, C. E. Resser, E. R. Pohl, and Frank Springer. Most of these collections focused attention on classic Silurian reefs in the area with their abundant and diverse faunas. On a local level, these collectors promoted and actively participated in natural history societies and museums.

It is no longer possible to assemble comparable collections on the Milwaukee area because of the change in quarrying methods, the general decline of that industry, and the lack of people willing to devote large amounts of both time and money to this pursuit. For these reasons the Day, Greene, Teller, and Monroe collections are more important than ever before.

Acknowledgments

I would like to thank Mary Dawson, Samuel Riggs, Jr., and Mary Riggs for supplying information on F. H. Day; Kathryn Teller, the late Edgar Teller, and the late Eugene Richardson for information on E. E. Teller; and the late Katherine G. Nelson for information on T. A. Greene. Joseph Emielity, Gilbert Raasch, and Christine Beauregard supplied general information. Special thanks are extended to Douglas Dewey and Waukesha Lime and Stone Company for research support. Joanne Kluessendorf helped gather information, provided suggestions, and critically read the manuscript. Richard A. Paull and Rachel K. Paull reviewed the manuscript. This work is based, in part, on doctoral research conducted under A. J. Boucot of Oregon State University.

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SILURIAN BENTHIC INVERTEBRATE ASSOCIATIONS OF EASTERN IOWA AND THEIR PALEOENVIRONMENTAL SIGNIFICANCE

Brian J. Witzke
Iowa Geological Survey
Iowa City, Iowa 55242

Abstract

The vertical and lateral distributions of benthic invertebrate associations in the Silurian carbonate sequence of eastern Iowa are interpreted in terms of widespread environmental changes created by relative changes in sea level and general water circulation patterns. Previous studies (especially Johnson, 1975, 1980) delineated three broadly-defined benthic invertebrate associations within the middle Llandoverian-lower Wenlockian sequence of eastern Iowa, and similar associations are recognized in younger Wenlockian strata in this study. The middle Llandoverian through middle Wenlockian interval in eastern Iowa includes three recurrent benthic associations characteristic of open-marine carbonate shelf environments: 1) coral-stromatoporoid, 2) pentamerid brachiopod, and 3) stricklandiid brachiopod. Petrographic, sedimentologic, and stratigraphic information evaluated for this study is consistent with the earlier suggestion that these associations respectively inhabited different depth-related benthic carbonate environments: 1) at or near fair-weather wave base, 2) generally below fair-weather wave base with episodic impingement of storm wave base on the bottom, and 3) below effective reach of fair-weather and storm wave base. However, the development of carbonate mounds (reefs) during Silurian deposition in eastern Iowa adds additional complexity to the paleotologic and sedimentologic framework. In addition, lateral biofacies variations suggest that basinal geometry influenced the geographic distribution of specific benthic associations.

The middle Wenlockian through Ludlovian interval in eastern Iowa is marked by a change from open-marine to restricted-marine carbonate deposition. A general offlap of the epeiric sea during that interval probably left eastern Iowa as a restricted embayment, in part hypersaline. When compared to the Llandoverian through middle Wenlockian interval, the younger Silurian benthic associations show a marked decline in diversity, and several major taxonomic groups are commonly absent. Abundant low-diversity brachiopod and coral-dominated faunas are well developed in the younger Silurian carbonate mound facies, but benthic invertebrate associations are characteristically sparsely developed to absent in the laminated inter-mound facies. However, Upper Silurian mound and inter-mound benthic associations generally increase in diversity eastward within the East-Central Iowa Basin. The stratigraphic distribution of these younger Silurian benthic associations is interpreted to be a joint response to relative changes in water depth and salinity stresses on the carbonate shelf.

Introduction and Comments

Silurian rocks of the central midcontinent region have been the subject of geologic and paleontologic investigations during the past 150 years. My personal interest in Silurian rocks was heightened during my teen and college years in Milwaukee, and Katherine Nelson played a significant role in cultivating that interest. Milwaukee is conveniently located in the Silurian outcrop belt, and Katherine took advantage of that fact by encouraging class field trips to nearby quarries. The Greene Museum collections (Univ. Wisc.-Milwaukee), tended by Katherine for many years, were the envy of local fossil collectors, like myself, and these collections certainly helped kindle student interest in Silurian paleontology.

While still living in Milwaukee, Don Mikulic and I first visited Silurian outcrops in eastern Iowa. These visits ultimately led to further study and graduate research on the Silurian rocks and fossils of Iowa (Witzke, 1976, 1981c; Mikulic, 1979). Although most of the Iowa Silurian rocks are extensively dolomitized, the contained fossils are commonly abundant and diverse. Paleontologic data obtained from the Iowa exposures and subsurface cores, when utilized with additional geologic information, form an essential basis for the interpretations of Silurian stratigraphy and depositional environments outlined in this report.

The general purpose of this report is to evaluate the vertical and lateral distributions of recurrent associations of benthic invertebrates within the Silurian sequence of eastern Iowa in terms of possible controlling paleoenvironmental parameters. Previously published paleocommunity models are reviewed and supplemented with new information, and models relating the various benthic associations to paleo-depth are independently tested utilizing petrographic and stratigraphic data. The study was approached through an analysis of paleontologic, sedimentologic, petrographic, stratigraphic, and structural information. Iowa Llandoverian stratigraphic data was geographically expanded over previous studies by utilizing subsurface cores (2 inch diameter). A first attempt at synthesizing Iowa Wenlockian-Ludlovian data in terms of regional sedimentation and benthic associations is presented in this report.

This report is intended to summarize some of the major conclusions of my dissertation research and to compare these results with some previous ideas. Because of the summary-and-review character of this paper, complete details of stratigraphic, petrographic, and paleontologic documentation cannot be presented in this volume. Further documentation is presented in Witzke (1981c).

Stratigraphy

The sequence of Silurian carbonate rocks is exceptionally well exposed in the outcrop belt of eastern Iowa, and supplementary exposures were examined in adjacent Illinois and Wisconsin. Integration of surface and subsurface (core) sections in Iowa has necessitated revision of previous stratigraphic interpretations. Following the lead of Wilson (1895) and Calvin and Bain (1900), Iowa Silurian lithostratigraphic relationships have recently been delineated (Johnson, 1975, 1977a; Witzke, 1981a, 1981c; Bunker *et al.*, 1983). A generalized interpretation of the composite eastern Iowa Silurian stratigraphic sequence is schematically illustrated in Figure 1. Units within the Hopkinton Formation are informally labelled Hopkinton A, B, and C which correspond, respectively, to the "*Syringopora*" and "*Pentamerus* beds," "*Cyclocrinites* beds," and "*Favosites* beds" of Johnson (1975). Member names within the Hopkinton Formation were recently proposed by Johnson (1983), which in ascending order include the Sweeney, Marcus, Farmers Creek, and Picture Rock Members.

The Scotch Grove Formation has been recently proposed as a stratigraphic unit by Bunker *et al.* (1983) to include the interval above the originally defined top of the Hopkinton and below the laminated and mounded carbonates of the Gower Formation. The Scotch Grove is characterized by a complex series of mounded (reef) and flat-lying carbonate facies that have been given informal facies names (see Fig. 1). The lower Scotch Grove interval of this report was included within the upper Hopkinton Formation by Johnson (1975, 1983). Johnson (1983) recognized members within this interval which he assigned, in ascending order, to the Johns Creek Quarry, Welton ("Emeline facies" of this report), and Buck Creek Quarry Members. Because of the recent status of Johnson's (1983) stratigraphic classification, time did not permit complete incorporation of the new terminology into

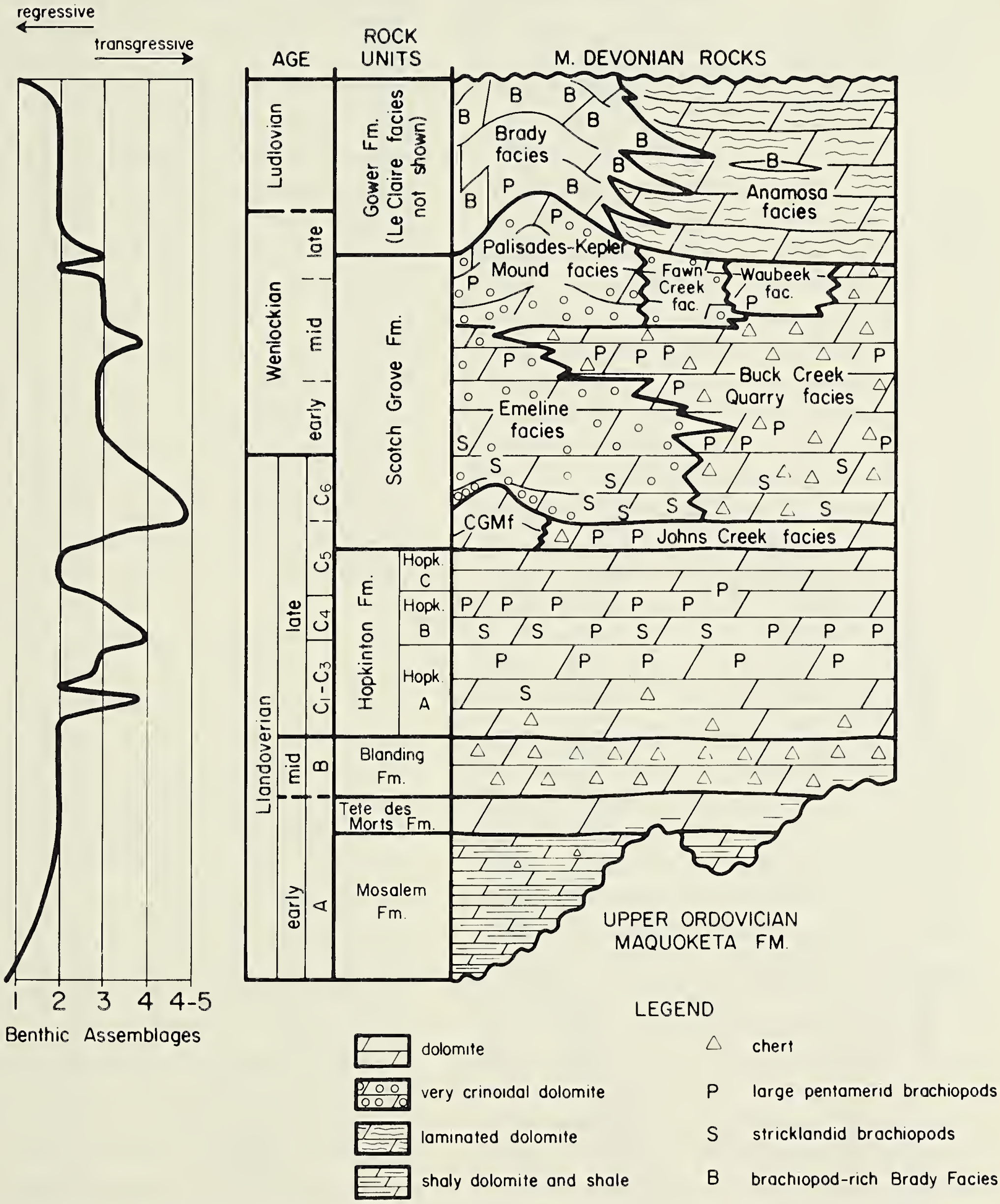

Fig. 1. Generalized Silurian stratigraphic sequence in east-central Iowa. Formal and informal stratigraphic terminology largely adapted from Johnson (1980), Witzke (1981c), and Bunker *et al.* (1983). Facies illustrated within the Scotch Grove and Gower Formations are highly schematic; the distribution of very crinoidal dolomites is shown for the Scotch Grove Fm. only. The sequence of Benthic Assemblages shown at left is generalized and adapted from Johnson (1980) and Witzke (1981c). Vertical scale is time. CGMf-Castle Grove Mound facies.

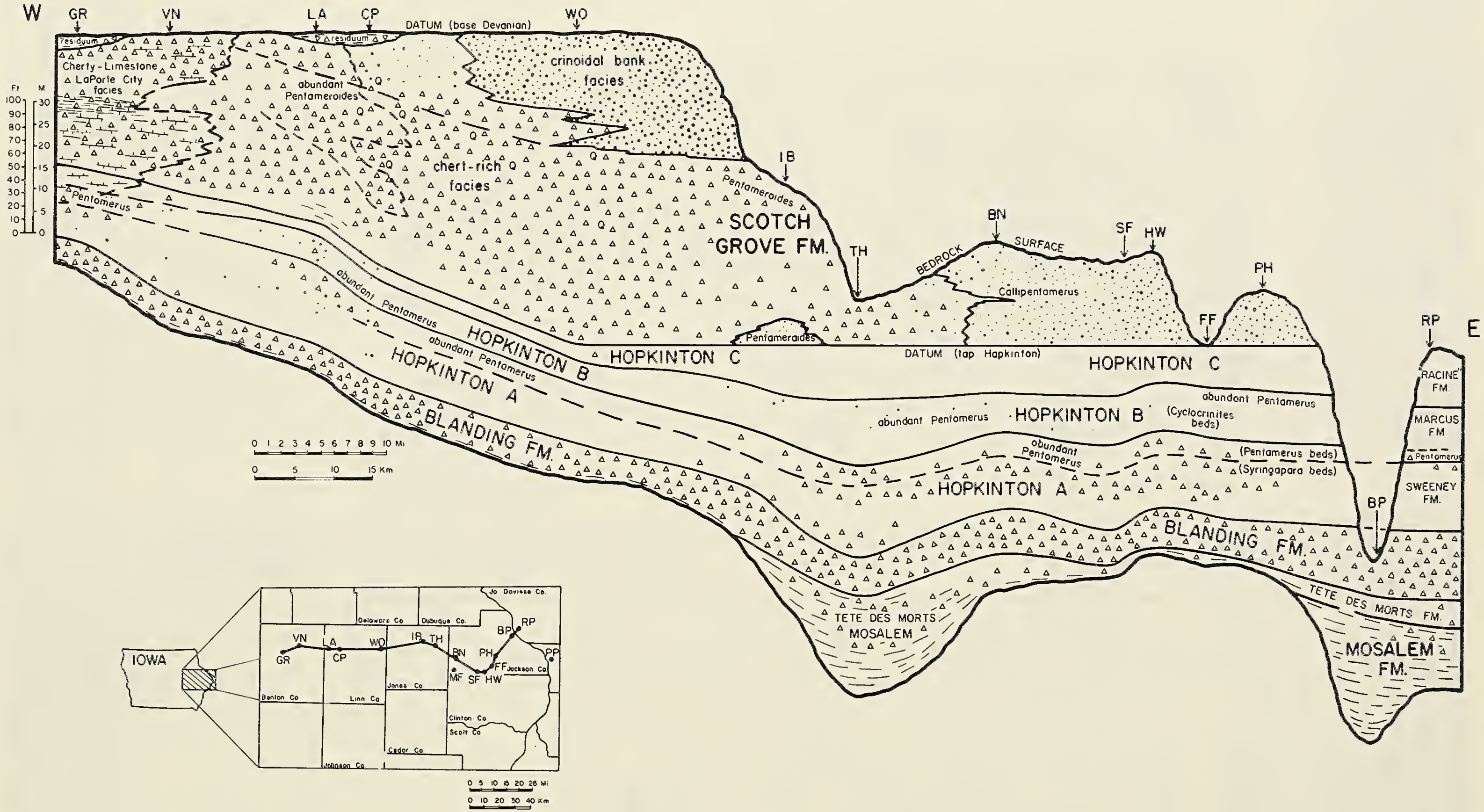

Fig. 2. East-west stratigraphic cross-section of Silurian strata in east-central Iowa. Datum is base of Devonian carbonates in west; datum is lowered to top of Hopkinton Fm. in east where Devonian rocks are absent. Symbols: triangles (chert), small circles (very crinoidal wackestone and packstone textures), Q (quartz-lined vugs), discontinuous thin lines (argillaceous carbonates), hachured lines (LaPorte City Fm. limestones), solid or discontinuous heavy lines (stratigraphic or biofacies boundaries). Subsurface Hopkinton B pentamerid occurrences generalized as *Pentamerus,* although *Harpidium maquoketa* is apparently represented in the eastern sections. Two-letter locality designations referenced in Witzke (1981c). Illinois stratigrapic terminology shown at locality RP.

this report, although union of informal terminology with the formal stratigraphic schemes is recommended for future publications. The Gower Formation includes three general facies: 1) flat-lying laminated dolomites of the Anamosa facies, 2) mounded (reef) brachiopod- and coral-rich rocks of the Brady facies (Philcox, 1970a), and 3) mounded to flat-lying crinoidal and brachiopod-rich rocks of the LeClaire facies. Many mounded (reef) carbonate exposures previously assigned to the LeClaire facies are now assigned to the Palisades-Kepler Mound facies of the Scotch Grove Formation.

The eastern Iowa Silurian sequence is composed primarily of dolomite and cherty dolomite. However, the dolomite sequences are replaced, in part, to the west and north by limestones and cherty limestones assigned to the LaPorte City and Waucoma formations (Witzke, 1981c). The fortuitous preservation of Silurian limestone facies in Iowa allows direct comparison of limestone petrographic fabrics with their dolomitized equivalents.

The thickest known sequence of Iowa Silurian rocks (146 m) occurs within the Silurian outcrop belt of east-central Iowa, and the Silurian sequence thins beneath the Devonian cover to the north, west, and south. Recent investigations in Iowa identified a Silurian structural and stratigraphic basin centered in eastern Iowa (Bunker, 1981; Bunker *et al.,* 1983; Witzke, 1981c). This paleobasin is termed the East-Central Iowa Basin. Although the central basin area was uplifted prior to Pennsylvanian deposition (ibid.), and the area has been subjected to extensive erosional truncation, thickening of individual Silurian stratigraphic units towards the center of the East-Central Iowa Basin is clearly evident in cross-section (Fig. 2). Erosional remnants of Silurian strata preserved in southwestern Wisconsin outliers compare closely with Lower Silurian sequences in the central basin area of eastern Iowa (Bunker *et al.,* 1983).

Brachiopod and conodont biostratigraphic studies in the eastern Iowa Silurian sequence provided a basis for inter-regional chronostratigraphic correlation (Johnson, 1975, 1979; Witzke, 1978, 1981c). The age relationships of the Iowa Silurian sequence are shown on Figure 1.

BENTHIC FOSSIL ASSOCIATIONS AND PALEOENVIRONMENTAL INTERPRETATIONS

Benthic Associations

Recurring associations of fossils (commonly termed communities) in the eastern Iowa Silurian sequence, when supplemented with stratigraphic, sedimentologic, and petrographic information, provide a basis for interpreting environmental changes through time. Ziegler (1965) and Ziegler *et al.* (1968) pioneered studies in Silurian community paleoecology and documented recurrent associations of brachiopods and other fossils in the Llandovery Series of the Welsh Borderland. They interpreted the distribution of these fossil associations to be environmentally controlled, and they correlated the controlling environmental parameters with water depth. Later studies, most of which are not enumerated here, identified other supposed depth-related Silurian fossil associations at other localities in Europe and North America. Johnson (1975, 1977a, 1980) identified five basic and recurrent fossil associations (or communities) in the Iowa Llandoverian sequence that, in part, paralleled Ziegler's in the Welsh Borderland. Johnson listed these in order of increasing water depth: 1) *Lingula,* 2) coral-algal, 3) pentamerid, 4) stricklandiid, and 5) "*Clorinda*-equivalent." Although some brachiopod taxa are shared between the Iowa and Welsh Borderland Llandoverian, many important differences in taxonomic composition between the two areas are noted, in part because of contrasting substrates (carbonate vs. terrigenous clastic). Most marine ecologists recognize modern marine communities as unique congregations of organisms, recognizable at the species level ("Peterson Animal Community" concept of Watkins *et al.,* 1973). In this context, the recurrent associations of fossils in the Iowa Silurian are not members of the same communities present in the Welsh Borderland. A broader community concept, the "parallel community," has also been defined which includes "a grouping of separate, related Peterson animal communities, describing an ecologic unit of great areal and temporal" extent recognized by similar associations of "characteristic genera" or "families" (ibid., p. 56).

In this study, the term "community" is not utilized, primarily to avoid confusion between the various community definitions, and the general term, "association," is preferred. As utilized here, a benthic association is defined to include a combination of taxa (usually at the generic or family level) that occur together in a specific stratigraphic interval and collectively form a discrete grouping unique from other associations. Although benthic associations could be defined and analyzed at any taxonomic level, including species level, the stratigraphic representation of the various associations is dependent on the hierarchic level employed by the observer (Anderson, 1973a). In a general sense, the benthic association definition utilized in this report roughly coincides with the "parallel community" concept.

The recognition and establishment of discrete benthic association types is, in part, an artificial procedure, and a certain degree of overlap in taxonomic composition between some associations is noted. There may be a degree of variation in the relative abundance of individual taxa within single benthic association types at different localities and in different collections. Nevertheless, the benthic association approach affords a reasonably consistent way of categorizing a mass of paleontologic information into environmentally and paleoecologically significant entities. In this study, most benthic associations are recognized and defined by the co-occurrence of two or three prominent key taxa in a single collection, and, although additional taxa are usually noted within a particular association, the full complement of additional taxa may not be recovered in all collections. The key taxa that define a particular association must be relatively abundant, although the name-bearing members of each association are not necessarily the most abundant fossil types present. For example, the skeletal volume of echinoderm grains in many of the Iowa Silurian benthic associations far exceeds that of the name-bearing members of the association. The benthic association concept utilized in this study is a broadly defined one that is suited for field observations as well as numerical assessment of dolomite block collections in the laboratory. In addition, rock core from Iowa subsurface Silurian intervals has yielded macrofossil collections that provide important data on the stratigraphic and geographic extent of various benthic associations, even though collection sample sizes are comparatively small and the sampling interval is generally thicker than in block collections derived from surface exposures. Rock core descriptions and fossil lists are recorded in Witzke (1981c).

An abbreviated review of the various benthic associations represented in the Iowa Silurian sequence and their environmental significance is presented later in this report. To a large extent, the Iowa Llandoverian associations used here closely parallel the community definitions of Johnson (1975, 1980). The reader is referred to the studies of Johnson (ibid.), Witzke (1976, 1981c), Witzke and Strimple (1981), and Mikulic (1979) for a more complete listing of the taxonomic composition and diversity of the various Iowa Llandoverian and early Wenlockian associations. In addition, valuable information on community evenness, diversity, and lateral homogeneity (as determined from block collection counts and "stretch-line" fossil censuses taken from Lower Silurian strata in the Iowa outcrop belt) is given by Johnson (1977a, 1980). A partial taxonomic listing of the various mid Wenlockian through Ludlovian benthic associations is given by Witzke (1981a, 1981c).

Benthic Assemblages

Boucot (1975, p. 11) introduced the term "Benthic Assemblage" for "a group of communities that occur repeatedly in different parts of a region (during some times even worldwide) in the same position relative to shoreline," and further suggested that "Benthic Assemblages are probably temperature-controlled as well as highly correlated with depth." Because community structures changed through time and individual taxa evolved, the Benthic Assemblage approach affords a method to compare the taxonomic and environmental similarities of various benthic associations on a broad temporal and geographic scale. Boucot (1975) proposed a simple numerical listing of Benthic Assemblages (B.A.), which increase in number moving away from the shoreline into progressively deepening water (e.g., B.A. 1—near shore, B.A. 6—farthest offshore). Boucot and others have categorized a great variety of Silurian fossil associations from around the world according to their general Benthic Assemblage position, and I have utilized Boucot's B.A. categories for the various Iowa Silurian associations. However, I have not uncritically utilized the B.A. categories, but have attempted to define the environmental parameters affecting each benthic association from sedimentologic, stratigraphic, petrographic, and other criteria. "Meaningful paleoecologic analysis of fossil assemblages is impossible without using environmental data which are independent of the paleontologic record," as stressed by Makurath (1977, p. 251). As such, the assertion that Benthic Assemblages are depth-related can be independently evaluated for specific Iowa Silurian benthic associations.

In general, the Iowa Silurian sequence was deposited in carbonate shelf environments within a "clear-water" epeiric sea, and terrigenous clastic influx was extremely low. The temporal and geographic distribution of the various benthic associations was related to environmental and biotic influences operating within the epeiric sea. Environmental factors that may have influenced the distribution of the various Iowa associations include water circulation patterns, salinity, relation to wave base, water turbulence, turbidity, light penetration, temperature, substratum, and nutrient availability. Most of these factors are strongly related to water depth and shelf physiography in areas of "clear water" carbonate shelf deposition (Irwin, 1965). Irwin (1965) stressed the importance of relative sea level change as a major controlling factor on the temporal sequence of environments on "clear water" carbonate shelves, and Anderson (1971, p. 301) suggested that recurrent benthic invertebrate associations are directly correlated with depth-related environmental zones in the epeiric seas.

If the distribution of Benthic Assemblages is depth-related, then the sequence of assemblages can be locally used to characterize relative changes in sea level, as previous workers have done for the Silurian of North America and Europe. Although some workers have criticized this approach (e.g., Makurath, 1977; Watkins, 1979), as will be shown, the stratigraphic and petrographic evidence from the Iowa Silurian generally supports *relative* differences in water depth for the various benthic assemblage types. However, the sequence of benthic assemblages in the Iowa Silurian is not necessarily a reflection of *absolute* changes in water depth since there is no assurance that each benthic assemblage maintained the same absolute depth range through time in a specific region. Sheehan (1980, p. 21) further suggested: "Benthic Assemblages are depth related in that, from shallow to deep, a consistent pattern of communities is maintained. But B.A.'s are not depth specific since the actual depth a given community inhabited probably varied significantly."

TABLE 1. Thin section point-count data averages from LaPorte City Formation limestones. General stratigraphic positions listed according to dolomite facies equivalents in the Hopkinton and Scotch Grove formations. (n = number of thin sections point-counted).

Stratigraphic equivalent	*n*	*Percentage of total rock volume*				*Percentage of skeletal grains*						
		matrix micrite & spar	*chert, chalcedony*	*skeletal grains*	*quartz silt & sylolites*	*echino-derm*	*bryo-zoan*	*brachi-opod*	*trilo-bite*	*ostra-code*	*sponge*	*indeter-minate*
Lower Scotch Grove	9	83	3	14	<1	60	16	14	1	1	2	6
Hopkinton C	5	69	<1	30	<1	77	1	1	<1	2		19
Hopkinton B	3	69	<1	30	<1	66	2	13				19

TABLE 2. Macroskeletal grid-count data averages from Waucoma and LaPorte City Formation limestones. Data for skeletal material >3mm only. General stratigraphic positions listed according to dolomite facies equivalents. (n = number of M^2 grid counts; * = present on outcrop but not on grids).

Stratigraphic equivalent	*n*	*Percentage macroskeletal volume*		*Average percentage of total macroskeletal volume*						
		average	*variation*	*stromatop-oroid*	*Favosites*	*Halysites*	*solitary rugosans*	*indet. coralline*	*brachi-opod*	*nautil-oid*
Hopkinton C	4	1.8	0.7-4.2	59.0	29.6	2.7	7.9	0.3	0.4	
Tete des Morts	2	1.6	1.2-2.0	95.4	*		1.2		0.3	3.1

Depth-related environmental factors that influenced carbonate depositional patterns, in particular those related to wave current activity, can be interpreted from petrographic and sedimentologic evidence. Such independent lines of evidence provide information critical for evaluating the *relative* depth positions of the various Iowa Silurian benthic associations.

Although the distribution of many Iowa Silurian benthic associations was apparently depth related, evaluation of additional non-depth-related environmental factors is also needed for adequate classification. In this report, all Iowa Silurian carbonate environments and their contained benthic associations are categorized into two general groupings: 1) open-marine, and 2) restricted-marine (varying degrees of elevated salinity).

Open-Marine Benthic Associations

General Characteristics

Iowa middle Llandoverian through middle Wenlockian rocks contain paleontologic and sedimentologic features suggestive of open-marine (stable marine salinity) carbonate depositional environments. 1) The contained faunas are characteristically diverse and include a number of biotic groups commonly regarded as stenohaline (see Heckel, 1972). In particular, echinoderm debris, commonly in great abundance, is present in all benthic associations here assigned to open-marine environments. 2) Iowa Silurian open-marine environments were generally characterized by the deposition of skeletal wackestone and packstone textures. All sedimentologic evidence suggestive of elevated salinites during deposition is absent. Unlike the restricted-marine environments discussed later, evaporite crystal molds, laminated carbonates, and oolites are conspicuously lacking.

Coral-Stromatoporoid Associations

Coral-stromatoporoid associations are noted in the Tete des Morts and Blanding formations, the Hopkinton A, B, and C intervals, and the lower La Porte City Formation. These associations are characterized by conspicuous tabulate corals (*Halysites, Favosites, Syringopora*) and disc-shaped stromatoporoids on outcrop. Other macrofossils commonly encountered include rugose corals (*Heliolites, Arachnophyllum,* solitary rugosans), brachiopods (*Hesperorthis, Leptaena*), nautiloids, and trilobites (*Stenopareia*). The brachiopod *Cryptothyrella* has also been recovered from the Blanding Formation (Johnson, 1977a). This recurrent coral-stromatoporoid association is assigned a B.A. 2 position following Boucot (1975). Although corals and stromatoporoids are conspicuous on outcrop, petrographic analysis reveals that the dominant skeletal constituent of these associations is disarticulated echinoderm debris (primarily crinoid with minor cystoid) less than 2 mm in diameter (Witzke, 1981c). Dolomitization has hampered recognition of the crinoidal component, although petrographic study reveals that moldic or dolomite-replaced crinoidal wackestone and packstone fabrics predominate in these associations (ibid.). Strata equivalent to Hopkinton C in the LaPorte City limestone contain a conspicuous coral-stromatoporoid fauna. However, petrographic study of these limestones reveals skeletal wackestone and packstone textures containing a great abundance of small echinoderm debris (see Table 1). Data in Table 1, due to thin section size limitations, is only for the rock matrix between the conspicuous coral and stromatoporoid colonies. Grid measurements (m^2) on vertical exposure faces indicate that corals and stromatoporoids, on the average, comprise less than 2% of the total rock volume in limestone strata containing coral-stromatoporoid associations (Table 2). Cross-sectional dimensions of all macroskeletal constituents within the m^2 grid whose long dimension exceeded 3 mm were recorded. However, this data tended to over-estimate coralline skeletal volume since corallite spar fillings were included in the volumetric measurements.

Johnson (1975, 1977a, 1980) interpreted the flat disc-shaped fossils in these associations as blue green algal stromatolites, and labelled this benthic association the "coral-algal community" accordingly. However, Johnson (1980, p. 200) acknowledged that some stromatoporoids "were undoubtedly included under this classification." All these disc-shaped fossils are herein interpreted as stromatoporoids and not algal stromatolites for two reasons. First, although the dolomitized or silicified specimens are typically poorly preserved, better preserved specimens bearing monticules and pillars are clearly stromatoporoids. Where identical benthic associations were examined in the LaPorte City and Waucoma limestones, no stromatolites were observed, and all laminar disc-shaped fossils were consistently recognizable as stromatoporoids. Second, there are no modern or ancient examples of isolated stromatolitic discs occurring within a groundmass of skeletal wackestone and packstone. Although normal-marine subtidal stromatolites have been identified in modern oolitic sand environments in the Bahamas (Dravis, 1983), the crudely laminated columnar heads and the surrounding sediment differ significantly from the Iowa Silurian examples. In general, most post-Lower Ordovician stromatolites are typically associated with environments of increased salinity or restricted circulation, whereas the Iowa examples occur in normal-marine associations.

Additional petrographic observations provide useful information for evaluating environmental parameters during deposition. Limestone fabrics include abraded skeletal grains, and the grains are, in part, moderately well sorted, suggesting relatively high-energy conditions in the B.A. 2 environments. However, skeletal wackestone and packstone textures indicate that carbonate mud was not completely winnowed out during deposition. Micrite envelopes occur around some skeletal grains in these associations. Moderate to strongly agitated open-marine conditions apparently prevailed in the B.A. 2 environments, and bottom conditions were apparently within the photic zone. Johnson (1980, p. 208) interpreted the flat, disc-shaped morphology of the corals and stromatoporoids as a probable response to the hydrographic factors, and further suggested that "effective wave base" may have reached the bottom during deposition of these intervals bearing such associations.

Pentamerid Brachiopod and Related Associations

Associations of large-shelled pentamerid brachiopods have been assigned a B.A. 3 position by Boucot (1975) and others. A variety of large pentamerid taxa are represented within the eastern Iowa sequence in the following stratigraphic positions: 1) *Pentamerus oblongus,* upper Hopkinton A, basal Hopkinton C; 2) *Harpidium (Isovella) maquoketa* (see Boucot and Johnson, 1979), Hopkinton B; 3) *Pentameroides subrectus,* basal and middle Scotch Grove (Johns Creek and Buck Creek Quarry facies); 4) *Pentameroides (Callipentamerus) corrugatus,* middle Scotch Grove (Emeline and Buck Creek Quarry facies); 5) *Rhipidium* sp., upper Scotch Grove (Waubeek facies). Due to incomplete recovery or poor preservation, *H. maquoketa* was not consistently distinguishable from *P. oblongus* in subsurface rock cores. Although all Hopkinton B pentamerids are tentatively listed as *Pentamerus* on the Figure 2 subsurface cross-section, many of the Hopkinton B specimens probably belong to *H. maquoketa* (which was assigned to *Pentamerus maquoketa* in earlier reports). In general, *Pentamerus* and *Harpidium* associations are spatially homogeneous and geographically widespread within specific stratigraphic intervals (Johnson, 1980). However, *Pentameroides, Callipentamerus,* and *Rhipidium* associations are not ubiquitous in specific stratigraphic intervals, but occur in spatially disjunct facies accumulations or "banks" (Witzke, 1981c). Although lacking large pentamerids, additional benthic associations laterally equivalent to the *Rhipidium* association in the upper Scotch Grove Formation (Buck Creek Quarry and Waubeek facies) are recognized and tentatively assigned a B.A. 3 position (Witzke, 1981a,b,c).

In general, the Iowa B.A. 3 associations are taxonomically more diverse than the B.A. 2 associations, although the brachiopod component is typically dominated by a single species. Additional biotic elements, not necessarily present in all pentamerid associations, include corals (primarily tabulates and solitary rugosans, some colonial rugosans), bryozoans, brachiopods (orthids, strophomenids, spiriferids), gastropods, nautiloids, trilobites, ostracodes, crinoids (rare articulated cups), and calcareous algae. Ecologic succession in the Hopkinton pentamerid associations is discussed by Johnson (1977b). Coralline developments or biostromes (highest diversity coral faunas noted in the Iowa Silurian) are evident in portions of the middle Scotch Grove Formation associated with abundant *Pentameroides* (Witzke, 1981c). Coralline biostromes associated with *Pentameroides* also occur within the basal Scotch Grove (Johnson, 1977a). Upper Scotch Grove B.A. 3 associations that lack large pentamerids are faunally varied and, although not enumerated here, include scattered small pentamerid (gypidulinid) brachiopods (ibid.).

Pentamerus, Harpidium, and *Pentameroides* associations in portions of the Hopkinton and Scotch Grove formations include small numbers of stricklandiid brachiopods, forms generally characteristic of B.A. 4 stricklandiid associations. The intermixing of pentamerid and stricklandiid faunas may suggest a degree of gradational overlap between B.A. 3 and B.A. 4 associations at times during deposition of the Iowa Silurian carbonates.

Pentamerid accumulations in the Iowa Silurian are preserved in two general ways with "a complete preservational spectrum" between the two extremes: 1) articulated brachiopod shells in life position with scattered truncated "submarine erosion" surfaces, and 2) "disarticulated shells accumulated as coquinas" (Johnson, 1977b, p. 86, 92). Johnson (ibid.) suggested periodic "scouring of the sea bottom" as a mechanism for the origin of the truncation surfaces. Many disarticulated pentamerid accumulations sampled by Johnson (1977a) showed a preservational bias of pedicle valves over brachial valves, suggesting a degree of current sorting. Bridges (1975, p. 89) described "storm-generated coquinas of *Pentamerus*" from the Welsh Borderland, and Anderson (1973b) suggested that pentamerid associations in the Appalachian Basin area inhabited skeletal sand substrates that were "occasionally wave reworked." Some pentamerid accumulations in the Iowa Silurian may represent storm lags. Iowa pentamerid associations occur within rocks displaying skeletal wackestone to packstone textures, both in dolomite and limestone facies. Echinoderm debris (most less than 2 mm diameter) is considerably more important volumetrically than macrofossil block counts would suggest, and the echinoderm component of the pentamerid associations can only be adequately evaluated petrographically (see Table 1; *Pentamerus*-bearing limestones, Hopkinton B equivalents). Moldic and dolomite-replaced echinoderm grains are also abundantly evident petrographically in the dolomite facies (Witzke, 1981c). *Pentamerus*-bearing limestones in the LaPorte City Formation contain some abraded grains, and agitated conditions were apparently present at times during the deposition of the B.A. 3 associations. However, abraded grains and current sorting are not pervasive throughout the pentamerid-bearing sequences, and agitated high-energy conditions were probably present in the B.A. 3 environments only at irregular intervals. Overall, the sedimentary evidence in the B.A. 3 pentamerid associations is consistent with a depositional environment generally below wave base. Johnson (1980, p. 208) also suggested that the pentamerid associations generally occupied a position "at or below effective wave base." The abundance of micrite and articulated fossils generally supports this interpretation. However, periodic turbulent conditions produced truncation surfaces, shell transport and sorting, and abraded grains, perhaps as a result of periodic storms in which storm wave base impinged on the bottom.

Carbonate Mound (Reef) and Related Associations

Open-marine carbonate mound (reef) facies are noted at two positions in the Scotch Grove Formation: 1) small-scale mounds (about 5-10 m high, 30-70 m across) informally included in the Castle Grove Mound facies, and 2) large-scale mounds (forming coalesced mounded complexes to 2.5 km across; single mounds up to 1 km across, 45 m thick) informally included in the Palisades-Kepler Mound facies (Witzke, 1981a,c). Both mound facies are laterally replaced, in part, by flat-lying intermound strata containing probable B.A. 3 associations. Stratigraphic relations indicate that, during deposition, the mound facies were elevated on the sea floor relative to the intermound facies. Since the B.A. 3 associations in the Palisades-Kepler mounds lived in shallower water than equivalent B.A. 3 associations in the intermound areas, the contention that each benthic assemblage occupied a distinct bathymetric zone characterized by a specific absolute depth range is probably incorrect. Mounds within the Castle Grove Mound facies contain central "cores" of dense dolomite with mudstone and wackestone textures containing scattered large colonies (to 3 m) of rugose and tabulate corals and crinoid debris. "Flank" beds (crinoid and fenestellid bryozoan packstone textures) bury the central mounds and contain a diverse assemblage of fossils. Philcox (1970b), Johnson (1980), and Witzke (1981c) noted a variety of brachiopods, crinoids, and other fossils in the "flank" beds that are characteristic of B.A. 4-5 associations. The "flank" beds post-date the development of the mounds that they enclose, and probably correlate with similar faunas in the lower Emeline facies. Development of the Castle Grove mounds was coincident with deposition of the flat-lying Johns Creek facies containing a B.A. 3 pentamerid association. However, active mound development apparently ceased during C_6 late Llandoverian as environments changed and B.A. 4-5 associations became established in eastern Iowa.

The benthic associations in the carbonate mounds of the Palisades-Kepler Mound facies are varied and diverse, although crinoids are volumetrically the dominant benthic invertebrate present in most of the mounds. Echinoderm debris is characteristically large (more than 3 mm diameter), and where identifiable echinoderms are present, the fauna is dominated by a variety of camerate crinoids (especially *Eucalyptocrinites, Siphonocrinus*) with lesser numbers of flexible and inadunate crinoids (especially *Crotalocrinites*) and cystoids (*Caryocrinites*). The carbonate mounds are primarily constructed of carbonate mud and crinoid debris with lesser quantities of other fossils, most notably corals and stromatoporoids. "The distribution and orientation of colonial coelenterates shows that in Iowa they did not construct rigid, wave-resistant frames, but were subordinate to crinoids in the reef-building role" (Philcox, 1971, p. 338). Relict isopachous fibrous submarine cements are observed petrographically, and the mounds apparently became rigid features on the sea floor primarily through submarine cementation processes (Witzke, 1981c). *Favosites* is the commonest coral in the facies, and a variety of other tabulates and solitary and colonial rugosans are also present. Branching and fenestellid bryozoans are locally significant within the mounds, especially in possible grain flow deposits in the flanking beds. Nautiloid and trilobite predators and scavengers in the mound environments were commonly concentrated by currents into fractures and depressions ("pockets") within the mound. A variety of brachiopods are present in the Palisades-Kepler mounds, but usually none is abundant. Within crinoidal and bryozoan-rich beds, the brachiopod fauna is primarily characterized by *Atrypa*, rhynchonellids, and strophomenids. Large pentamerid (*Conchidium, Lissocoelina*) and trimerellid brachiopods are locally present in the mounds; these brachiopods are included in a B.A. 3 position by Boucot (1975). In addition, sponge spicules, gastropods, bivalves, and calcareous green algae (*Ischadites*) are noted in the mounds.

Faunas within the Palisades-Kepler mounds are generally characterized by a greater abundance of large and more robust benthic invertebrates than contemporaneous faunas in the intermound position. The mound facies include an abundance of large camerate crinoids, rugose and tabulate corals (to 65 cm), and stromatoporoids, whereas the intermound Waubeek and Buck Creek Quarry facies associations are characterized by smaller crinoids and corals (rarely exceeding 8 cm). Colonial tabulates are the most abundant corals in the mound facies, whereas small solitary rugosans dominate the coral faunas in the intermound facies. Large, relatively smooth-shelled trilobites (e.g., *Bumastus*) were most successful in the mound facies, whereas smaller, more ornate trilobites (e.g., *Encrinurus*) achieved greater success in the intermound facies. Rhynchonellid, large pentamerid, and trimerellid brachiopods fared best in the mound facies, whereas generally small and thinner-shelled brachiopods (e.g., orthids, meristellids) achieved a higher level of success in the intermound facies. The general abundance of benthic invertebrates was considerably greater in the mound facies than in equivalent intermound facies, possibly reflecting the greater availability of nutrient-rich currents in the shallower water mound environments and greater habitat complexity.

The upper Scotch Grove Fawn Creek facies faunas and lithologies are similar to those in the mound facies, although the volume of skeletal grains in the non-mounded Fawn Creek facies is proportionately slightly less than in the mound facies, and the coralline fauna is of generally smaller size than in the mounds. The Fawn Creek facies probably represents a skeletal bank facies that occupied an intermound environmental position intermediate between the mound facies and the more distal intermound Buck Creek Quarry and Waubeek facies.

Stratigraphic relations clearly indicate that the carbonate mound environments occupied a shallower water position than the adjacent flat-lying intermound facies. Correspondingly, evidence of wave and current activity is more pronounced in the mound facies. The abundance of skeletal packstone and grainstone textures in the Palisades-Kepler mounds suggests that carbonate muds were partially to completely winnowed during deposition of some beds. Some beds with packstone-grainstone textures consist of crinoidal debris of relatively uniform size, which implies possible current sorting. In addition, some packstones contain possible current-oriented crinoid stems. Wedge-shaped grain flow deposits, some of which exhibit graded bedding, flank some of the mounds, suggesting periodic downslope mass movements. Overturned and transported corals are commonly observed, which were probably moved during periodic influxes of turbulent conditions across the mounds.

Philcox (1971, p. 345) studied coral growth forms and their relationship to the surrounding sediment in the Palisades-Kepler Mound facies, and suggested that "reef sedimentation was an irregular process" with "marked fluctuations in sediment rates'' across the mounds. He also found ''evidence for periodic local removal of sediment.'' These observations indicate that periodic water turbulence, possibly generated during storm events, played an important role in mound sedimentation. Less turbulent water currents were probably present across the mounds on a more regular basis. The abundant and diverse biota that inhabited the mounds required a continual influx of nutrients. The pervasive submarine cementation that occurred in the mounds probably required movement of large quantities of water through the mounds. Accumulations of nautiloids and trilobites within the mounds are also indicative of current activity (Mikulic, 1979). However, the lack of a rigid skeletal framework suggests that the mounds were not continuously exposed to high-energy environments. Philcox (ibid.) also concluded that ''turbulence was normally limited'' during the growth of the Palisades-Kepler mounds, although the mounds apparently grew upward into more agitated environments through time. The vertical limits to mound growth may have been controlled by normal fair-weather wave base, since the lack of a skeletal framework may have precluded further mound growth into the highly agitated wave-washed environments. Corals are most abundant in the upper portions of the mounds (Philcox, 1971), where presumably the greatest degree of current activity would have been operating during mound deposition. In summary, all evidence indicates that current activity and storm events exerted considerably more influence on sedimentation in the mound environments than in the laterally equivalent and deeper-water B.A. 3 environments in the intermound position.

Stricklandiid Brachiopod and Related Associations

Stricklandiid brachiopod and related associations occur at several positions in the eastern Iowa Silurian sequence (stricklandiid taxonomy after Johnson, 1979, 1983: 1) middle portion of Hopkinton A (*Stricklandia lens progressa*), 2) lower to middle Hopkinton B (*S. laevis*), 3) lower Scotch Grove Formation, Emeline and Buck Creek Quarry facies (*Costistricklandia castellana*), and 4) mid Scotch Grove Formation, Emeline, Buck Creek Quarry, and basal Fawn Creek facies (*C. castellana, C. multilirata*). Overall, the stricklandiid associations contain the most diverse benthic faunas recovered in the entire Iowa Silurian sequence. However, *Stricklandia* associations are interbedded with coral-stromatoporoid associations in one to several thin bands in the middle portion of the Hopkinton A in the eastern and northeastern Iowa outcrop belt, and these stricklandiid associations, typically characterized by corals and one to two species of brachiopods (Johnson, 1977a), are of generally lower diversity than younger Iowa stricklandiid associations. Although stricklandiid associations are usually assigned a B.A. 4 position (Boucot, 1975), interbedding of Hopkinton A stricklandiid associations with B.A. 2 coral-stromatoporoid associations suggests that the Hopkinton A stricklandiids may have occupied a position more closely analogous to B.A. 3 pentamerid associations. Johnson (1980, p. 206) further suggested that ''there is very little difference'' in general paleocommunity structure between the Hopkinton A ''*Stricklandia* community'' and typical Hopkinton ''pentamerid communities,'' perhaps due to similarities in shell packing (Johnson, 1979). Stricklandiids occur as a minor component of pentamerid-dominated brachiopod associations in younger intervals of the Hopkinton and Scotch Grove formations, suggesting that stricklandiids were apparently adapted for life in some B.A. 3 environments.

On the other hand, stricklandiid and related associations in the Hopkinton B and lower Scotch Grove (Emeline and Buck Creek Quarry facies) are very diverse and include faunal elements, excluding the stricklandiids, that are generally characteristic of B.A. 4 to B.A. 5 positions (Boucot, 1975). These associations commonly include: 1) sponge spicules, 2) stromatoporoids, 3) tabulate and rugose corals (most less than 10 cm diameter), 4) inarticulate, orthid, strophomenid, rhynchonellid, pentamerid, and spiriferid brachiopods, 5) bryozoans (abundant branching and fenestellid forms), 6) gastropods, bivalves, and nautiloids, 7) trilobites, and 8) echinoderms. The echinoderm faunas are dominated by a highly diverse assemblage of camerate crinoids (Witzke and Strimple, 1981), although inadunate and flexible crinoids, blastoids, paracrinoids, and rhombiferan cystoids also occur (Witzke, 1976). Johnson (1977a, p. 38-91) recognized additional stricklandiid-related associations in the lower Emeline facies: 1) "a unique bryozoan and trilobite fauna" and 2) "a high diversity fauna comparable to a cloridan community" (cloridan brachiopod communities assigned B.A. 5 position by Boucot, 1975). A similar bryozoan-rich association containing brachiopods (*Atrypa, Protomegastrophia, Dicoelosia*), solitary rugosans (including *Palaeocyclus*), crinoid debris (including abundant *Petalocrinus*), and trilobites occurs above *Pentameroides*-bearing beds in the middle Scotch Grove Formation (Buck Creek Quarry facies).

Closely similar stricklandiid associations occur within both the Buck Creek Quarry and Emeline facies in the lower Scotch Grove Formation, although the highly crinoidal Emeline facies contains proportionately more skeletal material. Wackestone and packstone textures are characteristic, and crinoidal debris is the dominant skeletal constituent in both facies (see Table 1 point-count data for a limestone interval equivalent to the lower Buck Creek Quarry facies). Petrographic and sedimentologic observations pertinent to environmental interpretations include: 1) skeletal grain abrasion/breakage not observed, 2) absence of current sorting or graded bedding, and 3) micrite envelopes around grains not observed. These features suggest relatively quiet depositional conditions in deeper-water environments than the B.A. 2 and 3 associations. In addition, the benthic faunas that thrived in the stricklandiid associations include forms whose delicate or thin-shelled morphology seems poorly suited for survival in agitated environments (Johnson, 1980). The presence of articulated echinoderms is consistent with a quiet depositional environment. Johnson (1980) proposed a relatively calm water depositional environment for the stricklandiid associations, "well below effective wave base." Although effective wave base can be substantially lowered during periodic storm events, the B.A. 4-5 associations in the Iowa Silurian lack sedimentologic evidence of episodic turbulence and thus are reasonably inferred to have occupied environments generally below maximum storm wave base. However, B.A. 4-5 environments in Iowa occupied a position partially or wholly within the photic zone (contrary to Boucot, 1981, p. 247), inasmuch as calcareous green algae have been recovered in stricklandiid associations in the Hopkinton and lower Scotch Grove formations.

Conclusions and Geologic Implications

The distribution of open-marine benthic associations in the Iowa Silurian was strongly controlled by depth-related environmental factors, primarily general position with respect to effective fair-weather and storm wave bases. As such, the temporal changes from one benthic association type to another can be reasonably correlated with depth-related environmental changes. The spatial distribution of various associations within specific stratigraphic intervals can also be evaluated in terms of depth-related facies changes over a geographic expanse. Johnson's studies within the eastern Iowa Lower Silurian outcrop belt led him to conclude several things about that region: 1) "the generally flat, Iowa sea bottom supported only a single spatially monotonous community at a time" (1977a, p. 118); 2) "their lateral uniformity in composition and structure was pervasive'' (1980, p. 213); and 3) ''contemporaneous facies, if present, existed in such widely spaced belts as not to be obvious in this particular region'' (1975, p. 130). However, comparisons of the Hopkinton benthic associations in the subsurface west of the outcrop belt (Linn-Benton counties; see map Fig. 2) with those in the outcrop belt suggest lateral variations in the distribution of benthic associations and facies on a slightly broader geographic scale.

The Hopkinton Formation doubles in thickness as one proceeds from the Benton County subsurface to the central area of the East-Central Iowa Basin (see Fig. 1), and the interpreted distribution of the contained benthic associations displays a pattern that is consistent with the basinal geometry (Fig. 3). Figure 3 is presented as a generalized and interpretive model that attempts to rectify the fossil distributions recognized in the western subsurface cores with those known in the Iowa Silurian outcrop belt. Subsurface data cannot be elaborated here, although core data recorded by Witzke (1981c, p. 486-544) forms the primary basis for the illustrated interpretations. Although *Stricklandia* associations occur in the middle Hopkinton A in the outcrop belt, the thinned Hopkinton A in the western subsurface has yielded no elements of this association (Fig. 3). The most dramatic lateral change in benthic associations apparently occurs in

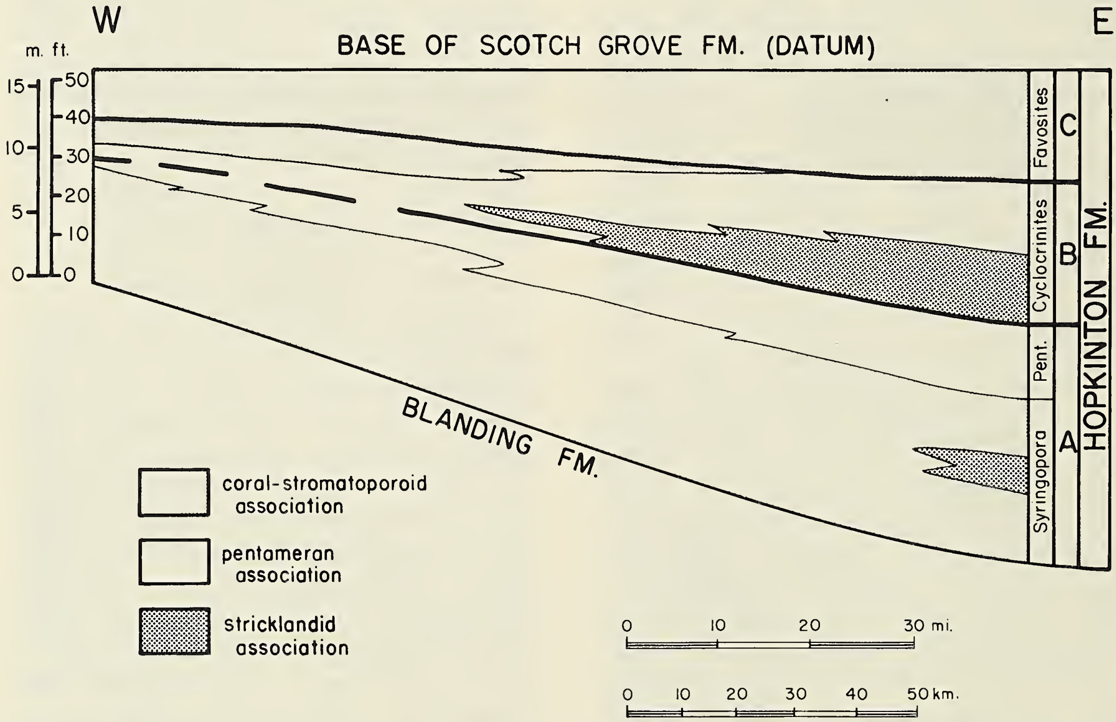

Fig. 3. Generalized interpretation of the vertical and lateral variation in the distribution of benthic associations in the Hopkinton Formation of east-central Iowa. Cross-section line is essentially the same as that used in Figure 2. The sequence of associations in the eastern outcrop belt is derived, in part, from Johnson (1975, 1977a). Subsurface paleotologic data in western subsurface sections generalized from Witzke (1981c). Distribution of Hopkinton A stricklandiid association is schematic, and is represented by several thin zones in the middle to upper ''*Syringopora* beds.'' The interpreted distribution illustrates an ''Israelsky Wedge,'' suggesting that Iowa Hopkinton deposition occurred during a major transgressive-regressive bathymetric cycle.

Hopkinton B. In the outcrop belt the Hopkinton B is characterized by a lower interval with a *Stricklandia* association and an upper interval with a pentamerid association (Johnson, 1980). However, the western subsurface Hopkinton B interval characteristically contains pentamerid associations in the lower portion, and the upper portion contains an abundant tabulate coral fauna with additional fossils (cup corals, stromatoporoids, crinoids, bryozoans, orthids, gastropods). The fauna in the upper interval is tentatively assigned to the coral-stromatoporoid association, although it contains a slightly more diverse fauna than that noted in similar associations in Hopkinton A and C. This association lacks the pentamerid and stricklandiid brachiopods present in the deeper water Hopkinton associations toward the east (Fig. 3). These observations suggest the following interpretations: 1) the lower Hopkinton B *Stricklandia* association in the central portion of the East-Central Iowa Basin is replaced westward by pentamerid associations, and 2) upper Hopkinton B pentamerid associations in the central area of this basin are replaced westward by a coral-stromatoporoid association.

As illustrated in Figure 3, the interpreted spatial distribution of the various Hopkinton benthic associations forms an "Israelsky Wedge" (Israelsky, 1949) in which, at any given time, deeper-water associations occupied the central basin area with stratigraphically equivalent shallower-water associations developed toward the basin margin. These observations offer independent evidence of the depth significance of each association type, since an "Israelsky Wedge" records the "deepening and shallowing phases of a bathymetric cycle" as determined by the relative positions of "bathymetrically controlled" benthic associations (Krumbein and Sloss, 1963, p. 386).

A sequence of probable depth-related open-marine benthic assemblages is identified in the Iowa Silurian, and these assemblages can be correlated with general depth-related environmental zones of Irwin (1965) and Anderson (1971). However, at any given time during the Silurian, only one or two benthic assemblage positions were represented in eastern Iowa. The full complement of onshore to offshore environments (B.A. 1-B.A. 6) at any one time, if developed, probably spread over a much broader geographic area in the epeiric sea. A hypothetical onshore-offshore transect depicts the position of B.A. 1 to 5 environments over a broad geographic area in the central midcontinent (Fig. 4), presumably many hundreds of kilometers across. The farthest offshore environments (B.A. 4-5) are shown in a position well below wave base. However, in Iowa, these environments were characterized by a diverse benthic biota that would have required a degree of current activity to replenish nutrients and maintain stable salinities. B.A. 3 associations inhabited two general carbonate environments in

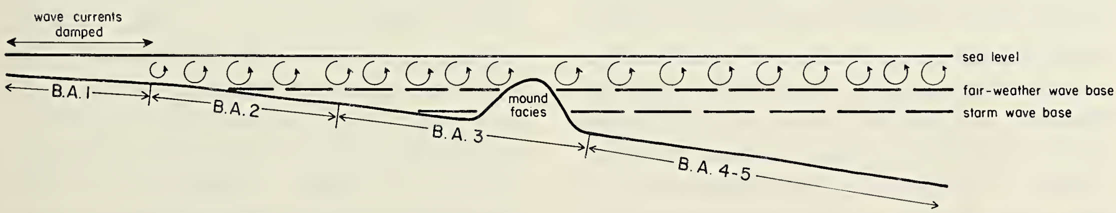

Fig. 4. Hypothetical onshore to offshore transect depicting environmental zones in the Early Silurian epeiric sea in the central midcontinent. Transect is presumably many hundreds of kilometers across. Relative positions of Benthic Assemblages 1 to 5 are shown in relation to fair-weather and storm wave bases. Stable open-marine salinities are maintained across the area occupied by B.A. 2-5, but wind-generated currents are damped in the B.A. 1 position where elevated salinities may be developed. The various environmental zones would migrate across the bottom during relative changes in sea level.

the Iowa Silurian: 1) flat-lying substrate (commonly pentamerid-bearing), and 2) carbonate mound (reef) environments. The flat-lying associations are positioned generally below fair-weather wave base, although periodic turbulent conditions suggest that storm wave base occasionally reached the bottom. On the other hand, carbonate mound environments were subjected to a greater degree of wave and current activity than the flat-lying environments and are placed in a position on Figure 4 where they would have been recurrently subjected to storm events but, in general, immediately below normal fair-weather wave base. B.A. 2 environments are positioned near wave base in the clear water epeiric sea, in part above and in part immediately below wave base (Fig. 4). B.A. 1 associations in Iowa display evidence of restricted circulation and elevated salinities and are discussed in the next section.

Restricted-Marine Benthic Associations

General Characteristics

Restricted-marine benthic associations inhabited environments of elevated or fluctuating salinity. During portions of the Iowa Silurian (early Llandoverian, late Wenlockian-Ludlovian) these environments encompassed a broad range of salinity variations constrained between two general extremes: 1) salinities close to normal-marine, and 2) hypersaline environments in which solutions were occasionally concentrated high enough to precipitate gypsum or halite. This spectrum of environmental conditions influenced sedimentation in a variety of ways, and a variety of distinctive rock types occur in intervals bearing restricted-marine associations. General rock types include: 1) dolomites with skeletal wackstone, packstone, or grainstone textures, 2) unfossiliferous or sparsely fossiliferous dolomites with mudstone textures, 3) domal and sheet-like stromatolitic carbonates, 4) thinly-bedded dolomites and shaly dolomites, 5) laminated dolomites, and 6) dolomites containing evaporite crystal molds. In addition, the contained faunas are characteristically of lower diversity than the open-marine faunas, and several invertebrate groups commonly regarded as stenohaline (see Heckel, 1972) are absent in many of the associations.

Lingulid Brachiopod and Related Associations

Deposition of the Mosalem Formation in eastern Iowa occurred above an irregular Ordovician shale surface along the margin of the transgressing Early Silurian epeiric sea. The surrounding shale hills supplied clays to the Mosalem environments, where argillaceous carbonate deposition prevailed. Mosalem deposition in Iowa was restricted to the eastern part of the state, apparently within isolated cul-de-sacs and embayments in a nearshore position. The Ordovician shale hills were progressively buried by Silurian sediments as the Silurian transgression progressed, and authochthonous open-marine carbonate depositional patterns became established across much of Iowa by the middle Llandoverian (Blanding Formation).

The benthic associations contained in the Mosalem Formation are assigned a nearshore B.A. 1 position. Unlike the younger Iowa Llandoverian environments where normal-marine faunas are well represented, the Mosalem biota is a low-diversity assemblage locally dominated by lingulid brachiopods. Rhynchonellid and strophomenid brachiopods and gastropods are also locally noted (Johnson, 1975, 1977a). Corals, stromatoporoids, echinoderms, and trilobites are characteristically absent in the Mosalem. Where the Mosalem Formation is thin, a basal zone of stromatolitic algal mats is observed (ibid.). Skeletal grains in the Mosalem are non-abraded, suggesting generally quiet depositional conditions. The thinly-bedded argillaceous dolomites and shales and horizontally-laminated stromatolites in the Mosalem are also consistent with relatively quiet depositional environments. The preservation of organic matter in the Mosalem, including plant filaments (ibid.), graptolites, and soft-bodied worms (T. Frest, 1982, personal comm.), also suggests a non-agitated depositional setting.

The restricted fauna and low-energy B.A. 1 environment of the Mosalem Formation in Iowa are characteristic of the "low-energy zone" of Irwin (1965) and "restricted subtidal" environment of Anderson (1971). Wave current activity was probably damped somewhere offshore (B.A. 2 position), restricting circulation in the nearshore zone (see Fig. 4). The discovery of possible halite pseudomorphs in the Iowa Mosalem suggests that elevated salinities may have been present at times during Mosalem deposition. However, some currents were occasionally present in the nearshore Mosalem environments, as evidenced by rare ripple marks low in the sequence.

Stegerhynchus Association

The uppermost portion of the Scotch Grove Formation (upper Waubeek and Buck Creek Quarry facies) and basal Gower Formation (Anamosa facies) in Linn and Jones Counties, Iowa (Fig. 2 map) contain benthic associations of considerably different composition from those in underlying Scotch Grove strata. Block collections have produced a relatively low diversity assemblage characterized by brachiopods and, locally, small tabulate and solitary rugose corals. This assemblage is termed the *Stegerhynchus* association. In addition to *Stegerhynchus,* other brachiopods, commonly *Protathyris, Spirinella,* and *Meristina,* are prominent members of this association. Of special interest is the absence of bryozoans and trilobites and general absence of echinoderms, which renders the association considerably different from the underlying Scotch Grove associations. *Protathyris* is known only from a B.A. 2 position (Boucot, 1975), and the presence of *Protathyris* in the *Stegerhynchus* association suggests the same position.

The lowest occurrence of the *Stegerhynchus* association in the upper Scotch Grove Formation is interbedded with strata containing scattered small echinoderm debris. Collections recovered from this position contain a slightly more diverse assemblage than *Stegerhynchus* association collections identified a few meters higher stratigraphically, and small colonial rugosans (*Heliolites*), gastropods, bivalves, and additional brachiopod taxa are present (Witzke, 1981c, p. 409). However, *Protathyris* is absent in these collections. Higher in the sequence, the uppermost Scotch Grove *Stegerhynchus* association is further reduced in diversity, contains fewer brachiopod taxa, and completely lacks echinoderm debris. Brachiopods are the only benthic group represented in some uppermost Scotch Grove collections. This general change in benthic association diversity in the uppermost Scotch Grove is also marked by the appearance of two brachiopod genera, *Protathyris* and ?*Nalivkinia,* not represented lower in the sequence. The presence of an atrypid tentatively identified by Boucot (1981, personal comm.) as ?*Nalivkinia* is noteworthy, as the genus has previously been identified only in central Asia. Elements of the uppermost Scotch Grove *Stegerhynchus* association survived past the close of Scotch Grove deposition, and *Protathyris* and rhynchonellids are prominent throughout much of the Gower Formation.

The disappearance of several probable stenohaline groups (most notably the bryozoans, trilobites, echinoderms) in the uppermost Scotch Grove Formation in the western portion of the East-Central Iowa Basin (Linn-Jones counties) suggests that elevated salinities may be, in part, responsible for the biotic changes. The major changes in benthic association structure evident in the uppermost Scotch Grove Formation immediately preceded, or were coincident with, the appearance of laminated Gower carbonate deposition in eastern Iowa, and there appears to be a close link between the appearance of the *Stegerhynchus* association and major changes in the patterns of carbonate deposition in Iowa. As will be discussed later, the appearance of laminated carbonate deposition in eastern Iowa probably marked a significant change in the patterns of water circulation that led to elevated salinities. Uppermost Scotch Grove *Stegerhynchus* associations, assigned a B.A. 2 position, overlie normal-marine B.A. 3 associations, and a relative drop in sea level towards the close of Scotch Grove deposition in Iowa is inferred. Unlike relative sea level drops earlier in the Silurian, the probable drop in sea level at the close of Scotch Grove deposition created physiographic conditions that led to the restriction of normal-marine epeiric circulation in eastern Iowa. This change is not only reflected in the patterns of carbonate deposition, but also by a general reorganization of benthic community structure.

Laminated Carbonate Environments and Associations

The onset of Gower deposition was marked by the widespread appearance of laminated carbonate sediments over much of east-central Iowa. Although three general facies are recognized in the Gower Formation of Iowa, flat-lying sequences containing laminated dolomites (Anamosa facies) typify much of the formation. The bulk of the Anamosa facies is comprised of laminated dolomites; individual laminae generally range between about 0.3 and 3 mm thick, and laminae as thin as 30 microns are noted. The laminated rocks include three general lithologies: 1) wavy- or crinkly-laminated rocks interpreted as subtidal algal stromatolitic mats (Philcox, 1972; Henry, 1972); 2) planar-laminated rocks, possibly representing varved carbonate accumulations deposited by episodic or seasonal carbonate precipitation (Witzke, 1981c); and 3) faintly-laminated dolomites. In addition, the Anamosa facies includes a variety of secondary rock types: thinly-bedded dolomites, dense to porous non-laminated dolomite mudstones, intraclastic dolomites, dolomites with evaporite crystal molds, and fossiliferous dolomites with skeletal wackestone to packstone textures. Individual laminae and dolomite mudstone beds are laterally persistent on outcrop (up to distances of 3 km or more), suggesting widespread quiet-water depositional environments. The rare presence of evaporite crystal molds (Henry, 1972), probably gypsum, along with the general absence of benthic faunas, indicates that the Anamosa facies was, at least in part, deposited under conditions of elevated salinity. Similar laminated carbonate intervals are present in evaporitic sequences in the Salina Group of the Michigan Basin. Although the bulk of the Anamosa facies was probably deposited under quiet conditions, the occasional presence of truncated laminae and intraclast beds in the sequence suggests that periodic turbulent conditions, perhaps generated during storm events, occurred during deposition.

The Anamosa facies is characterized by a general absence of benthic invertebrates (including burrowers), although a few low-diversity associations are scattered within some Anamosa sequences. The beds containing benthic faunas are typically quite thin, indicating that benthic faunas lived in the Anamosa environments for relatively short periods of time. Benthic faunas are most commonly encountered in the Anamosa facies in the general vicinity of the Brady facies mounds, where abundant brachiopod and coral faunas thrived in the shallower mound environments. These faunas are included in the *Protathyris*-rhynchonellid association, an association best developed in the mound facies. This association interfingers with laminated Anamosa dolomites near the mound margins. However, thin beds bearing the *Protathyris*-rhynchonellid associations are occasionally present within the Anamosa facies at localities removed from areas of Brady facies mound developments; thus at times when laminated

Anamosa deposition was interrupted, this association may have briefly lived in the intermound environments. In general, the *Protathyris*-rhynchonellid association typically includes an abundance of few taxa, most notably athyrid (*Protathyris, Hyattidina*) and indeterminate rhynchonellid brachiopods and small tabulate and solitary rugose corals. Gastropods, bivalves (*Pterinea*), and ostracodes have also been observed. Echinoderm debris is characteristically absent throughout the Anamosa facies, although some small echinoderm debris has been locally noted, most commonly near the contact with the underlying Scotch Grove Formation.

A second benthic association, termed the "rod"-algal mat association, is also identified in the Anamosa facies. This association is not only noted at a position where the Brady and Anamosa facies interfinger, but also at localities far removed from any carbonate mounds. The "rods" are enigmatic cylindrical fossils generally about 1 cm by 2 mm in size, but occasionally reaching lengths of up to 4 cm. They are usually associated with algal-laminated beds. The "rods" were apparently soft when deposited, as indicated by draping of individual "rods" to conform to bedding surface undulations (Henry, 1972). The "rods" have been variably interpreted as fecal pellets or dwelling tubes of an unknown benthic invertebrate. However, the "rods" are exceptionally large for most known fecal pellets. Gill (1977) illustrated "rods" from algal-laminated dolomites of the A-1 carbonate in the Michigan Basin which he interpreted as being of "fecal origin," probably produced by unknown "mat-grazing organisms." However, if the abundant "rods" were produced by burrowing or grazing organisms, there should be evidence of burrowing within the laminated dolomites or truncated grazed surfaces on individual algal laminae adjacent to the "rod"-bearing beds. Such features have not been observed in the laminated Gower dolomites. In addition, well-preserved "rods" have a hollow central chamber, a feature not easily explained if they are of fecal origin. Henry (1972) alternatively suggested that the "rods" were soft, gelatinous dwelling tubes of an unknown "worm"-like organism. The organisms that lived in these tubes may have been filter feeders. The general exclusion of a benthic fauna in most laminated Anamosa environments suggests that benthic conditions were hostile to most invertebrates, probably due to elevated salinities. However, the "rod" organisms were apparently uniquely adapted for survival in some of the subtidal organic-mat environments.

Carbonate Mound (Reef) and Related Associations

Carbonate mound facies interfinger with laminated dolomites of the Anamosa facies within the Gower Formation of eastern Iowa. Two mound facies are recognized, each generally occupying a distinct geographic region of eastern Iowa. The Brady facies includes coral- and brachiopod-rich mounds typically developed in the western and central portions of the East-Central Iowa Basin. Stratigraphic relations indicate that the Brady mounds were deposited in shallower-water environments than the adjacent flat-lying Anamosa beds (Witzke, 1981a). Brady facies mounds and mound complexes vary in size from about 150 m to 1 km in diameter; maximum vertical dimensions are unclear due to post-Silurian erosion (up to 25 m preserved). Dips average about 20 to 50° in the mounds, and slump-folds locally achieve dips up to 90° (Hinman, 1968).

The Brady facies is characterized by fossiliferous dolomite with skeletal wackestone-packstone (some grainstone and boundstone) textures. Dense non-laminated to laminated dolomites, in part with prominent stromatolites, are interbedded with the fossil-rich beds. Although, in a general sense, Brady rock types resemble those of the Anamosa facies, the Brady facies is *markedly* more skeletal rich. The Brady mounds lack a rigid skeletal framework, and, as evidenced by abundant relict fibrous isopachous cements, the mounds apparently became rigid features on the sea floor primarily through submarine cementation processes.

A profusion of fossils is evident in the Brady facies, but the faunas are of relatively low diversity. As previously discussed, dense brachiopod accumulations of the *Protathyris*-rhynchonellid association comprise much of the Brady facies. The abundant small brachiopods are normally articulated, and dolomite-replacement of delicate athyrid spiralia is not uncommon. The *Fletcheria* association is well developed within some Brady facies mounds, commonly intimately associated with *Protathyris*-rhynchonellid beds. This association is dominated by clusters of the solitary rugose coral, *Fletcheria* sp., and small colonies (usually less than 20 corallites) of an indeterminate tabulate coral are commonly encountered. Small solitary rugosans, *Halysites,* and *Favosites* are locally present. The coral-rich *Fletcheria* association intergrades with the *Protathyris*-rhynchonellid association in the Brady facies, and *Fletcheria* and small tabulates are locally represented in the brachiopod-rich beds. The abundance of corals and *Protathyris* in these associations suggests a B.A. 2 position. Toward the edges of the Brady facies mounds, the *Protathyris*-rhynchonellid association interfingers with laminated dolomites of the Anamosa facies. At this general position, algal-laminated dolomites, in part containing "rods," become prominent, and domal stromatolites are locally observed. "Rod" packstones are noted near the mound edges.

A distinct benthic association is locally present in the central mound areas of the Brady facies, stratigraphically below *Fletcheria* and *Protathyris*-rhynchonellid associations. Large pentamerid (*Harpidium*) and trimerellid brachiopods are conspicuous in this association, forms generally characteristic of a B.A. 3 position (Boucot, 1975). In addition, spiriferid, strophomenid, and rhynchonellid brachiopods are also represented, although athyrids are absent. Gastropods, bivalves, and nautiloids are present, but corals are generally rare. The *Harpidium*-trimerellid association locally contains rare echinoderm debris, but trilobites, bryozoans, and stromatoporoids have not been observed.

The LeClaire facies occupies a position near the southeast margin of the East-Central Iowa Basin, and is best developed in Scott County, Iowa (see Fig. 2 map) and adjacent areas of Illinois. The LeClaire facies includes mounded and flat-lying strata that interfinger with the Anamosa facies in a complex manner. The LeClaire facies contains several different benthic associations. Unlike benthic associations in the Brady facies, the LeClaire facies locally includes associations with an abundance of crinoidal debris, both in flat-lying and mounded sequences. Large crinoid debris, including identifiable cups (especially *Eucalyptocrinites, Crotalocrinites*), is locally common in some LeClaire mounds, and small indeterminate crinoid debris is present in some flat-lying LeClaire sequences. Trilobites also occur in some LeClaire mounds. The presence of crinoid debris and trilobites in the LeClaire facies (these groups commonly regarded as stenohaline) suggests that LeClaire environments were developed, in part, in water of generally normal-marine salinity. Crinoidal rocks in the LeClaire facies resemble typical lithologies in the Palisades-Kepler Mound facies, although, unlike the Palisades-Kepler mounds, the LeClaire facies occurs higher stratigraphically and is laterally equivalent to laminated dolomites. However, the LeClaire facies also includes lithologies and benthic associations that closely resemble those in the Brady-Anamosa facies.

Fletcheria associations are well developed in the LeClaire facies, both in flatlying and mounded sequences, and are locally interbedded with crinoidal or laminated dolomites. The LeClaire *Fletcheria* associations contain rugose and tabulate corals, brachiopods (rhynchonellids, atrypids), and rare gastropods, but echinoderm debris is absent. Additional brachiopod-dominated associations, commonly containing rhynchonellids and atrypids (aff. ?*Nalivkinia*), occur in the facies. The LeClaire mounds also locally contain a brachiopod association characterized by large pentamerids (*Conchidium*) and trimerellids; large bivalves ("*Megalomus*"), gastropods, and solitary rugose corals also occur. The LeClaire rhynchonellid-atrypid and *Conchidium*-trimerellid faunas resemble, in a general sense, the *Protathyris*-rhynchonellid and *Harpidium*-trimerellid associations, respectively, in the Brady facies. A degree of faunal similarity between the Brady and LeClaire mounds is apparent, although important faunal differences, particularly with respect to the crinoidal component, need to be stressed.

As with the upper Scotch Grove mounds, mound facies in the Gower Formation were subjected to water currents during deposition to varying degrees. These currents brought a continuing supply of nutrients to the abundant suspension-feeding invertebrates that lived on the mounds, and also facilitated the movement of water through the mound promoting submarine cementation. However, the characteristic preservation of abundant articulated brachiopods implies that agitated wave-washed conditions were not continually present in the mound environments. Although the LeClaire mounds, in part, contain crinoidal faunas suggestive of open-marine conditions, more Gower mound faunas, especially those in the Brady facies, are characterized by low-diversity associations lacking several biotic groups commonly interpreted as having stenohaline normal-marine environmental requirements (most notably echinoderms, trilobites, bryozoans). In addition, the Gower mound facies interfinger with laminated Anamosa carbonates that were probably deposited in environments of elevated salinity. It is consistent with those observations to suggest that the Gower mound environments were also subjected to conditions of fluctuating or elevated salinities during their deposition.

Upper Gower Faunas and Environments

The final phases of Silurian sedimentation in Iowa have been largely erased by pre-Middle Devonian erosion. However, the uppermost Gower rocks examined contain faunal and lithologic characteristics distinct from those in underlying strata. The uppermost portion of the Anamosa facies at one locality in Jones County (see Fig. 2 map) includes non-laminated to faintly-laminated dolomites that are locally intraclastic. Specimens of a large ostracode, *Leperditia* sp., were found in this interval. No other fossils were recovered, and the fauna was undoubtedly one of very low diversity. The presence of intraclastic rocks suggests the development of shallower water conditions during upper Gower deposition. Intraclasts may have been incorporated into the enclosing fine-grained carbonate sediments during episodic incursions of agitated conditions. This shallowing trend evident in the upper Gower led to eventual offlap of the Silurian sea from eastern Iowa.

Gower Depositional Model

The progression of normal-marine benthic associations in the middle Llandoverian through middle Wenlockian sequence in Iowa bespeaks long-term maintenance of stable salinities and effective circulation in the Iowa portion of the epeiric sea. However, a profound change in benthic association structure and carbonate depositional patterns occurred during the middle to late Wenlockian. Epeiric water circulation patterns in Iowa were apparently disrupted at that time. Diverse marine B.A. 3 associations in the upper Scotch Grove are replaced by relatively low-diversity restricted-marine B.A. 2 associations near the contact with the Gower Formation. A relative drop in sea level may have contributed to these changes.

What other factors contributed to the restriction of water circulation in eastern Iowa during the late Wenlockian? I previously suggested that the late Wenlockian drop in sea level "left central Iowa emergent at the beginning of the Gower deposition, and open circulation across the carbonate shelf was thereby cut off" leaving "east-central Iowa as a restricted embayment of the Silurian sea" (Witzke, 1981a, p. 17). During marine regression, the seas would retreat first from the structurally elevated areas and be retained longest within the basinal areas (in this case, the East-Central Iowa Basin). A tentative model of Gower deposition is proposed in which a restricted embayment of the Silurian sea in east-central Iowa opened eastward into Illinois where better circulation and more normal marine salinities prevailed.

The onset of Gower deposition was marked by the widespread appearance of laminated carbonate sediments (Anamosa facies) over much of east-central Iowa. I concur with Henry (1972, p. 78) and Philcox (1972, p. 701) in interpreting the depositional environment of the laminated Gower carbonates as one of quiet conditions of restricted circulation and high salinities. However, equivalent carbonate mound facies developed in waters that were generally shallower than the laminated Anamosa facies. The nearer-surface water conditions in the mound environments were apparently more favorable for the flourishing of benthic organisms than the slightly deeper environments where subtidal organic mats and "evaporitic" carbonates were deposited. These interpretations suggest that a vertical stratification of the water column was developed during Gower depositional in eastern Iowa. The probability of hypersaline conditions in the Gower environments further suggests that the water column may have been divided into two water masses by a halocline. The halocline marked the boundary between the denser, more saline bottom waters and an upper surface layer of less saline and better aerated waters. The Brady facies mounds apparently developed in the shallower and more hospitable surface waters, whereas deposition of the Anamosa facies predominated beneath a halocline (Witzke, 1981a, p. 21). Because the Brady faunas, while extremely abundant, are generally of low diversity and characteristically lack several normally stenohaline groups, the waters of the upper surface layer apparently still posed stresses that tended to exclude several groups of marine organisms, and somewhat elevated salinities are suggested. Skeletal-rich Brady facies beds may have spread laterally into the flat-lying Anamosa facies at times when the halocline became depressed or disrupted.

The LeClaire facies includes a more diverse benthic fauna compared to the more restricted faunas of the Brady facies, suggesting that surface water conditions were more favorable for marine faunas in the eastern portion of East-Central Iowa Basin than farther west. This can be explained if surface water salinities increased westward within the basin. Carbonate buildups and skeletal/mud banks of the LeClaire facies in the eastern portion of the basin may have served to attentuate open marine circulation between Illinois and eastern Iowa. The LeClaire facies may thereby have formed an effective circulation barrier, promoting the development of a stratified water column in the East-Central Iowa Basin. The halocline must have vanished eastward into Illinois, where saline bottom waters presumably mixed with more open-marine waters. The LeClaire-Anamosa facies belt lies at a position transitional between the western Brady-Anamosa facies belt, where a relatively stable and long-lived halocline was apparently developed, and an open-marine facies belt in Illinois. The LeClaire facies, occupying this intermediate environmental position, contains both open-marine and restricted-marine benthic associations.

Conclusions

The central objective of this report was to evaluate the distribution of the Iowa Silurian benthic associations in terms of possible controlling paleonvironmental parameters. The Iowa Llandoverian depth-related benthic paleocommunity model of Johnson (1975, 1980) was tested using additional petrographic and stratigraphic information. In general, the distribution of the three basic level-bottom open-marine benthic associations (coral-stromatoporoid, pentamerid, stricklandiid) was found to be highly correlated to depth-related paleoenvironmental parameters, in particular the relative position of effective wave base. Open-marine epeiric circulation patterns were maintained across the carbonate shelf in Iowa during the middle Llandoverian through middle Wenlockian, and the temporal sequence of benthic asociations and facies is linked to widespread depth-related environmental changes. Open-marine environments and faunas are correlated to general Benthic Assemblage positions within the epeiric sea, and the change from one B.A. type to another in the Iowa stratigraphic sequence can be consistently interpreted in terms of relative changes in sea level. As illustrated in Figure 1, several transgressive (deepening) and regressive (shallowing) trends are evident. However, the change from one B.A. type to another only documents *relative* changes in sea level, and absolute changes in water depth may not be accurately reflected. This is particularly evident in the open-marine mound facies. Although the mounds typically contain B.A. 3 associations, water depths and environmental conditions in the mound facies were considerably different than in the intermound environments where B.A. 3 associations also occur. In many respects, the environmental factors operating during mound deposition share more similarities with flat-lying B.A. 2 environments than with the B.A 3 intermound environments.

The disruption of open-marine epeiric circulation patterns during the late Wenlockian and Ludlovian resulted in a dramatic reorganization of benthic association structure and carbonate depositional patterns. The temporal and geographic distribution of the Late Silurian benthic assemblages was related, not only to relative changes in sea level, but more importantly, to salinity stresses within the restricted eastern Iowa sea. As salinity stresses increased within the eastern Iowa seaway, several stenohaline groups, notably the echinoderms, trilobites, and bryozoans, were excluded from the benthic associations. Although Benthic Assemblage analysis, when utilized with additional stratigraphic and sedimentologic evidence, provides a basis for evaluating relative changes in sea level, a strict correlation of Benthic Assemblages with specific water depths is overly simplistic. Additional environmental parameters operating on epeiric carbonate shelves, especially those related to salinity, also exerted significant influence on the distribution of Benthic Assemblages and their contained biotic associations. In general, relative changes in sea level affected carbonate deposition by modifying the position of storm and fair-weather wave base and, in combination with physiographic and climatic factors, water circulation patterns.

Acknowledgments

Many people freely offered assistance during the course of this study, and the efforts of J. Barrick, A. Boucot, M. Bounk, B. Bunker, M. Carlson, T. Frest, W. Furnish, B. Glenister, R. Heathcote, P. Heckel, G. Klapper, J. Kluessendorf, G. Ludvigson, D. Mikulic, and J. Swade are especially appreciated. Review comments by M. Johnson, P. Sheehan, and R. Paull are acknowledged. P. Lohmann prepared the illustrations, and L. Comstock, typed the manuscript.

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OBSERVATIONS ON THE COMMENSALISM OF SILURIAN PLATYCERATID GASTROPODS AND STALKED ECHINODERMS

Joanne Kluessendorf
Illinois State Geological Survey, Champaign, IL 61820

Abstract

Commensalism of coprophagous platyceratid gastropods and stalked echinoderms persisted from the Ordovician through the Permian. Reported examples from the Silurian are few although this association was well established by that time.

Among Silurian crinoids only camerates are involved in this commensalism. These taxa comprise only nine genera from seven families among the 57 genera represented by 21 Silurian camerate families. Four of these genera (*Dimerocrinites, Lyriocrinus, Macrostylocrinus, Saccocrinus*) are found in the Rochester Shale of New York and Ontario. Other host crinoid genera include *Ptychocrinus* (Power Glen Shale, New York and Ontario), *Periechocrinus* (Waldron Shale, Indiana), *Scyphocrinites* (Silurian-Devonian boundary, Morroco), and *Marsupiocrinus* and *Clematocrinus* (Wenlock Limestone, England). *Dimerocrinites* with attached platyceratids are also known from the Högklint beds at Häftingsklint, Gotland, Sweden.

The cystoid *Caryocrinites* from the Rochester Shale is also found as a platyceratid host. This is the only cystoid known as a host in the Silurian. *Caryocrinites* is unique among cystoids because of its morphologic similarity to crinoids, particularly camerates.

The non-camerate host crinoids (six genera of poteriocrinine inadunates and one taxocrinid flexible) in the geologic record bear morphologic and behavioral similarities to camerates, and these characteristics may influence host selectivity. The tegmen and anus morphologies of host crinoids are variable, and the degree of control which these features exert on host selectivity is uncertain.

Introduction

Platyceratid gastropods are found attached to the tegminal area of certain Paleozoic stalked echinoderms, primarily crinoids and rarely cystoids and blastoids. Presumably, the platyceratid settled during its larval stage onto a young host echinoderm and led a sedentary life situated over the echinoderm's anal opening where it fed on discharged fecal material. This commensalism was apparently successful since it persisted from the Ordovician, when platyceratids first appeared, through the Permian, when both platyceratids and the echinoderms which served as hosts became extinct (Bowsher, 1955). This platyceratid-echinoderm relationship has been reviewed in general by several authors (Keyes, 1888; Clarke, 1921; Bowsher, 1955; Lane, 1978) but little has been previously published about Silurian occurrences even though this association was well established by that period. This paper will relate the known Silurian commensal occurrences, describe the types of echinoderms that serve as hosts, and suggest some possible factors in host selectivity by platyceratids.

Silurian Occurrences

The existence of this commensalism in Silurian time has been known at least since 1851 when Hall figured (1851), Pl. 49, fig.

Fig. 1 *Naticonema* in place on the crinoid *Saccocrinus* (ROM 35797, Royal Ontario Museum) from the Rochester Shale of Ontario. Photo courtesy of C. E. Brett. (x2)

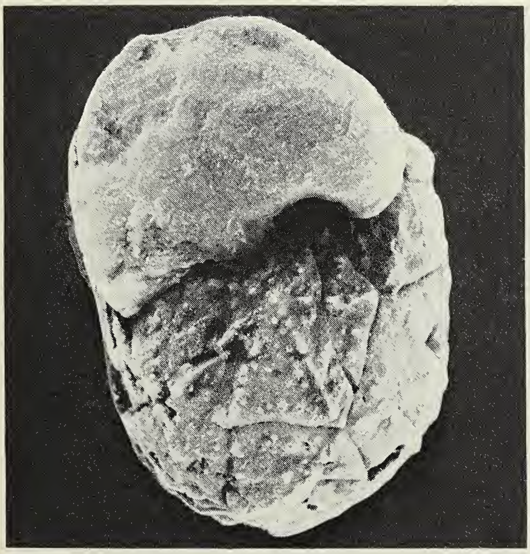

Fig. 2. *Platyceras* on the theca of the cystoid *Caryocrinites ornatus* (E25477, Buffalo Museum of Science) from the Rochester Shale of New York. Photo courtesy of C. E. Brett. (x2)

1d) the cystoid *Caryocrinites ornatus* from the Rochester Shale of Lockport, New York, with a platyceratid firmly attached to it. Hall did not attempt an interpretation of this relationship, but he concluded that it represented an association in life and was not just a fortuitous occurrence. The earliest report of a Silurian crinoid host was provided by Murchison (1854) who figured a specimen of *Marsupiocrinus caelatus* with attached platyceratid from the Wenlock Limestone of Dudley, England. Murchison believed that this crinoid was carnivorous and the gastropod was its prey.

The oldest Silurian occurrence of the platyceratid-echinoderm relationship is known from the Llandoverian Power Glen Shale of New York and Ontario (Brett, 1978a). Brett reported a high density of platyceratids at one locality where *Naticonema niagarense* was found attached to many of the more than 100 crowns of the crinoid *Ptychocrinus medinensis* present.

Additional Silurian examples of this commensalism were found in the Wenlockian Rochester Shale of New York and Ontario. Bowsher (1955) and Brett (1978b) reported *Naticonema niagarense* attached to the crinoid *Macrostylocrinus ornatus* from this unit. *Naticonema* was also found attached to the cystoid *Caryocrinites ornatus* (Hall, 1851); Bowsher, 1955; Brett, 1978b) and to the crinoids *Lyriocrinus, Saccocrinus,* and *Dimerocrinites* (C. Brett, 1977, pers. comm.) in the Rochester Shale. The Wenlockian Högklint beds at Häftingsklint, Gotland, Sweden, have also yielded *Dimerocrinites* with attached platyceratids (C. Franzén, 1978, pers. comm.). *Saccocrinus* and *Caryocrinites* from the Rochester Shale are illustrated as playceratid hosts in figures 1 and 2, respectively.

Platyceras haliotis has long been known as a commensal on the crinoid *Marsupiocrinus caelatus* from the Wenlock Limestone of Dudley, England (Murchison, 1854); Springer, 1926; Bowsher, 1955; Watkins and Hurst, 1977). The crinoid *Clematocrinus*

Fig. 3. Slab of abundant well-preserved *Clematocrinus retiarius* showing two crowns with attached platyceratids. This slab (A12749, Fletcher Collection, Cambridge University) is from the Wenlock Limestone of Dudley, England. (x2)

retiarius (figs. 3 and 4), previously unreported as a host, also occurs with attached platyceratids in the Wenlock Limestone at Dudley. Watkins and Hurst (1977) described this monotaxic crinoid assemblage in detail (under the name *Hapalocrinus*) but did not report the presence of platyceratids. Several slabs of abundant well-preserved *C. retiarius* from Dudley in the Fletcher Collection (Cambridge University) show a rather common occurrence of small commensal platyceratids. The incomplete preparation of the slabs and the small size of the gastropods make it difficult to observe the relationship, therefore, an even higher density of platyceratids possibly exists here.

Fig. 4. Crown of the crinoid *Clematocrinus retiarius* (A12743, Fletcher Collection, Cambridge University) with attached platyceratid, also from Wenlock Limestone at Dudley, England. (x4)

Another previously unreported Silurian example of this commensal behavior was found in the Wenlockian Waldron Shale near Waldron, Indiana, and was brought to my attention by Jeff Aubrey and Kenneth Sever. In this unit platyceratids are found *in situ* on the crinoid *Periechocrinus christyi.* Both the platyceratid and *Periechocrinus* individuals are unusually large for Silurian occurrences of this relationship. One unique specimen of *Periechocrinus,* collected by Kenneth Sever and loaned to me for this study, bears two platyceratids (figs. 5-7). The larger of the two gastropods has an irregular apertural margin corresponding to the distribution of the crinoid arm facets,

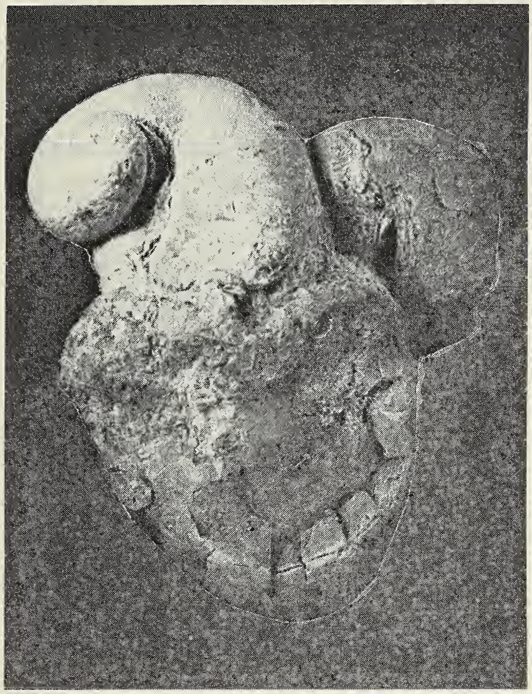

Fig. 5. Large *Periechocrinus christyi* aboral cup associated with two platyceratid gastropods, from the Waldron Shale, near Waldron, Indiana. Specimen in figs. 5-7 is in the collection of Kenneth Sever. Figs. 5 and 6 are x 0.8.

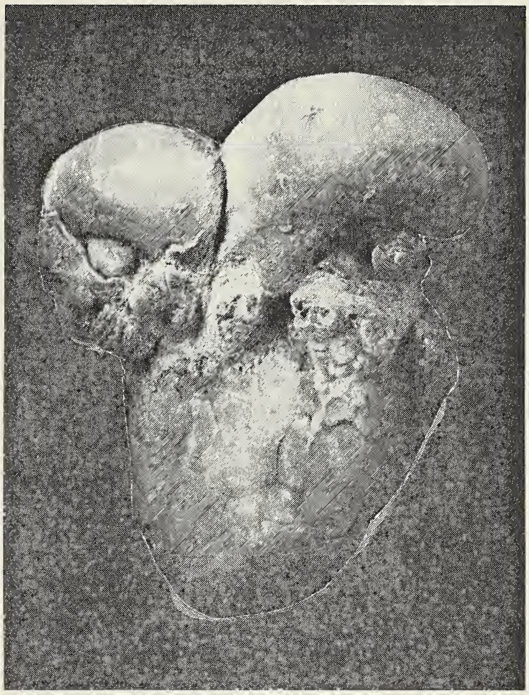

Fig. 6. Another view of the *Periechocrinus* specimen in fig. 5.

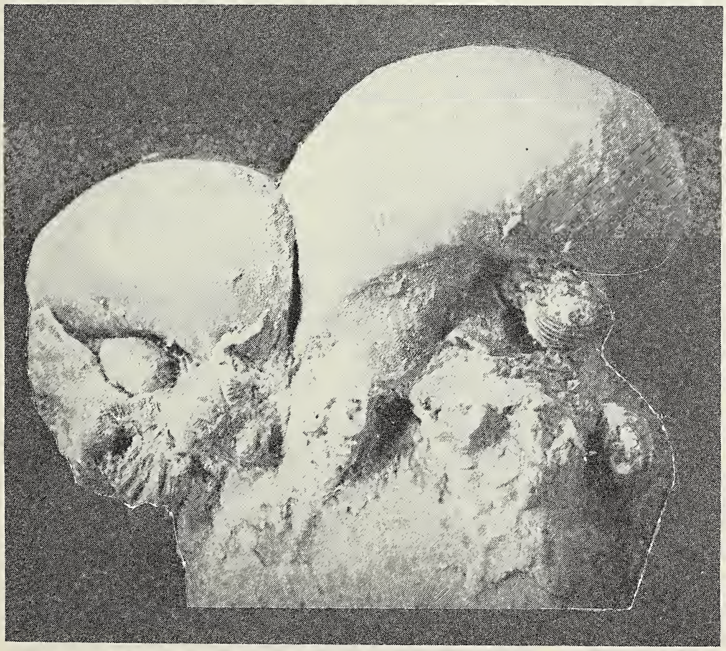

Fig. 7. Close-up of the attachment area on the *Periechocrinus* specimen in figs. 5 and 6. Note the irregular growth lines and apertural margin of the larger gastropod and also the epifaunal organisms which are present on both platyceratid shells. (x1.2)

and its aperture is oriented over the crinoid tegmen. The smaller gastropod is displaced with its aperture partly facing the other gastropod. The apertural margin of the smaller gastropod shows no modification to accommodate the larger shell, but a portion of its margin is irregular in outline, suggesting it may once have been attached to this or another crinoid, but dislodged at the time of burial. Several rhynchonellid brachiopods are associated with the gastropods, three of which are oriented with their pedicles towards the smaller gastropod, suggesting that they may have been attached to it in life. The platyceratid shells are heavily encrusted by ectoproct bryozoans, however, and the brachiopod attachment site is concealed. Several cornulitids are also attached to the gastropod shells. The presence of the same epifaunal organisms on both shells suggests a living association may have existed between the two platyceratids; however, it is also possible that the presence of the smaller gastropod is only fortuitous.

Examples of this commensalism have also been found at the Silurian-Devonian boundary in southeastern Morocco. Lierl (1982) reported both *Platyceras (Orthonychia) elegans* and *Ptychospirina* sp. attached to specimens of the crinoid *Scyphocrinites elegans* there.

No examples of this commensal behavior are known from the diverse North American Silurian reef echinoderm faunas. Many of the camerate host crinoids *(Dimerocrinites, Lyriocrinus, Macrostylocrinus, Marsupiocrinus, Periechocrinus)* and the cystoid *Caryocrinites* commonly occur in Silurian reefs, as do platyceratids. The absence of this relationship from the reef environment appears to be an artifact of preservation because the high energy and low sedimentation rates characteristic of reefs are not conducive to the type of rapid burial needed to preserve articulated echinoderms. Once an echinoderm begins to disarticulate any attached platyceratids could be mechanically detached from it, destroying evidence of the original association. A brief survey of the Greene Museum collections (University of Wisconsin-Milwaukee) has revealed several loose platyceratid specimens from the Hawthorne and Bridgeport Silurian reefs (Chicago, Illinois) with irregular apertural margins suggesting that they may have been attached to crinoids or cystoids.

Relation of Commensalism to Crinoid Morphology and Behavior

Several of the Silurian crinoid taxa which serve as hosts to platyceratids are not anchored by holdfasts or roots and are capable of some mobility. Some, such as *Dimerocrinites,* had prehensile distally-coiling stalks to provide limited mobility. One of the host crinoids, *Scyphocrinites,* was eleutherozoic and drifted by means of an air-filled, bulbous float (Strimple, 1963; Lierl, 1982). *Clematocrinus* had nodal rings of cirri on its stem suggesting it had the ability to reorient itself on the soft sediments on which it lived (Watkins and Hurst, 1977). The lack of direct contact with the substrate and the mobile lifestyles of some of the Silurian host crinoids lend support to the idea that platyceratids settled on their hosts as free-swimming larvae.

Evidence for the sedentary lifestyle of platyceratids is provided by several Silurian examples in which the attached gastropod has an irregular apertural margin which conforms to irregularities on the host at the attachment site. The large platyceratid attached to the *Periechocrinus* specimen in figure 7 provides a fine example of this apertural modification.

The presence of a large, smooth, flat tegmen has been proposed as the principal factor in host selectivity by platyceratids (Bowsher, 1955; Lane, 1978). The Silurian crinoids which serve as hosts, however, exhibit a variety of tegmen morphologies ranging from flat to conical to depressed. The type of anal area also varies among these crinoids. The anus may be a simple opening on the tegmen (e.g., *Marsupiocrinus*) or marginal to the tegmen (e.g., *Macrostylocrinus*). In some taxa an anal ridge (e.g., *Ptychocrinus*) or anal tube (e.g., *Periechocrinus*) exists. The length of the anal tube increases dramatically in some later hosts, particularly in Carboniferous taxa such as *Stellarocrinus*. No matter what the structure of the anus or the morphology of the tegmen the platyceratid is always associated with the anal opening. In those taxa with a long anal tube or marginal anus the platyceratid may have had no contact with the tegmen at all. Factors other than tegmen morphology apparently are significant in controlling host selectivity.

Camerate crinoids and feeding adaptations

All of the Silurian crinoids to which platyceratids are found attached belong to the subclass Camerata. Among 57 genera (21 families) of known Silurian camerates nine genera (seven families) are involved in this commensalism (Table 1). The earliest known example in the Ordovician also involved a camerate host (*Glyptocrinus*) (Bowsher, 1955), and of the numerous post-Silurian host crinoid genera all are camerates except for six genera in the inadunate suborder Poteriocrinina and one genus *(Taxocrinus)* from the subclass Flexibilia. This relationship occurs rarely in the fossil record among known host taxa; however, many other camerates were possible platyceratid hosts, but specimens exhibiting this commensal association have yet to be found.

Table 1. Classification of Silurian crinoids serving as platyceratid hosts.

Subclass Camerata
Order Monobathrida
Family Hapalocrinidae
Clematocrinus
Family Marsupiocrinidae
Marsupiocrinus
Family Patellocrinidae
Macrostylocrinus
Family Scyphocrinitidae
Scyphocrinites
Family Periechocrinidae
Periechocrinus
Saccocrinus
Order Diplobathrida
Family Rhodocrinitidae
Lyriocrinus
Family Dimerocrinitidae
Dimerocrinites
Ptychocrinus

The three groups of crinoids which were hosts to platyceratids shared similar morphologic and behavioral adaptations. Most camerate and some flexible crinoids, particularly taxocrinids, are considered to have been rheophilic, filtration-fan feeders (Breimer, 1978). These crinoids maintained a passive feeding posture with their highly pinnulated or ramulated arms forming a filtration net oriented normal to the horizontal current (Macurda and Meyer, 1974). This feeding method provided an efficient means of capturing plankton and other detritus. In this orientation the crinoid had to have some means of supporting its heavy crown. This balance control necessitated a stalk which was flexible enough to bend in the feeding posture but rigid enough to provide elevation and anchorage. Most camerates possessed a stalk capable of considerable flexure in the middle while rigidity at the proximal and distal ends provided maximum leverage. The distally-coiling stalks of dimerocrinitids (e.g., *Dimerocrinites*) and rhodocrinitids (e.g., *Lyriocrinus*) may have been very useful in balance control because they were able to yield somewhat to prevent too much longitudinal stress in the stalk (Breimer, 1978). Movement of the pinnules provided additional control. This passive rheophilic feeding method did not require complicated movements and was well suited to camerates which lacked muscular contacts between brachials (Breimer, 1978). Breimer (1978) has also suggested that advanced inadunate crinoids possessed pinnulate arms capable of muscular control and could actively orient their crowns into the current at a specific angle in a rheophilic posture in order to derive lift from the current. Although not all poteriocrinine inadunates (the only inadunates known as platyceratid hosts) had developed muscular articulation, they had earlier evolved pinnulate arms and were capable of the rheophilic feeding posture

(Lane and Breimer, 1974; Breimer and Webster, 1975).

Crinoids adapted to the alternative, rheophobic feeding posture either rested directly on the substrate or were supported by a short, rigid stalk. Rheophobes are thought to have lived in areas with very slight currents, or none, where they fed on plankton and other detritus which settled gravitationally through the water column onto their outstretched non-pinnulated arms (Breimer, 1978). No rheophobes have been reported as platyceratid hosts.

What in particular made rheophiles attractive, or rheophobes unattractive, to platyceratids as hosts is unknown. Platyceratids may have selected rheophilic hosts because these crinoids could effect some balance control and were capable of supporting a gastropod while maintaining their feeding postures. The most effective rheophiles may have been camerates such as dimerocrinitids and rhodocrinitids with prehensile stalks, and several of the Silurian host crinoids are of this type. The sessile rheophobic crinoids may have possessed some chemical or mechanical means of preventing organisms from settling on them in order to keep their feeding surfaces clear. Utilizing different feeding methods at different feeding levels rheophobes and rheophiles may have had different food sources. Rheophiles may have fed on smaller sized plankton and detritus than rheophobes (Meyer and Lane, 1976; Watkins and Hurst, 1977). The difference in food source may have been reflected in the crinoid's fecal contents. Rheophobes were probably less efficient feeders than rheophiles. Also they may have had a lower metabolic rate resulting in lower feces production than rheophiles (D. B. Macurda, 1983, pers. comm.).

Morphology of *Caryocrinites*

The rhombiferan cystoid *Caryocrinites ornatus* is the only Silurian cystoid known to host platyceratids. *Caryocrinites* is an unusual cystoid having many morphologic similarities to crinoids, particularly camerates. A "tegmen" of specialized plates covers the mouth of *Caryocrinites* and bears a morphologic similarity, but is not homologous, to the tegmen of crinoids (Kesling, 1967). The long flexible stalk of *Caryocrinites* is also very crinoid-like and dissimilar to most other cystoids which are eleutherozoic or possess very short rigid columns. Brett (1978b) compared the radix-type root of *Caryocrinites* to that of some camerate crinoids. The biserial arrangement and pinnulation of *Caryocrinites* arms is unlike most other cystoids, which have simple unbranched brachioles, but is reminiscent of camerate crinoid arm structure. Sprinkle (1975) suggested that the development of such arms in *Caryocrinites* increased its food-gathering capacity. Also, the theca of *Caryocrinites* is similar in appearance to many camerate crinoid calices (Kesling, 1967). The commensal platyceratid is commonly situated on the upper surface of the *Caryocrinites* theca in a position corresponding to that occupied on many crinoids. Based on its general morphology Sprinkle (1975) believed that *Caryocrinites* was a top layer rheophilic filter-feeder.

Caryocrinites is the only Silurian cystoid known to be involved in this commensalism, and it is the only one to possess numerous camerate crinoid morphologic characteristics. This morphologic similarity to camerates (which are the only Silurian crinoids that host platyceratids) may have been the reason that *Caryocrinites* was a suitable host for these gastropods.

Summary

All Ordovician and Silurian host crinoids as well as the majority of post-Silurian hosts are camerates. The non-camerate hosts comprise only six genera of poteriocrinine inadunates and one flexible. These inadunate and flexible crinoids bear resemblance to camerates, and all three groups are thought to have been rheophilic filter-feeders. The only Silurian cystoid *(Caryoc-*

rinites) known to be a platyceratid host mimics many camerate crinoid traits. This evidence suggests that echinoderms possessing certain morphologic or behavioral characteristics of camerate crinoids were selected as hosts by platyceratids. What specific characteristics possessed by these echinoderms influenced host selectivity is uncertain, but possibly this selectivity was related to particular morphologic or behavioral adaptations associated with rheophilic feeding. The variety of tegmen and anus types exhibited by Silurian and later crinoid hosts suggests that factors other than the morphology of these features were critical in host selection.

Acknowledgments

I would like to thank C. E. Brett, A. J. Boucot, C. Franzen, and D. G. Mikulic for kindly providing me with unpublished data. C. E. Brett also generously provided photos used in figures 1 and 2. J. Aubrey and K. Sever kindly drew my attention to the existence of this relationship in the Waldron Shale, and special thanks are extended to Mr. Sever for his patience and gracious loan of the *Periechocrinus* specimen illustrated in figure 4. I would also like to express my appreciation to R. E. Gernant, D. R. Kolata, D. B. Macurda, and D. G. Mikulic for critically reviewing the manuscript.

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MICROFAUNA OF THE MIDDLE SILURIAN WALDRON SHALE, SOUTHEASTERN INDIANA

SUSAN M. SIEMANN-GARTMANN
Amoco Production Company
1340 Poydras Street
New Orleans, Louisiana 70150

Abstract

A distinctive microfauna developed around crinoid holdfasts on the soft-bottomed environment of the Middle Silurian Waldron Shale of southeastern Indiana. This microfauna was less diverse than the microfauna outside of the crinoid meadows. The echinoderms exerted an unknown control on the microfauna, that permitted selected foraminiferid (*Psammosphaera* and *Saccamina*) and ostracode (?*Cyrtocyprus* and *Leperditia*) genera to monopolize the micro-environment. Scolecodonts were the faunal group least affected by the presence of crinoids.

INTRODUCTION

This study examines the influence of crinoids upon the distribution of microfossils in the Middle Silurian (Wenlockian) Waldron Shale of southeastern Indiana.

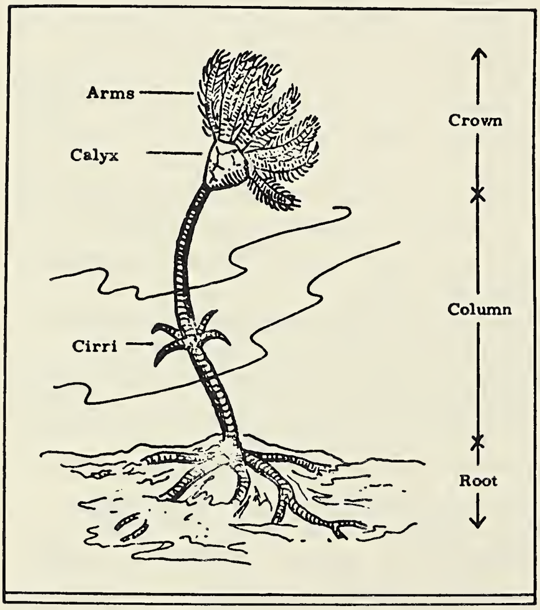

Fig. 1. Diagrammatic sketch of *Eucalyptocrinites* illustrating the basic structured parts of the animal.

Most crinoids inhabiting the shallow sea during deposition of the Waldron muds possessed root systems (holdfasts) that attached to the sea bottom. The attachment device was composed of cirri and radial rootlets located at the base of the stem (Fig. 1). The animals anchored themselves by wrapping the roots around firm objects, such as brachiopods, or by attaching directly to the sea bottom. Because two species of *Eucalyptocrinites, E. crassus* (Hall) and *E. tuberculatus* (Miller and Dyer), are the most abundant crinoids in the Waldron Shale, the root systems examined in this study are assumed to be of these species (Macurda, 1968; Halleck, 1973) (Fig. 2).

According to Halleck (1973, p. 239), *Eucalyptocrinites* was so abundant locally during Waldron deposition that they formed crinoid "meadows," which, along with algal growths, acted as sediment traps. This unique environment could have a microfauna distinctive from that of adjacent areas without major crinoid beds. Furthermore, because the crinoids acted as sediment traps, the microfossils recovered from sediment around the root systems should provide a good record of the forms that existed in the

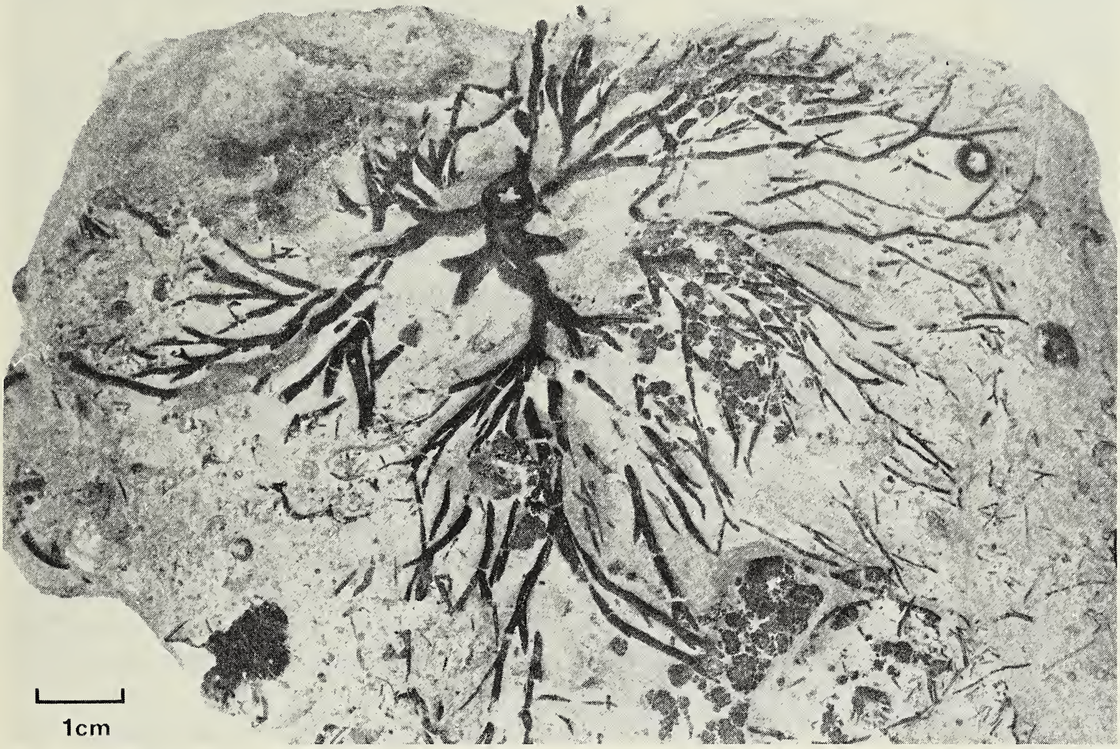

Fig. 2. *Eucalyptocrinites* holdfast or root system from the Middle Silurian Waldron Shale in southeastern Indiana. Greene Museum specimen G27371.

crinoid "meadows" at time of deposition. This study was designed to evaluate these assumptions.

Previous Investigations

The celebrated invertebrate fauna in the Waldron Shale of southeastern Indiana was first detailed in the literature by James Hall (1864). Elrod (1883) applied the name Waldron Shale to the upper part of the Middle Silurian (Wenlockian) calcareous shales cropping out in southeastern Indiana, in order to distinguish it from the underlying Laurel Limestone. Reports on the Waldron Shale during the early 1900s were completed by Price (1900), Cumings (1900), and Kindle and Barnett (1909).

Studies of ostracodes from the Waldron Shale include the work of Berry (1931), Coryell and Williamson (1936), and Morris and Hill (1951, 1952). Other paleontological work on the Waldron included foraminiferal studies by Hattin (1960) and McClellan (1966), and a study of acritarchs by Krebs (1972).

Evolution and paleoecology of the Waldron fauna were evaluated by Tillman (1962), McClellan (1966), Macurda (1968), and Halleck (1973). Macurda (1968) described the ontogenetic development of the crinoid *Eucalyptocrinites,* while Halleck (1973) studied the relations of crinoids to the existence of a hardground at the Laurel-Waldron contact.

Stratigraphy

The Waldron Shale crops out along a discontinuous, elongated strip extending from northern Indiana to western Tennessee, where it was originally called the Newsom

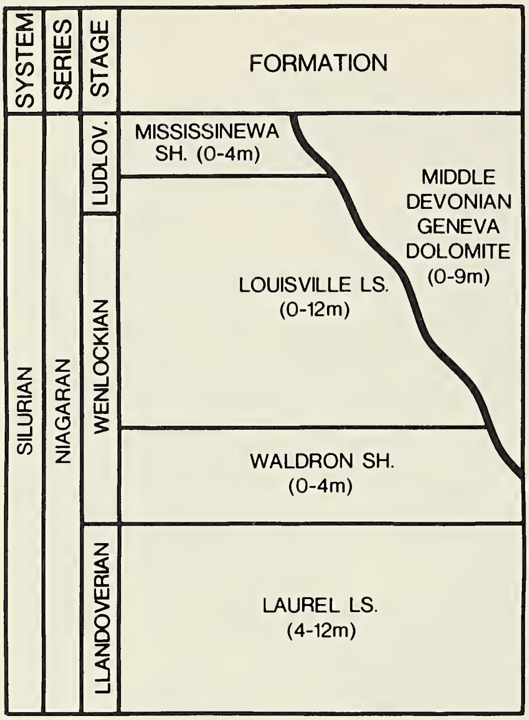

Fig. 3. Part of the Middle Silurian stratigraphic section for southeastern Indiana. The relative position of Middle Devonian Geneva, which unconformably overlies Silurian rocks, is also shown. The thickness of all units is given in meters. Modified from McClellan (1966, p. 451).

Shale. In the study area of southeastern Indiana, the Waldron Shale is generally underlain by the Laurel Limestone, and overlain by the Louisville Limestone (Fig. 3). However, at several localities, the Waldron Shale is unconformably overlain by the Middle Devonian Geneva Dolomite due to erosion during Early Devonian time. The Laurel, Waldron, and Louisville formations are all of Middle Silurian (Wenlockian) age, as established by the presence of ostracodes of the *Drepannellina clarki* zone in both the Laurel and the Waldron formations, and the presence of the brachiopod *Rhipidium* in the Louisville Limestone (Berry and Boucot, 1970).

The Waldron consists of nonresistant, blue-gray, silty shale, which is easily differentiated from resistant carbonates of the underlying Laurel or the overlying Louisville or Geneva formations (Fig. 4). The blue-gray shale pales to a buff-gray where it is weathered or more calcareous, as at Sandusky, Indiana. The parting changes from blocky to very fissile, depending on the amount of carbonate present. The Waldron is locally fossiliferous, especially where it is

Fig. 4. Waldron Shale at Tunnel Mill near Vernon, Indiana.

highly calcareous. According to Heele (1963), the shale is composed of calcite and dolomite, with lesser amounts of feldspar, illite, kaolinite, pyrite and quartz.

The Waldron varies in total thickness from 0 to 4 m, and thins to the north and east. In western exposures, the formation is about 2.5 m thick, and it reaches a maximum of 4 m near Louisville, Kentucky (McClellan, 1966).

Paleogeographic Setting

During Wenlockian time, present-day Indiana was covered by a tropical epicontinental sea with an extensive reef system. These reefs developed in the southeastern Trade Wind belt of the southern latitudes, and formed around the margins of the proto-Michigan basin and the Vincennes basin in southern Illinois and Indiana (Shaver, 1977) (Fig. 5). The Waldron muds were deposited in shallow water on the Wabash platform between the developing basins (Shaver, 1977).

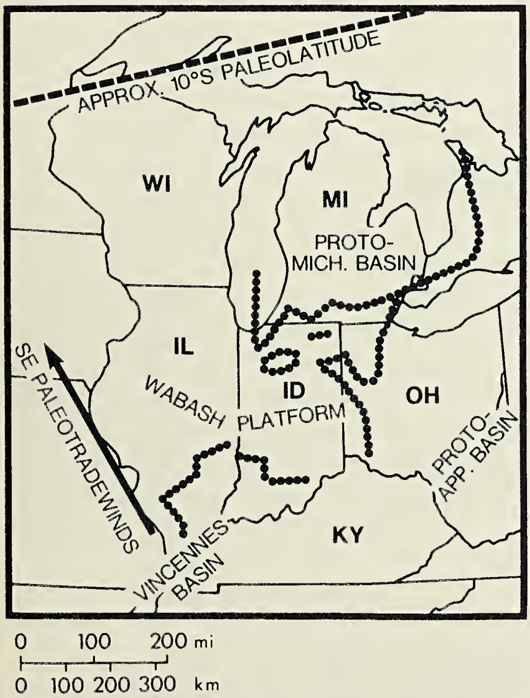

Fig. 5. Major reef systems (dotted lines) and paleogeographic features in the central Great Lakes region during the Silurian. Adapted from Shaver (1977, p. 1409 and p. 1422).

Methods

Samples

Twenty-eight of the 36 crinoid holdfasts used in this study came from the Greene Memorial Museum Collection at the University of Wisconsin-Milwaukee. These samples were purchased by Thomas A. Greene, a Milwaukee pharmacist and amateur paleontologist, from J. T. Doty, a fossil collector from Waldron, Indiana in the early 1880s. Other samples were collected from 4 expo-

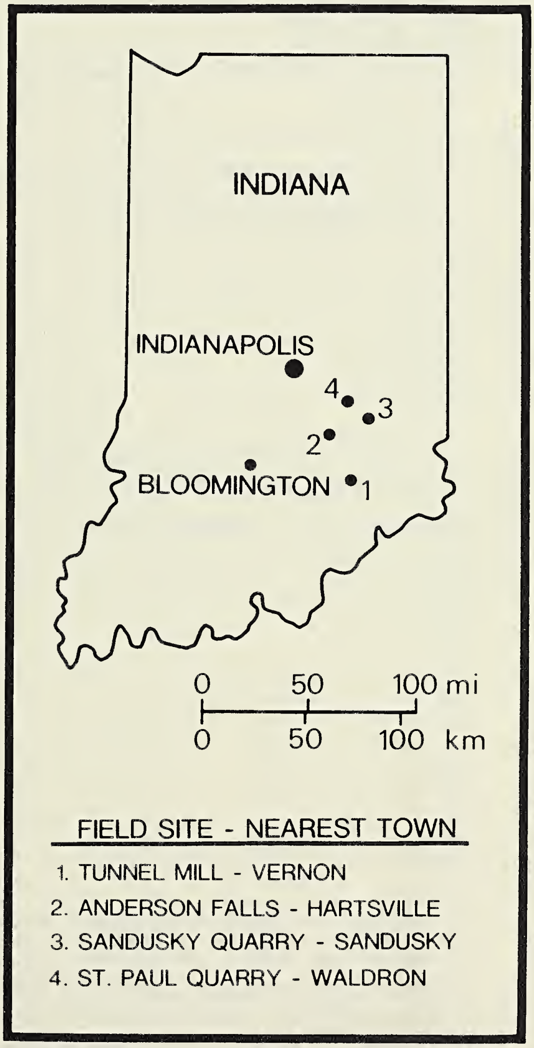

Fig. 6. Location of field localities discussed in the text.

sures of Waldron Shale in southeastern Indiana. The 4 field localities were: Tunnel Mill, Anderson Falls, Sandusky quarry, and St. Paul quarry (Fig. 6). The only 2 crinoid holdfasts found in place were collected at Tunnel Mill, although 6 displaced specimens were collected at the St. Paul quarry. Other localities provided control samples from areas where holdfasts were not present.

Laboratory Work

In order to recover microfossils, samples were crushed to approximately 3 cm prior to chemical treatment. The most satisfactory

TABLE 1. Summary of samples utilized in this study.

Holdfast Samples from Greene Museum	*Weight in Grams*
GM-1 (17744, 17745, 17750, 17754)	97
GM-2 (1162, 17743, 17751, 17755)	95
GM-3 (17746, 17747, 17748, 17753)	96
GM-4 (17741, 17749, 17752)	97
GM-5 (1008, 1660)	123
GM-6 (17758, 17762)	116
GM-7 (1630, 17756, 17757, 17759, 17760, 17761)	119
GM-8 (17740)	130
GM-9 (17742)	122
TOTAL OF 9 HOLDFAST SAMPLES FROM GREENE MUSEUM	743
Holdfast Samples Collected in the Field	
TM-4	122
SPQ-5	188
SPQ-6	56
SPQ-7	251
SPQ-8	82
SPQ-9	91
SPQ-10	33
TOTAL OF 7 HOLDFAST SAMPLES COLLECTED IN THE FIELD	823
TOTAL OF ALL 16 HOLDFAST SAMPLES	1566
Nonholdfast Samples Collected in the Field	
TM-1	300
TM-2	300
TM-3	300
AF-1	100
AF-2	300
AF-3	300
AF-4	200
SQ-1	300
SQ-2	300
SQ-3	300
SPQ-1	300
SPQ-2	300
SPQ-3 & 4	300
TOTAL OF 13 NONHOLDFAST SAMPLES COLLECTED IN THE FIELD	3600

Explanation for Table 1: GM numbers 1 through 7 are composite samples of the Greene Museum cataloged specimens listed in parentheses. There was sufficient material of Greene Museum samples 17740 and 17742 to run them separately. Indiana field sites are shown on Fig. 5. Sample locations are: TM-Tunnel Mill, AF-Anderson Falls, SQ-Sandusky quarry, and SPQ-St. Paul quarry.

disaggregation technique utilized Quaternary 0, a detergent with a good wetting character. Although Zingula (1968, p. 102) recommended a 20% solution of Quaternary 0, a concentration of 33% produced better results for samples used in this study. The disaggregated material was washed through nested sieves of 35, 60, 120, and 170 mesh. The 35 mesh fraction represented rock material that did not break down, and it was discarded. The other 3 fractions were manually picked for microfossils, although the 170-mesh fraction proved to be unfossiliferous. Over 1500 microfossils were recovered, and 1328 of these could be identified to generic level.

The size of the samples processed was dependent upon availability of material. Holdfast samples were generally limited to about 100 gm, while 300 gm of non-holdfast field samples were used. To have sufficient material to process most of the Greene Museum holdfast specimens, samples of similar lithology from the same locality were combined (Table 1).

As shown in Table 1, a total of 16 holdfast samples totaling 1566 gm was processed. Of these, 7 were composite samples. A total of 3600 gm from 13 field samples not associated with holdfasts was also processed. This disparity in sample number and amount created some problems in interpreting the results of microfauna analysis. Furthermore, the stratigraphic position of Greene Museum samples within the Waldron was unknown. Hence, the microfauna recovered must be considered to be "time averaged" in that they probably represent the accumulation of fossils throughout the time represented by deposition of the Waldron Shale.

Micropaleontology

Analysis

The microfossils recovered included 656 foraminifera, 443 ostracodes, 181 brachiopod fragments, 35 scolecodonts, 13 gastropods, and lesser numbers of echinoid spines, bryozoan fragments, and crinoid parts.

Sources used in the identification of the microfossils included: Coryell and Williamson, 1936; Stewart and Priddy, 1941; Morris and Hill, 1951, 1952; Hattin, 1960; Moore, 1961, 1962, 1964; McClellan, 1966; Lundin and Newton, 1970; and Glaessner, 1972. Generic identification was difficult in many cases, because a majority of the brachiopods, gastropods and ostracodes were internal casts.

Because the gastropod casts probably represent juvenile forms, no attempt was made to classify them to genera. However, the coiling pattern and shell shape were distinctive enough to infer that at least 3 genera were present. The three gastropod "form genera" were identified as "Bellerophontiform," "Conispiral," and "Planispiral" (Fig. 7).

The brachipods presented the same problem as the gastropods. Although distinctive variations in the valves were evident, the internal casts were not definitive enough to identify genera. Based on valve shape and the presence or absence of ribbing, at least three "form genera" were inferred to be present. These were designated as "Ribbed," "Spatulate," and "Sulcate" (Fig. 7).

For each sample studied, the 60 and 120 mesh fractions were analyzed individually. In general, the 120 mesh yielded relatively few microfossils and the forms were similar to those present in the 60 mesh fraction.

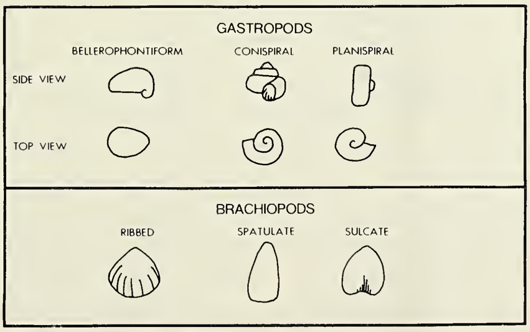

Fig. 7. "Form genera" for microbrachiopods and microgastropods described in this study.

Siemann-Gartmann (1979, p. 33-34) provided detailed counts of the microfauna for each sieve size and for each sample processed. However, this information only served to establish that all the samples processed could be combined into holdfast samples and nonholdfast samples. Table 2 provides this summary.

Abundance and Diversity

Table 2 lists the individual genera identified from the two basic lithogenetic

TABLE 2. Summary of the number of microfauna genera ("form genera" of brachiopods and gastroods) and individuals recovered from 16 holdfast samples totaling 1566 gm and 13 nonholdfast samples totaling 3600 gm. The difference in the number and weight of samples in each category must be considered in this comparison.

Holdfast Microfauna (Genera) - Individuals		*Nonholdfast Microfauna (Genera) - Individuals*	
Brachiopods (3)	61	*Brachiopods* (3)	120
Ribbed	9	Ribbed	9
Spatulate	6	Spatulate	11
Sulcate	46	Sulcate	100
Foraminifera (6)	356	*Foraminifera* (9)	300
Metamorphina	2	Hemisphaeramina	2
Psammosphaera	128	Metamorphina	7
Saccammina	222	Psammonyx	1
Sorosphaera	1	Psammosphaera	108
Sorostomasphaera	2	Saccammina	156
Webbinelloidea	1	Sorosphaera	14
		Sorostomasphaera	8
		Thurammina	2
		Webbinelloidea	2
Gastropods (2)	2	*Gastropods* (3)	11
Bellerophontiform	1	Bellerophontiform	1
Planispiral	1	Conispiral	6
		Planispiral	4
Ostracodes (10)	213	*Ostracodes* (14)	228
Bairdia	26	Bairdia	20
Beyrichia	4	Beyrichia	3
Buthocyrus	11	Bythocyrus	20
?Cyrtocyprus	97	?Cyrtocyprus	84
Entomozoe	4	Entomozoe	4
Eridochoncha	13	Eridochoncha	2
Euprimitia	4	Euprimitia	15
Halliella	2	Halliella	4
Leperditia	48	Hemiaechminoides	2
Primitia	4	Leperditia	43
		Primitia	22
		Schmidtella	3
		Thlipsuroides	3
		Waldronites	3
Scolecodonts (2)	17	*Scolecodonts* (4)	18
Arabellites	4	Arabellites	3
Nereidavus	13	Nereidavus	13
		Staurocephalites	1
		Ungulites	1
TOTAL GENERA: (23)	649	TOTAL GENERA: (33)	677

associations described above. The total genera present is also provided in this table. The holdfast samples yielded 23 genera, while 33 genera were present in nonholdfast samples. In spite of a large bias in the weight of nonholdfast samples, it seems that they contain a more diversified microfossil assemblage than the holdfast samples.

All three brachiopod "form genera" are present in the grouping of microfossil forms from both primary lithologic associations. Since more than twice as much nonholdfast material was processed, it seems that microbrachiopods were present in essentially equal numbers in the two groups under study. In both instances, the most common brachiopod form was the "Sulcate."

All six genera of foraminifera which are present in the holdfast samples are also present in the nonholdfast samples. Although 3 more genera are present in the latter lithologic association, they are represented by only 5 specimens. Although the foraminiferal fauna is dominated by *Psammosphaera* sp. and *Saccammina* sp. in both associations, it is more abundant with holdfasts. When one considers the biased sampling against holdfast lithologies, this difference is given more significance. Other foraminiferal genera common to both lithologic associations are lower in total number of individuals per genus in the holdfast samples. However, the total number of foraminifera individuals is still higher in holdfast samples (356) than in nonholdfast rocks (300). This indicates that the holdfasts contain more foraminifera, although the fauna was less diverse, than the samples without holdfasts.

Only two of the gastropod "form genera" were found in association with holdfasts, and these were each represented by only one specimen. Eleven gastropods representing 3 "form genera" were identified from nonholdfast samples.

Holdfast samples contained only 10 of the 14 ostracode genera recovered during this study. Of these 10 genera, 5 (*Bairdia, Beyrichia, ?Cyrtocyprus, Eridochoncha* and *Leperditia*) occurred in greater numbers than in the nonholdfast control samples, and one (*Entomozoe*) was represented by 4 specimens in each rock type. The total number of individual ostracodes recovered was 213 from holdfast samples and 230 from nonholdfast rocks. However, these numbers are misleading if one does not consider that approximately 2.3 times more nonholdfast rock was processed.

Two genera of scolecodonts were found in holdfast material, whereas four genera were recovered from nonholdfast samples. However, the 2 unique genera were each represented by a single specimen. The two scolecodont genera, *Arabellites* and *Nereidavus,* that occur in both sample types are present in almost equal numbers. Furthermore, the total number of scolecodonts is similar in both associations (17 in holdfast samples and 18 in nonholdfast rocks). Once again, if sample bias is considered, the holdfast samples are characterized by more individual scolecodonts, but fewer genera.

The holdfast and nonholdfast faunas described above were tested with the Shannon index, which provides a measure of diversity for nominal scale data. The Shannon index for each group was then utilized to determine relative diversity of each group (Zar, 1974, p. 35). These tests verified the apparent diversity differences noted in a visual examination of Table 2. Although both faunas have a moderately high diversity, the holdfast fauna is relatively less diverse.

Interpretation

When I began this study, I presupposed that the microfauna associated with crinoid holdfasts would be more diverse and abundant than the control fauna. This assumption was based on the view that the Waldron crinoids supposedly lived in well-circulated marine waters with a constant supply of food. Such an environment should also allow a diverse microfauna to flourish. Furthermore, I visualized effective entombment of these organisms upon death because the crinoids, along with algal mats, would act as effective sediment traps (Halleck, 1973; Abbott, 1975). My conceptual model was only half right. As previously described, the microfauna associated with the crinoid holdfasts is more abundant, than with nonholdfast rocks, but it is less diverse.

The percentage of each faunal group present in the total microfossil assemblage in the holdfast and nonholdfast samples is summarized in Table 3. Based on these figures, it is evident that brachiopods are relatively less abundant in association with holdfasts than they are in nonholdfast rocks. More than half (54.9%) of the microfauna associated with holdfasts consists of foraminifera, while they comprise only 44.1% of the microfauna in nonholdfast rocks. Gastropods are a minor element in both microfaunas, but they are more abundant in nonholdfast samples. Ostracodes made up approximately one third of all the microorganisms in both holdfast and nonholdfast groups. Scolecodonts are present in equal percentages in both rock types.

Table 3. Percentage of microfaunal groups in holdfast and nonholdfast samples utilized in this study.

	Holdfast	*Nonholdfast*
Brachiopods	9.4%	17.7%
Foraminifera	54.9%	44.1%
Gastropods	.3%	1.6%
Ostracodes	32.8%	33.9%
Scolecodonts	2.6%	2.7%
Total	100.0	100.0

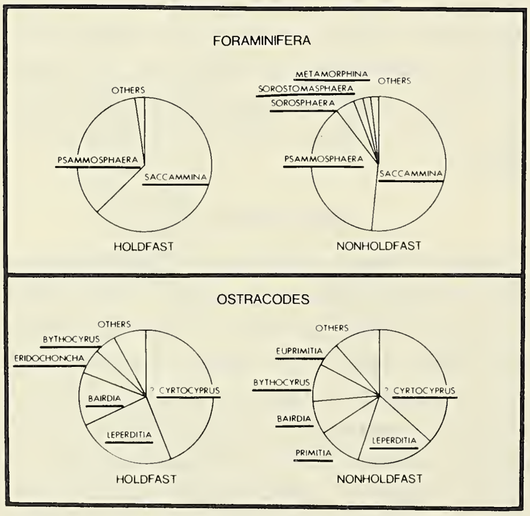

Fig. 8. Percent of genera for the foraminifera and ostracode faunal groups.

As described above, the foraminifera constitute 54.9% of holdfast samples, and 98.2% of this fauna is composed of two genera, *Psammosphaera* (35.9%) and *Saccammina* (62.3%) (Fig. 8). The remaining 1.8% includes four genera (*Metamorphina, Sorosphaera, Sorostomasphaera,* and *Webbinelloidea*). Foraminifera make up 44.1% of the microfauna of nonholdfast samples, with five genera constituting 97.5% of the fauna. These genera are *Psammosphaera* (36%), *Saccammina* (52%), *Sorosphaera* (4.7%), *Sorostomasphaera* (2.7%) and *Metamorphina* (2.3%) (Fig. 8). The remaining 2.4% consist of the following genera: *Hemisphaeramina, Psammonyx, Thurammina* and *Webbinelloidea.*

Although the percentage of ostracodes in both groups is similar, the relative amounts of the genera represented are different. Genera present in holdfast samples consist of *?Cyrtocyprus* (45.5%), *Leperditia* (22.5%), *Bairdia* (12.2%), *Eridochoncha* (6.1%), and *Bythocyrus* (5.2%) (Fig. 8). These 5 genera represent 91.5% of the ostracode fauna, while the remaining 8.5% consists of *Beyrichia, Entomozoe, Euprimitia, Halliella,* and *Primitia.*

In nonholdfast samples, 88.7% of the ostracode fauna is composed of six genera. These are: ?*Cyrtocyprus* (36.5%), *Leperditia* (18.7%), *Primitia* (9.6%), *Bairdia* (8.7%), *Bythocyrus* (8.7%), and *Euprimitia* (6.5%) (Fig. 8). The remaining 11.3% consists of the following nine ostracode genera: *Beyrichia, Entomozoe, Eridochoncha, Halliella, Hemiaechminoides, Schmidtella, Thlipuroides,* and *Waldronites.* The two most abundant ostracode genera, ?*Cyrtocyprus* and *Leperditia,* comprise 68% of the total ostracode fauna in the holdfast samples compared with only 55% in nonholdfast rocks (Fig. 8).

Two foraminifera genera (*Psammosphaera* and *Saccammina*) and two ostracode genera (?*Cyrtocyprus* and *Leperditia*) dominate the microfauna. These forms may have been generalists, who occupied an environment that was not highly specialized. Since the 4 taxa listed above comprise 76.3% of the total population of microorganisms present in the holdfast assemblage, this might indicate the environment associated with the crinoid roots was not partitioned into narrow ecological niches which would have favored a wider range of microorganisms. Once established in this nonspecialized environment, generalists would flourish and probably crowd out other genera. Hence, environmental factors favoring a large population of nonselective microorganisms could explain the lower diversity previously described. However, it may be that the most abundant taxa were merely better adapted to the environment associated with the holdfasts.

It is also possible the crinoids themselves were responsible for lower diversity in the microfauna associated with the holdfasts. Watkins and Hurst (1977) constructed a model of crinoid ecology for the Middle Silurian Wenlock Limestone of Dudley, England. These workers concluded that crinoids affected the associated fauna by their high-level suspension feeding habits. A dominance of crinoids resulted in "high crinoid species diversity, partitioning of planktonic resources, and maintenance of suspension feeding height over other fauna" (Watkins and Hurst, 1977, p. 216). Lane (1973), who reported on Carboniferous crinoids from Crawfordsville, Indiana, arrived at similar conclusions in a study that focused on a depositional environmental receiving terrigenous sediment.

According to Watkins and Hurst (1977), one key to the successful dominance of the crinoids was their diversity, which allowed for stratified feeding heights. Although species diversity in crinoids of the Waldron Shale was probably inhibited by the soft bottom environment, they may have exerted some control on the associated microfauna.

Size comparisons between the holdfast and nonholdfast foraminifera and ostracodes do not indicate that crinoids selectively filtered out some forms for food. Furthermore, the rooted crinoids would feed well above the level of the substrate where the microfauna lived (Fig. 1).

The scolecodonts were the faunal group that appears to be least affected by the presence of crinoids. These microfossils are the jaws of worms that inhabited the substrate at least part of the time, and this would minimize any influence by crinoids.

Based on the discussion above, there is a difference between the microfaunas associated with holdfast and nonholdfast samples. However, my work does not establish what caused this difference. Certainly the controls are somehow related to the presence of crinoids, or crinoid holdfasts.

Conclusions

This study establishes that the microfauna associated with crinoid holdfasts in the Middle Silurian Waldron Shale of southeastern Indiana is distinctive from control samples not associated with holdfasts. The crinoid holdfast microfauna is characterized by a large percentage of foraminifera and ostracodes. A small percentage of the microfauna is composed of brachiopods, scolecodonts and gastropods. A total of only 23 genera represents the five faunal groups present in the crinoidal microfauna, whereas 33 genera are present in the same 5 faunal groups in nonholdfast samples. Thus, the holdfast faunal assemblage is characterized by a relatively abundant microfauna with lower diversity than that recovered from the control samples.

Crinoids, or crinoid holdfasts, exerted an unknown controlling influence over the microfauna, although several possibilities are discussed. The genera that make up 76.5% of the crinoidal microfauna were *Psammosphaera* and *Saccammina* (foraminifera), and ?*Cyrtocyprus* and *Leperditia* (ostracodes). The only faunal group that was not significantly affected by the rooted crinoids were the scolecodonts. These conclusions support the findings of Watkins and Hurst (1977), who also concluded that crinoids exerted a control on the associated fauna.

Acknowledgments

I would like to thank Dr. Katherine Nelson for suggesting and guiding this study. I also wish to acknowledge the following individuals for professional assistance: J. M. Berdan, U.S. Geological Survey, Frank J. Charnon and Dr. Robert E. Gernant of The University of Wisconsin-Milwaukee, Mr. Kenneth Hodginson, a paleontologist with Exxon Company U.S.A., Dr. Gary Lane of The University of Indiana-Bloomington, Drs. Richard A. and Rachel K. Paull of The University of Wisconsin-Milwaukee, and Dr. Peter Sheehan, The Milwaukee Public Museum. On a more personal note, I would like to thank my parents for moral and financial support, and my husband, Chuck, for continual encouragement.

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EVOLUTION OF A BIOSTRATIGRAPHIC ZONATION; LESSONS FROM LOWER TRIASSIC CONODONTS, U.S. CORDILLERA

Rachel Krebs Paull
Dept. of Geological and Geophysical Sciences
University of Wisconsin-Milwaukee
Milwaukee, Wisconsin 53201

Abstract

Condonts have exceptional value as biostratigraphic tools, and more than 100 conodont biozones are recognized in Ordovician through Triassic rock. They facilitate correlation in Triassic strata where stratigraphically significant ammonoids are rare or absent. A biostratigraphic zonation for the entire Triassic System was first developed in 1971 by integrating parts of a Lower Triassic zonation developed in West Pakistan with zonations from the Cordillera of the western United States.

Conodonts were considered to be 'facies breakers,'' and paleoecologic influences were not recognized in the Great Basin and Middle Rocky Mountains by many earlier workers. This resulted in a number of proposed modifications for the Smithian Stage. Additional conodont biostratigraphic studies extended the total ranges of some conodont species and eliminated the utility of several overlapped biozones. As regional biostratigraphic work on Lower Triassic conodonts continued, it became apparent that simplification of the zonal scheme would make it more useful in a variety of marine depositional environments on a worldwide basis, if the spirit of Albert Oppel's ''ideal profile'' were followed.

Lower Triassic conodont biozones are based on: *Hindeodus typicalis* for the Griesbachian Stage, *Neospathodus kummeli* and *Neospathodus dieneri* for the Dienerian Stage, and *Neospathodus waageni* for the Smithian Stage. The uppermost Early Triassic Spathian Stage biozones are based on: *Neospathodus triangularis, Neospathodus collinsoni, Neogondolella jubata,* and *Neospathodus timorensis.*

The refined Lower Triassic zonation presented here is a progress report that extends the generic ranges of *Gladigondolella* and *Platyvillosus* downward into the Smithian. Further biostratigraphic studies will modify this contemporary effort, as total ranges of zone diagnostic conodonts are ultimately defined.

Introduction

Conodonts were widespread in early oceans for a span of 400 million years, from the latest Precambrian or earliest Cambrian into the latest Triassic (Sweet and Bergström, 1981). Their resistant, phosphatic, microskeletal components, while providing very limited clues as to the biologic nature of the conodont animal, possess exceptional value as biostratigraphic tools.

Conodonts were probably small (up to several centimeters in greatest dimension), bilaterally symmetrical, free-moving organisms which occupied pelagic to benthic marine environments. A recently described, elongate, soft-bodied animal with an apparatus of conodont elements, apparently in place, shows similarities to both chordates and chaetognath marine worms (Briggs and others, 1983). The microscopic elements served as teeth or as supports for respiration or feeding activities, and were embedded in, or covered by, fleshy tissue (Bengston, 1976; Jeppsson, 1979; Clark, 1981a). After death, these carbonate-apatite structures became dissociated, so natural assemblages of hard parts are rare. Crushing and processing rock for recovery of conodonts further isolate individual elements.

Within the past 35 years, coincident with the use of the acetic acid method for dissolution of carbonate rocks, conodont study accelerated and the literature burgeoned. Work during this period focused primarily upon the stratigraphic distribution of diagnostic forms. As a result, more than 100 conodont biostratigraphic units are recognized from Ordovician through Triassic rock (Sweet and Bergström, 1981).

The widespread occurrence of conodonts in diverse lithologies led to the general belief that they were largely independent of environmental influences, and stratigraphers envisioned a universal spread of individual taxa in marine environments. The same species were observed, for example, in Ordovician lithofacies that included shelly shelf limestone, black graptolitic shale, and deep water chert-shale sequences containing sponge spicules and radiolaria. The ubiquitous nature of some forms prompted an unnamed geologist to remark that "Conodonts are like God—they are everywhere" (Lindström, 1976).

By 1950, conodont faunas from Ordovician through Permian rocks were described for the United States. Müller (1956) described the first fully-documented North American Lower Triassic conodont fauna from strata in Nevada. Clark (1957) pioneered the use of conodonts to establish the Triassic age for marine strata in the eastern Great Basin. However, documentation of Triassic conodonts lagged behind Paleozoic efforts. Factors contributing to this situation include the limited areal extent of marine Triassic rocks, the remote, often desolate, character of the Great Basin outcrop area, the limited abundance of most Lower Triassic conodont faunas, and a small number of persistent workers. Apparently, the paucity of knowledge about the Triassic in the western United States is only part of a worldwide problem, for Derek Ager states, "Much is hidden in the mists of the early Triassic, which is probably the least known episode in the long history of Phanerozoic time" (1981, p. 99).

Conodont faunas of both the Late Permian and Early Triassic lack diversity, but include distinctive forms. An evolutionary crisis in Early Permian time eliminated many long-ranging Paleozoic taxa, and only four or fewer major superfamilies survived (Clark, 1972; Sweet, 1973; Sweet and Bergström, 1981). The cosmopolitan nature of Lower Triassic marine faunas reflects the assembly of a single supercontinent, with the Pacific and Tethyan oceans forming a continuous water body around the shores of Pangaea (Valentine and Moores, 1973).

Biozones and Correlation

Worldwide biostratigraphic zonation and correlation of Permian and Triassic marine rocks are historically based on ammonoid faunas, which are arranged in a standard succession. In North America, at least 35 ammonoid zonal units provide a biostratigraphic framework for the marine Triassic (Silberling and Tozer, 1968). Although ammonoids were widely distributed in late Paleozoic and Mesozoic seas, they are rare fossils in many geographic areas. More recently, conodonts were used to facilitate or refine correlation where ammonoids are scarce or absent (Clark and Behnken, 1971; Sweet and others, 1971).

Regardless of the fossil content utilized, the purpose of biostratigraphic zonation is to provide a means by which the relative timing of biologic and geologic events can be determined and correlated on a worldwide basis. These biozones must necessarily have time significance, and may involve evolutionary changes, migrations, and extinctions (Eicher, 1968).

Three principal categories of biostratigraphic units are used, depending upon circumstances and available fauna (North

American Commission on Stratigraphic Nomenclature, 1983). However, range (interval) zones of various types are the most widely employed. Interval zones are defined by the lowest and/or highest, documented occurrences of less than three taxa (Fig. 1). They include: the interval between the lowest and highest occurrences of a single taxon (taxon range zone), the interval between the lowest occurrence of one taxon and the highest occurrence of another taxon (concurrent range zone or partial range zone), or the interval between successive lowest or highest occurrences of two taxa (lineage zone or interval zone). Unfossiliferous intervals are also recognized between or within biozones (barren interzones and intrazones).

An assemblage zone is characterized by the association of three or more taxa, and in practice, two different concepts are used

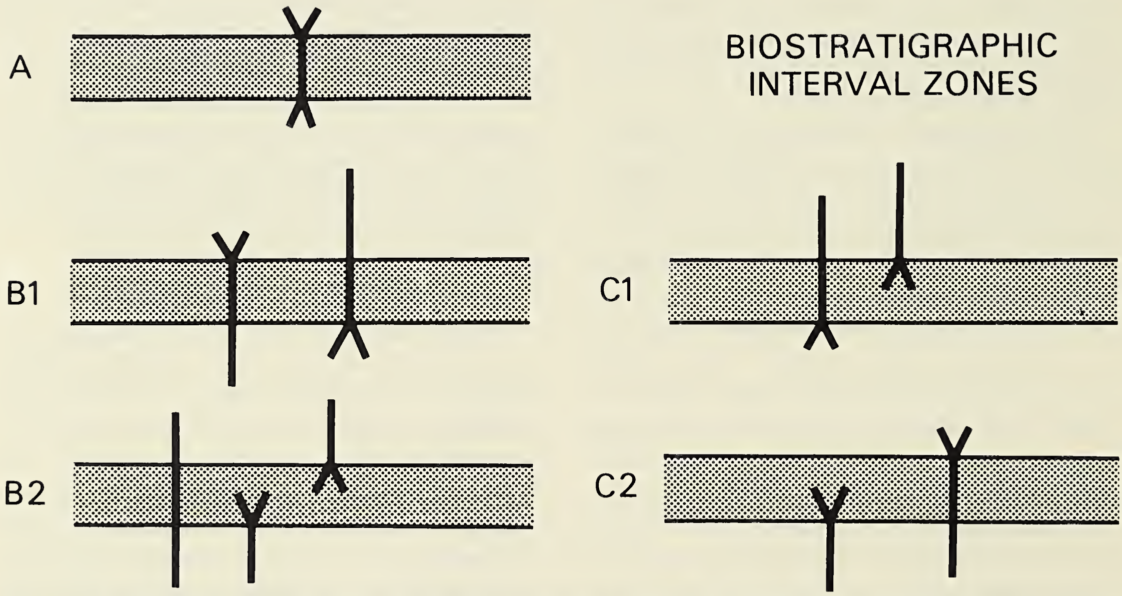

Fig. 1. Biostratigraphic interval zones, as defined by the North American Commission on Stratigraphic Nomenclature (1983). Examples include: A) taxon range zone, B1) concurrent range zone, B2) partial range zone, C1) lineage zone, C2) interval zone.

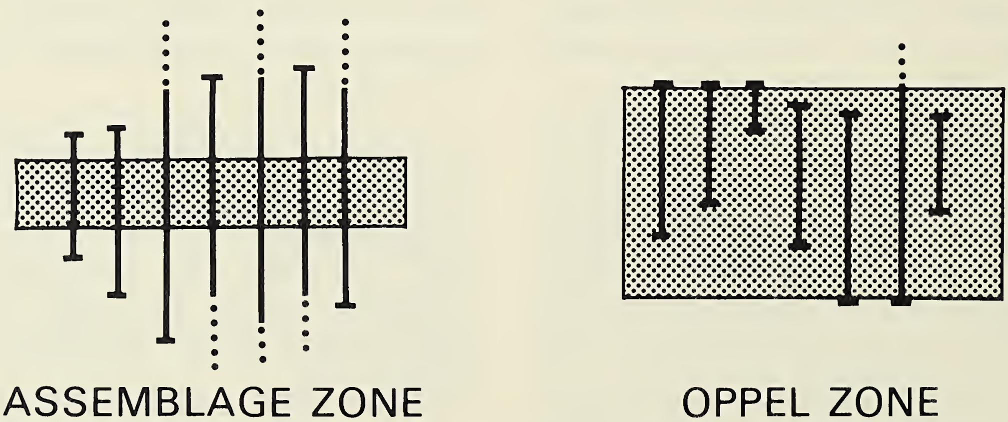

Fig. 2. Assemblage zones, as defined by the North American Commission on Stratigraphic Nomenclature (1983). Examples include: Left) assemblage zone, not based upon the ranges of the included species; Right) Oppel zone, a concurrent range zone defined by more than two taxa.

(Fig. 2). One, the assemblage zone, is characterized by a certain association of taxa without regard to their range limits. The second type is an Oppel zone, with boundaries based on two or more documented, first and/or last occurrences of the taxa characterizing the zone. This is also a form of concurrent range zone.

The third category, or abundance zone, is characterized by quantitatively distinctive maxima of relative abundance of one or more taxa (Fig. 3). This is the acme zone of the International Subcommission on Stratigraphic Classification (Hedberg, 1976).

Although all fossils, in a general sense, may be considered "facies fossils" (Ager, 1981), some assemblage and abundance biozones may reflect strong local ecologic control, and are not necessarily time significant. The appearance of the included taxa in these cases may be due to the shift or return of favorable, or optimal environmental conditions within a geographic area.

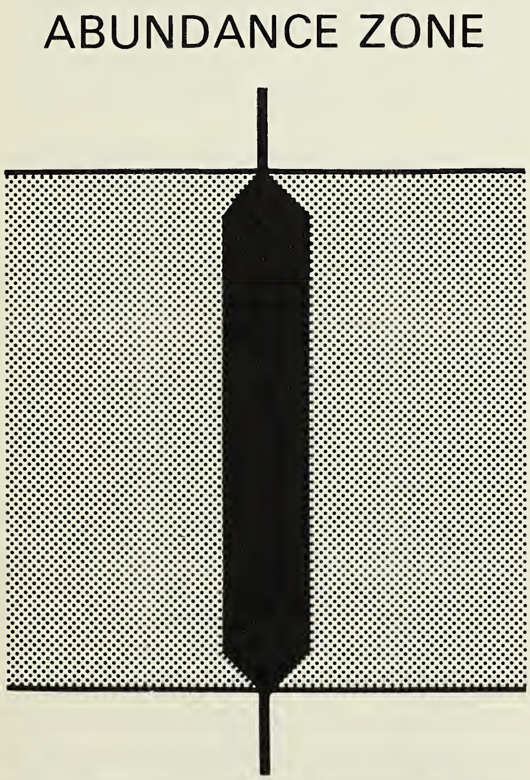

Fig. 3. Abundance zone, as defined by the North American Commission on Stratigraphic Nomenclature (1983). This biozone is based on a marked increase in abundance of the defining taxon or taxa.

Whether based on the range of a single taxon or of a specific combination of taxa, a biozone conceptually includes all the rocks deposited anywhere during the entire time the defining taxon or taxa existed (total range), whether their remains are recognized or not. Most local range zones (teilzones) are only fragments of the total taxon/taxa record. The development and application of biozones were elegantly detailed in 1856 by young Albert Oppel during his study of Jurassic biostratigraphy. Oppel visualized the general succession of fossils as independent of the actual paleontologic or lithic succession at any one place (Hancock, 1977). In discussing correlation based on fossil content, Oppel observed:

> "This task is admittedly a hard one, but it is only by carrying it out that an accurate correlation of a whole system can be assured. It necessarily involves exploring the vertical range of each separate species in the most diverse localities, while ignoring the lithological development of the beds; by this means will be brought into prominence those zones which, through the constant and exclusive occurrence of certain species, mark themselves off from their neighbours as distinct horizons. In this way is obtained an ideal profile, of which the component parts of the same age in the various districts are characterised always by the same species" (translation in Hancock, 1977, p. 12).

The search for the "ideal profile" became the aim of all biostratigraphers who followed.

Lower Triassic Conodont Zonation

Early Zonations

Müller (1956) first suggested the possibility of establishing a time-significant, conodont biostratigraphic succession within the Triassic, and Clark (1960), Mosher and Clark (1965), and Mosher (1968) identified preliminary sequences. The first extensive Lower Triassic zonal scheme based on

LOWER TRIASSIC	SPATHIAN	9 Neospathodus timorensis
		8 Neogondolella jubata
	SMITHIAN	7 Neospathodus waageni
	DIENERIAN	6 Neospathodus pakistanensis
		5 Neospathodus cristagalli
		4 Neospathodus dieneri
		3 Neospathodus kummeli
	GRIESBACHIAN	2 Neogondolella carinata
		1 Anchignathodus typicalis

Fig. 4. Lower Triassic conodont zonation of Sweet (1970), based on specimens from the Salt and Trans-Indus ranges of West Pakistan.

SERIES		STAGE
LOWER TRIASSIC	SCYTHIAN	SPATHIAN
		SMITHIAN
		DIENERIAN
		GRIESBACHIAN

Fig. 5. Lower Triassic stage names for North America.

LOWER TRIASSIC	SPATHIAN	13 Neospathodus timorensis	GREAT BASIN
		12 Neogondolella jubata	
		11 Neospathodus n. sp. G	
		10 Platyvillosus	
	SMITHIAN	9 Neogondolella milleri	
		8 Neospathodus conservativus	
		7 Parachirognathus-Furnishius	
	DIENERIAN	6 Neospathodus pakistanensis	PAKISTAN
		5 Neospathodus cristagalli	
		4 Neospathodus dieneri	
		3 Neospathodus kummeli	
	GRIESBACHIAN	2 Neogondolella carinata	
		1 Anchignathodus typicalis	

Fig. 6. Lower Triassic conodont zonation of Sweet and others (1971), combining data from West Pakistan and the Great Basin of the western United States.

conodonts was provided by Sweet (1970) from the uppermost Permian and Lower Triassic of West Pakistan (Fig. 4). The Lower Triassic was divided into nine zones based on the vertical distribution of six genera, with the oldest zone spanning the Permian-Triassic boundary (Sweet, 1970). Five of the zones were also represented in Triassic collections from Europe and North America, but four were of utility only in West Pakistan. Figure 5 provides series and stage names for the Lower Triassic.

A cooperative effort by North American conodont workers led to the development of a biostratigraphic zonation for the entire Triassic System (Sweet and others, 1971) (Fig. 6). Thirteen Lower Triassic conodont zones were established, and correlated with the ten North American ammonoid zones of Silberling and Tozer (1968). The type strata for the lower Scythian zones are in the Salt and Trans-Indus ranges of West Pakistan. Type localities for all but the topmost upper Scythian zones are in the Great Basin of the western United States (Sweet and others, 1971).

Continuity between the Pakistan and Great Basin portions was not immediately confirmed, although some conodont species were common to both regions. Diagnostic Salt Range forms, such as *Neospathodus pakistanensis* of zone 6, underlying the suture, had not been found in the Great Basin, while *Neospathodus waageni* of zone 7 was not yet reported from the *Parachirognathus-Furnishius* Zone of North America (Figs. 4 and 6) (Sweet and others, 1971).

The *Parachirognathus-Furnishius* interval of Sweet and others (1971) was based on work in Utah and Nevada, and it forms the lowest zone of the North American part of the combined zonation (Fig. 6). This dual assignment was based on the suspicion that, "there may be a facies relationship between *Furnishius*- and *Parachirognathus*-bearing strata" (Sweet and others, 1971, p. 452). To evaluate this concern, *Parachirognathus-Furnishius* ratio studies were conducted along the margin of the Lower Triassic seaway. The paleoecologic work of Clark and Rosser (1976) assumed a basin to shelf transect from the deeper parts of the Cordilleran geosyncline on the west to progressively shallower marine environments to the east, where terrigenous red beds intertongue with marine sediments. Regional stratigraphic work (Koch, 1976; Collinson and Hasenmueller, 1978; Paull, 1980; Carr and Paull, 1983), however, established that the geographic distribution of sections sampled by Clark and Rosser (1976) was biased toward the shelf (shallow transitional) environment (Fig. 7). Although their western sections are thicker than those to the east, this did not mean deeper water, and a true basin to shelf survey was not made.

The upper Scythian conodont biostratigraphy reported by Solien (1979) from Fort Douglas, Utah, was in the same relative basin to shelf position and had a depositional environment similar to the sections used by Clark and Rosser (1976). Progressive changes in the vertical distribution of *Furnishius* and *Parachirognathus* in this single section were included in a modified zonation proposed by Clark and others (1979) (Fig. 8).

Solien (1979) recovered *Neospathodus pakistanensis* from the lower part of his sequence, finally forging the link between Pakistan and the Great Basin. *N. pakistanensis* was also conditionally reported by Clark and others (1979) from southern Idaho. Solien's study, was well as the work of Collinson and Hasenmueller (1978), also confirmed the occurrence of *Neospathodus waageni* with the *Parachirognathus-Furnishius* fauna of western North America (Fig. 4 and 6).

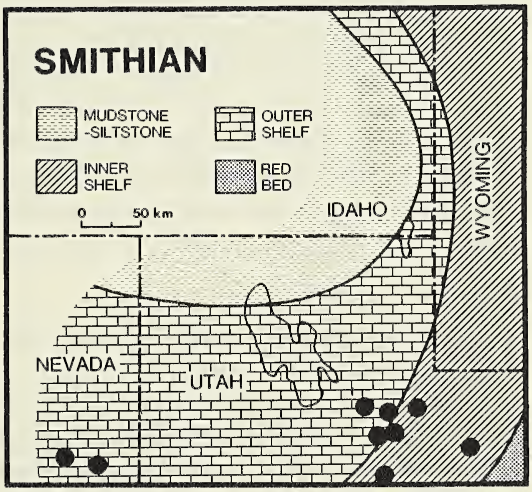

Fig. 7. Lithofacies map of the Lower Triassic during the Smithian Stage. Dots represent study localities of Clark and Rosser (1976) and Solien (1979).

COMPARISON OF LOWER AND MIDDLE SCYTHIAN CONODONT ZONATIONS					
STAGE	FROM: SWEET, 1970	FROM: SWEET AND OTHERS, 1971	FROM: CLARK AND OTHERS,1979	FROM: COLLINSON AND HASENMUELLER, 1978	THIS PAPER
SMITHIAN	NEOSPATHODUS WAAGENI	NEOGONDOLELLA MILLERI NEOSPATHODUS CONSERVATIVUS PARACHIROGNATHUS-FURNISHIUS	NEOGONDOLELLA MILLERI PARACHIROGNATHUS ETHINGTONI PARACHIROGNATHUS-FURNISHIUS FURNISHIUS TRISERRATUS	NEOSPATHODUS WAAGENI FURNISHIUS TRISERRATUS	NEOSPATHODUS WAAGENI
DIENERIAN	NEOSPATHODUS PAKISTANENSIS N. CRISTAGALLI N. DIENERI N. KUMMELI	NEOSPATHODUS PAKISTANENSIS N. CRISTAGALLI N. DIENERI N. KUMMELI	NEOSPATHODUS SPP. NEOSPATHODUS PECULIARIS	NEOSPATHODUS DIENERI NEOSPATHODUS KUMMELI	NEOSPATHODUS DIENERI NEOSPATHODUS KUMMELI
GRIESBACHIAN	NEOGONDOLELLA CARINATA ANCHIGNATHODUS TYPICALIS	NEOGONDOLELLA CARINATA ANCHIGNATHODUS TYPICALIS	NEOGONDOLELLA CARINATA ANCHIGNATHODUS TYPICALIS	HINDEODUS TYPICALIS	HINDEODUS TYPICALIS

Fig. 8. Comparison of Lower and Middle Scythian conodont zonations.

It is instructive to compare the three zonations at this point (Fig. 8). The initial scheme of Sweet (1970) utilizes a single Smithian zone, and six lower Scythian intervals. With the compilation of the 1971 biostratigraphy, the lower zones were retained. However, the Smithian was subdivided and tailored to the Great Basin, where the stratigraphic value of *Neospathodus waageni* had not yet been realized.

The zonation of Clark and others (1979) reflects Smithian conodont distributions in transitional despositional environments (Fig. 8). Dienerian biozones, although still based on neospathodids, were reduced in number, when compared to the scheme of Sweet and others (1971). This change reflects the limited abundances and diversity of conodont faunas from the Lower Triassic Dinwoody Formation.

Paleoecologic Influences

Most early workers believed that the conodont animal was nearly independent of depositional facies. Yet, as additional distributional data were collected, it became apparent that at least some conodont taxa were prone to ecologic control. Recognition of paleoecologic patterns led to a symposium focused on conodont paleoecology, and two opposing models of marine lifestyle were proposed. Seddon and Sweet (1971) envisioned a depth-stratified, pelagic existence, while Barnes and Fahraeus (1975) suggested lateral variation of biofacies reflected a nektobenthic or benthic habit. However, a cautionary note was introduced by Klapper and Barrick (1978), who found that distributional data alone were not definitive of a pelagic or a benthic habit for these extinct organisms. Development of parallel zonations for major Triassic facies was suggested as a way to avoid some paleoecologic pitfalls (Sweet and Bergström, 1981; Clark, 1981b). This would allow the use of two or more semi-"ideal profiles."

The sedimentological history of the upper, or Dienerian, part of the Dinwoody Formation was one of progressive progradation from a shelf region to the east (McKee and others, 1959). As terrigenous sediments encroached basinward, the environment was not favorable to the conodont animal. Also, the rate of Dienerian sedimentation was probably rapid. Observations indicate that conodont numbers, as well as general faunal abundance, decrease with increasing rates of sedimentation (Lindström, 1964; Kidwell, 1981). Other factors adversely affecting the presence and diversity of conodonts during this time include evolution, extinction, and migration. All of these items influence current attempts to refine the zonation of the Dienerian Stage in the western United States.

Paleoenvironmental work supported by quantitative efforts continues. Two recent studies of the spatial distribution of conodonts in the Lower Triassic Thaynes Formation of the western Cordillera distinguished three discrete biofacies (Carr, 1981; Carr, Paull, and Clark, 1983). As a result, conodont species with little facies dependence, and more temporal significance, were identified. Amalgamation of this type of research with stratigraphic distribution studies should enhance the biostratigraphic utility of conodonts, and improve further zonal subdivisions.

Proposed Zonation

Continued biostratigraphic and petrographic work in the western Cordillera resulted in increased understanding of Early Triassic depositional history and paleogeography, and the conodont biozonation was again modified. Collinson and Hasenmueller (1978) suggested a zonation reminiscent of Sweet's original (1970) version (Fig. 8). Additional regional studies (Paull, 1980; Carr and Paull, 1980; Carr, 1981; Paull, 1982; Carr and Paull, 1983) established a workable zonation from basin to shelf that resulted in additional reduction in biozones (Fig. 8).

With this simplified zonation, what was done in the name of *refinement?* The philosophy behind Shaw's (1964) graphic method, which has the potential for a detailed and more quantitative correlation, may provide some insight. In order to arrive at a composite standard reference section, the technique seeks the maximum stratigraphic range for each taxon used, despite local environmental influence or poor preservation (Miller, 1977).

Refinements in correlation may proceed in one of two directions as additional studies are conducted. If the fauna is large and diverse, the result should be a sequence with greater resolving power and a corresponding increase in significant biozones. If the fauna is modest and of limited diversity, biostratigraphic refinement consists of extending the local stratigraphic ranges of faunal elements toward their maximum values. As a result, zonal units may be eliminated (Fig. 9).

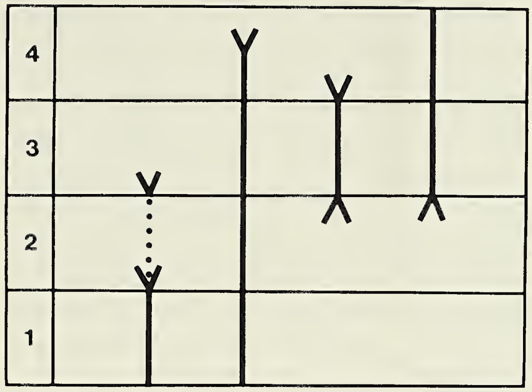

Fig. 9. Extension of range, depicted by dotted line, results in deletion of zone 2, previously a partial range zone.

This latter situation describes the evolution of Lower Triassic conodont zonation. Extension of the local ranges of species resulted in the deletion of the *Neogondolella*

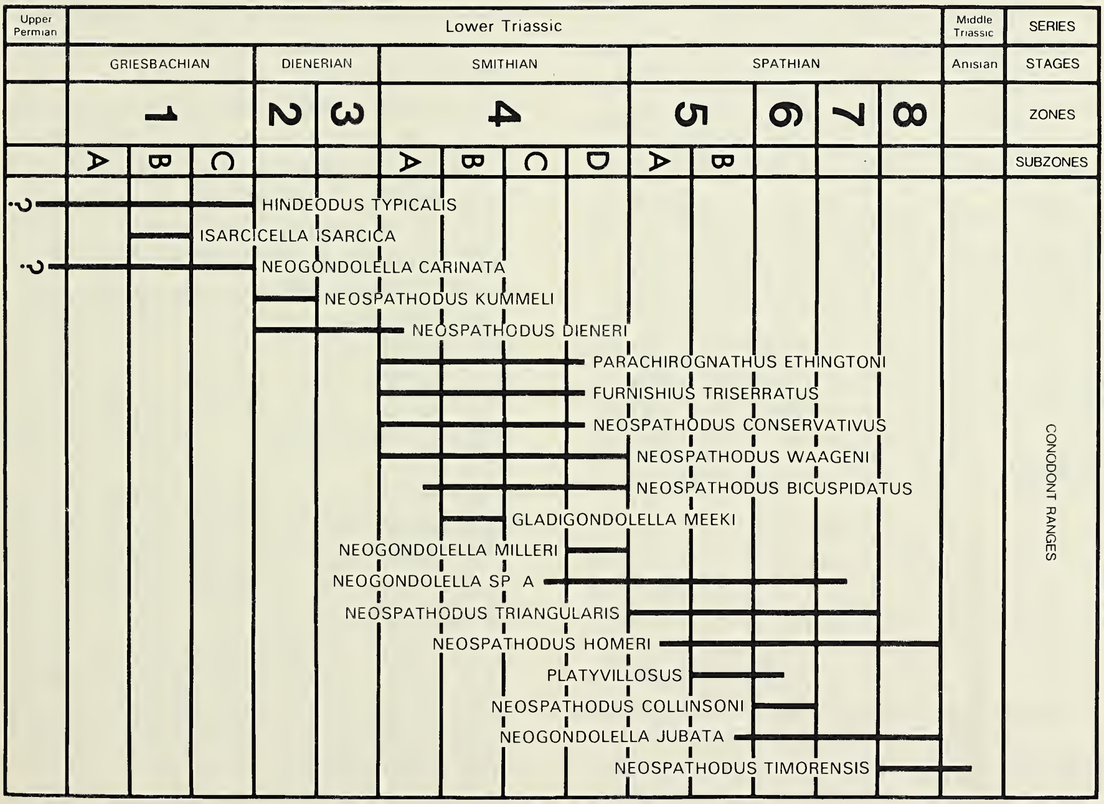

Fig. 10. Lower Triassic conodont zonation of Carr and Paull (1983).

carinata Zone (Sweet, 1973, 1979; Collinson and Hasenmueller, 1978), the *Neospathodus conservativus* Zone (Collinson and Hasenmueller, 1978; Solien, 1979), the *Parachirognathus ethingtoni* Zone (Collinson and Hasenmueller, 1978), and the *Furnishius triserratus* Zone (Paull, 1980, 1982) (Fig. 8). Solien (1979) and Clark and others (1979) recommended expansion of the *Parachirognathus-Furnishius* Zone of Sweet and others (1971), but retained these conodonts as zonal indicators (Fig. 8).

In conclusion, the zonation proposed in Figure 10 is a progress report, and the following facts suggest that the biozones will change again.

1) *Gladigondolella,* a stranger to North America, makes a Smithian appearance. This genus was previously known only from the Middle and Upper Triassic of Europe and Asia (Paull, 1982, 1983) (Fig. 10).
2) *Platyvillosus costatus,* a lower Spathian indicator, is reported with Smithian forms (Goel, 1979; Wang, 1980; Paull, in prep.) (Fig. 10).

With these observations in mind, and others that undoubtedly will be made, one is impressed with the wisdom often attributed to Mark Twain, when he noted: "Researchers have already cast much darkness on the subject, and if they continue their investigations, we shall soon know nothing at all about it." Nevertheless, the search for the ultimate Lower Triassic zonation goes on.

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CONODONTS AND BIOSTRATIGRAPHY OF THE MUSCATATUCK GROUP (MIDDLE DEVONIAN), SOUTH-CENTRAL INDIANA AND NORTH-CENTRAL KENTUCKY

Curtis R. Klug
Dept. of Geology
University of Iowa
Iowa City, Iowa 52242

Abstract

Eighty-two samples were collected and processed for conodonts from strata of the Middle Devonian Muscatatuck Group of south-central Indiana and north-central Kentucky. In this region, the Muscatatuck Group consists of two formations, the Jeffersonville Limestone and the overlying North Vernon Limestone. Although conodonts are abundant (over 20,000 specimens were recovered), diversity is relatively low. *Icriodus* and *Polygnathus* are the dominant faunal elements. Nineteen conodont species and subspecies are recognized including one new subspecies, *Icriodus angustus obliquus.* Few of the recognized species are diagnostic of the standard Middle Devonian conodont zones, making long-distance correlations uncertain. Consequently, a zonation consisting of three local zones and one standard subzone is adopted. These are, in ascending order, the *Icriodus latericrescens robustus* Zone, the *Icriodus angustus angustus* Zone, the *Polygnathus pseudofoliatus* Zone, and the Lower *Polygnathus varcus* Subzone. Examination of the conodont faunas suggests an Eifelian age for the lower part of the Muscatatuck Group and a Givetian age for the upper part.

Acknowledgments

The author very gratefully acknowledges the invaluable assistance of Gilbert Klapper during all phases of this study. Thanks are also extended to Dale Sparling for making available unpublished information on conodont faunas from the Columbus and Delaware Limestones of Ohio. The Graduate College of The University of Iowa provided funding and access to the JEOL JSM-35C Scanning Electron Microscope with which the photographs for the conodont figures were made. The Department of Geology at The University of Iowa provided access to darkroom facilities, and thin-section and conodont-processing laboratories.

Introduction

Since 1820, over 175 papers have been published on the Devonian stratigraphy and paleontology of the Falls of the Ohio and surrounding area. Relatively few publications, however, have included a detailed discussion of the conodont faunas and biostratigraphy. One of the earliest papers to report Middle Devonian conodonts from the Falls of the Ohio was that of Branson and Mehl (1938), which included the description of a new species, *Icriodus latericrescens.* A number of other papers (e.g., Rexroad and Orr, 1967; Orr and Pollock, 1968; Klapper et al., 1971) mention the occurrence of conodonts in these strata but do not include illustrations of specimens. Only a few publications include both discussion and illustrations of the Middle Devonian conodonts of south-central Indiana and north-central Kentucky (e.g., Orr and Klapper, 1968; Klapper, Philip and Jackson, 1970; Klapper and Johnson, 1980). By far the most important paper on this subject is

Orr's (1946b) unpublished M.A. thesis. Although the stress of this thesis is on the Middle Devonian conodonts of southern Illinois, four sections in south-central Indiana were also included. Conodont faunas are well illustrated, and a local zonal scheme of six conodont zones was established. Since the writing of Orr's thesis, the understanding of Middle Devonian conodont faunas and biostratigraphy has been considerably refined. The main purpose of the present paper is to examine, in greater detail, the conodont faunas of the Middle Devonian Muscatatuck Group of south-central Indiana and north-central Kentucky and to provide an updated biostratigraphy based on these faunas.

Procedures

Eighty-three samples were collected from eight Middle Devonian sections in south-central Indiana and north-central Kentucky. The eight localities lie along a nearly north-south trending line from Jennings County, Indiana to Jefferson County, Kentucky (see Figs. 1 & 2). An effort was made to visit type localities of the lithostratigraphic units under consideration; when not possible, nearby alternate localities were substituted. See the Appendix for detailed location of sections. Samples were generally collected from major beds with spacing no more than 1 meter apart, and with individual samples including no more than 10 cm of vertical section. When possible, one kilogram of each sample was processed for conodonts using standard acidizing procedures with formic acid. In the case of particularly argillaceous samples, the acidizing procedure was supplemented with Stoddard's solvent treatment as described by Collinson (1963). Residues were washed through three nested sieves of 20, 120, and 230 U.S. standard mesh. Only the residue retained on the 120 mesh sieve was picked for conodonts. All specimens that retained the basal cavity were picked to guarantee that only individual elements were collected. In the case of some particularly large samples, only part of the residue was picked. The conodonts illustrated in this paper were photographed on the JEOL JSM-35C scanning electron microscope at The University of Iowa, Iowa City. Lithologic nature of the samples was determined by examination of hand samples, polished slabs, insoluble residues, and, in most instances, thin sections.

Lithostratigraphy

The stratigraphic terminology employed herein is primarily that in use by the Indiana Geological Survey as set forth by Shaver et al. (1970) and modified by Perkins (1963), Shaver (1974), and Droste and Shaver (1975). The Muscatatuck Group, proposed by Shaver (1974, p. 3), in south-central Indiana and north-central Kentucky includes two formations, the Jeffersonville Limestone and the overlying North Vernon Limestone.

The Jeffersonville Limestone was named by Kindle (1899, p. 8) for the "limestone lying between the Sellersburg beds and the *Catenipora* beds of the Niagara" as exposed at the Falls of the Ohio between Jeffersonville, Indiana, and the mouth of Silver Creek. Droste and Shaver (1975) considered the Jeffersonville Limestone to include three members in generally ascending order: the Dutch Creek Sandstone, Geneva Dolomite, and Vernon Fork Members. They considererd the Dutch Creek Sandstone Member to be equivalent to the basal Jeffersonville of the southern Indiana outcrop. This sandstone has a discontinuous distribution and was not encountered in any of the sections examined in this study.

The Geneva and Vernon Fork Members are considered to be northern facies equivalents of the type Jeffersonville Limestone. Of these two members, only the Vernon Fork was sampled for conodonts in this study. Orr (1964b), however, examined samples from the Geneva Member for conodonts, but found them to be nonproductive.

The Vernon Fork Member was examined,

for this paper, only at its principal reference section, the Berry Materials Corp. Quarry (BMQ) (see Droste and Shaver, 1975, p. 405). The sampled strata consist of light yellowish- to brownish-gray, slightly calcitic, sandy, "dolomicrite." Birdseye structures, laminations, and intraclasts also occur in this unit. The term "dolomicrite," as used above, refers only to the fine-grained nature of these dolostones and does not necessarily imply a primary origin for the dolomite.

Of greater concern to this study is the southern facies of the Jeffersonville Limestone. This formation, as exposed at its type locality at the Falls of the Ohio, has not been subdivided into members, as it has in its more northerly occurrences. Several schemes, however, have been proposed to subdivide the formation based on faunal content (see, e.g., Kindle, 1901; Patton and Dawson, 1955; Perkins, 1963; Conkin and Conkin, 1976). To facilitate the discussion of the Jeffersonville Limestone, the zonal scheme as proposed by Perkins (1963, p. 1338) has been adopted. He recognized five zones which are, in ascending order: (1) coral zone; (2) *Amphipora* Zone; (3) *Brevispirifer gregarius* Zone; (4) fenestrate bryozoan-brachiopod zone; (5) *Paraspirifer acuminatus* Zone (Fig. 2). A detailed description of each of these zones and the associated lithologies can be found in Perkins (1963).

The Jeffersonville Limestone is overlain by the North Vernon Limestone (= Sellersburg Limestone of authors). This unit was named by Borden (1876, p. 160-161) for strata occurring at North Vernon, Jennings County, Indiana, and lying "at the horizon of the hydraulic limestone" (Silver Creek Member) of Clark County, Indiana. In Borden's concept, the North Vernon Limestone was overlain by gray, crystalline, commonly crinoidal limestone (= Beechwood Member of present usage). Kindle (1899, p. 8, 20) proposed the name Sellersburg beds for the strata underlying the New Albany Shale down to the lowest beds worked by the cement quarries. As used in this sense, the Sellersburg beds include the Beechwood and Silver Creek Members only. More detailed discussions of the nomenclatural history of these strata can be found in papers by Patton and Dawson (1955, p. 39-43) and Burger and Patton, *in* Shaver et al. (1970, p. 120-122). Through time, usage of the names North Vernon Limestone and Sellersburg Limestone has come to be nearly synonymous, referring to the strata underlying the New Albany Shale and overlying the Jeffersonville Limestone. In this paper, North Vernon Limestone is used in this sense. Three members are recognized in the North Vernon Limestone. These are, in ascending order: the Speeds, Silver Creek, and Beechwood Members.

Sutton and Sutton (1937, p. 326) proposed the name Speeds Member for an 18-inch thick, shaly limestone below the cement rock (= Silver Creek Member) in the Speeds Quarry, near Sellersburg, Indiana. In thin section, the Speeds is a slightly- to highly-dolomitic, packed biomicrosparrudite.

Campbell (1942, p. 1060) considered the Speeds to be of formational status, overlain by the Deputy Formation, a blue to gray limestone weathering light gray. He designated the quarry 3/4 mile south of Deputy, Jefferson County, Indiana, as the type locality. According to Campbell, the Deputy is difficult to distinguish from the Speeds in fresh material, except by the fossil content. In thin section, the Deputy at the type locality is a slightly- to moderately-dolomitic biomicrosparite to biosparite. The Deputy is only locally developed and is considered herein as a facies of the Speeds Member.

The overlying Silver Creek Member was originally proposed by Siebenthal (1901, p. 345-346) for "a homogeneous, fine-grained, bluish to drab, argillaceous, magnesian limestone, the calcined form of which has the property of hydraulicity." This unit is typically exposed in the vicinity of Silver Creek in Clark County, Indiana. Siebenthal originally considered the Silver Creek to be of formational status. Butts (1915, p. 118) reduced it to the rank of member, as it is considered herein. Thin section examination shows the Silver Creek to vary from highly dolomitic, argillaceous biomicrite to fossiliferous, argillaceous "dolomicrite." The Silver Creek Member thins northward from its maximum thickness in Clark County, Indiana. At the same time, the underlying Speeds Member shows a corresponding thickening. Based on stratigraphic position and the inclusion of lentils or tongues of one lithology in the other, the two members have been considered to be contemporaneous facies (see e.g., Patton and Dawson, 1955, p. 42).

The Beechwood Member is the youngest member of the North Vernon Limestone. The name was proposed by Butts (1915, p. 120) for a gray, thick-bedded, coarsely crystalline crinoidal limestone containing black phosphatic pebbles in the basal few inches. Butts named this unit for exposures near Beechwood Station, Jefferson County, Kentucky, but did not establish a type section. Orr and Pollock (1968, p. 2258) proposed a principal reference section for the Beechwood Member, about 4.5 miles west of the old Beechwood Station in Louisville, Jefferson County, Kentucky. In thin section, the Beechwood varies from echinoderm biosparite to biosparrudite. Dolomitization is generally minimal to moderate but may be extensive in some beds. Phosphate pebbles and flattened, phosphatic ooids(?) are frequently encountered at the base of the unit.

Biostratigraphy

The conodont faunas of the Muscatatuck Group in south-central Indiana and north-central Kentucky include few diagnostic species common to the standard zonation, which is reviewed, for example, by Klapper and Johnson (1980). The local zonal scheme proposed by Orr (1964b) and modified by Orr (1971) is further modified and used in this paper (Fig. 3).

Conodonts were not recovered from the Jeffersonville Limestone below the *Brevispirifer gregarius* Zone. Oliver (1976, Fig. 3) considered these lower strata to be of late Emsian to early Eifelian age, as determined from the coral faunas.

Icriodus latericrescens robustus Zone

This, the lowest conodont zone recognized in the study area, corresponds to the *Icriodux latericrescens* n. subsp. Zone of Orr (1964b, p. 36-37). The lower limit of this zone is defined by the lowest occurrence of *I. l. robustus,* and the upper limit by the lowest occurrence of *I. a. angustus. Polygnathus* cf. *P. angusticostatus, I.* sp. A, and *I.* n. sp. E of Weddige first occur near the top of the *Brevispirifer gregarius* Zone below the lowest occurrence of *P. c. costatus* (see Fig. 4). This association suggests that the *I. l. robustus* Zone, of the study area, may be equivalent, in part, to the *P. costatus patulus* Zone of the standard zonation. For ranges of the above-mentioned forms in the standard zonation, the reader is referred to Klapper and Johnson (1980, p. 420-422).

Icriodus angustus angustus Zone

The lower boundary of this zone is defined by the lowest occurrence of *I. a. angustus.* The upper boundary is defined by the lowest occurrence of *Polygnathus pseudofoliatus. Polygnathus c. costatus* and *P. l. linguiformis* first occur in the *I. a. angustus* Zone. In the examined sections, the *I. a. angustus* Zone is recognized in the fenestrate bryozoan-brachiopod zone and the *Paraspirifer acuminatus* Zone of the Jeffersonville Limestone. Correlation of the *I. a. angustus* Zone with the *P. c. costatus* Zone of the standard zonation is suggested.

Polygnathus pseudofoliatus Zone

The base of the *P. pseudofoliatus* Zone is defined by the lowest occurrence of the nominal species. The top is defined, in the study area, by the lowest occurrence of *P. timorensis. Icriodus* n. sp. E of Weddige

(1977), *I.* sp. A, and *I. retrodepressus* show their maximum development in this zone. Below this zone *I. retrodepressus* is represented only by tentatively identified specimens. *Icriodus angustus obliquus* first occurs at the base of the *P. pseudofoliatus* Zone. Faunas characteristic of the *P. pseudofoliatus* Zone were recovered from the Speeds (including the Deputy facies) and Silver Creek Members of the North Vernon Limestone.

A single, apparently weathered specimen of *Polygnathus timorensis* was recovered from a sample (SSQ-5) at the top of the Silver Creek Member. In another sample (OGQ-4), from the top of this member, several fragmentary specimens of *Icriodus l. latericrescens* were recovered below the first occurrence of *P. timorensis* in the overlying Beechwood Member. Also recovered from this sample were a number of flattened phosphatic ooids(?) like those typical of the basal part of the Beechwood Member. The presence of these ooids(?) and the weathered appearance of the specimen of *P. timorensis* suggest the possibility of stratigraphic leak. Orr and Pollock (1968, p. 2261) also reported *I. l. latericrescens* from a fauna without "*P. varcus*" from the top of the Silver Creek Member at the Atkins Quarry, in Clark County, Indiana. On evidence of that occurrence, Orr (1971, p. 17) considered the upper part of the Silver Creek Member to belong to his *I. l. latericrescens* Zone. This zone, however, cannot be recognized with any confidence in the present study.

The relationships of the *Polygnathus pseudofoliatus* Zone with the standard conodont zonation are far from straightforward. Correlation of this zone with part or all of the sequence from the *Tortodus kockelianus australis* Zone (Eifelian) through the *Polygnathus xylus ensensis* Zone (Eifelian-Givetian, Weddige, 1977) is possible.

Lower *Polygnathus varcus* Subzone

The Lower *Polygnathus varcus* Subzone of Ziegler, Klapper and Johnson (1976, p. 113) is recognized in the Beechwood Member of the North Vernon Limestone. *Polygnathus timorensis, P. linguiformis weddigei* and *P. linguiformis klapperi* make their first appearance at the base of this member. Several species, for example *Icriodus angustus angustus, Icriodus angustus obliquus* and *Icriodus retrodepressus,* range upward into the lower *P. varcus* Subzone (see Fig. 4). These forms are not known to occur at this level outside of the study area and many represent reworked elements in the present collections.

One sample (SSQ-1) from the thin limestone at the base of the New Albany Shale Group was also processed for conodonts. A diverse fauna including *Polygnathus cristatus* was recovered from this sample but, because of stratigraphic position, is considered beyond the scope of this paper and will not be discussed further herein. For a detailed description of this fauna, the reader is referred to the paper by Orr and Klapper (1968).

Conodont-based correlations of the Muscatatuck Group with Middle Devonian strata in surrounding areas are shown in Fig. 5.

Systematic Paleontology

Nineteen conodont species and subspecies were recognized from among the 22,154 specimens recovered in this study. For distribution of species see Figs. 6 and 7. Emphasis is placed on platform and some coniform elements. Multielement reconstructions have generally not been attempted owing to the poor preservation of most nonplatform elements. General associations, however, are noted. Figured specimens are reposited at the University of Iowa (SUI).

Belodella cf. *B. resima* (Philip, 1965)
Fig. 12 G,L

cf. *Belodus resimus* Philip, 1965, p. 98, Pl. 8, Figs. 15-17, 19.

Remarks.—Proclined to erect, denticulate coniform elements have been recovered from several samples in south-central Indiana and north-central Kentucky. These forms are comparable in shape, denticulation, and the development of anterolateral flanges, to *Belodella resima* (Philip, 1965). In *B. resima,* however, the cross-sectional shape is a narrow isosceles triangle whereas in the present material it is a narrow right triangle. Also, the anterolateral flanges of *B. resima* appear to be smooth whereas in the material at hand they are made up of minute, confluent denticles similar to those of the posterior keel. Uyeno, *in* Uyeno, Telford, and Sanford (1982, Pl. 5, Figs. 30-32) illustrated three specimens of *Belodella* sp. which also appear to have denticulated anterolateral flanges.

Material.—39 specimens

Occurrence.—Fenestrate bryozoan-brachiopod zone and *Paraspirifer acuminatus* Zone of the Jeffersonville Limestone and upper Speeds, Silver Creek and Beechwood Members of the North Vernon Limestone.

Coelocerodontus cf. *C. biconvexus*
Bultynck, 1970
Fig. 12 H-K, M-O

cf. *Coelocerodontus biconvexus* Bultynck, 1970, p. 94, Pl. 27, Figs. 13-15.

Remarks.—Erect to slightly recurved coniform elements comparable to *Coelocerodontus biconvexus* are common in the Middle Devonian strata of south-central Indiana and north-central Kentucky. The present material differs, however, from Bultynck's specimens in that the cross-sectional outline of the Indiana and Kentucky specimens varies from biconvex to triangular to concavo-convex, and none of these specimens has a denticulated posterior keel, although denticulation of the anterolateral costa is commonly well-developed. *Paltodus* sp. of Orr (1964a, p. 13, Pl. 2, Figs. 4, 7) and *Coelocerodontus* sp. of Uyeno, *in* Uyeno, Telford, and Sanford (1982, p. 34, Pl. 5, Figs. 25-29) are apparently conspecific with the present form.

Material.—686 specimens.

Occurrence.—*Brevispirifer gregarius* Zone, fenestrate bryozoan-brachiopod zone, *Paraspirifer acuminatus* Zone, and Vernon Fork Member of the Jeffersonville Limestone; Speeds, Silver Creek, and Beechwood Members and Deputy facies of the North Vernon Limestone.

Icriodus angustus angustus
Stewart and Sweet, 1956
Fig. 8 A-F

Icriodus angustus Stewart and Sweet, 1956, p. 267, Pl. 33, Figs. 4, 5, 11, 15; Klapper and Ziegler, 1967, Pl. 10, Figs. 1,?2, 3; Klapper, *in* Ziegler, 1975, p. 75-76, *Icriodus*—Pl. 2, Figs. 6, 7; Klapper and Johnson, 1980, p. 447, Pl. 3, Figs. 3-6; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 31, Pl. 3, Figs. 1-4.

Remarks.—The specimens herein assigned to *Icriodus angustus angustus* agree well with those described by Stewart and Sweet (1956, p. 267, Pl. 33, Figs. 4, 5, 11, 15). See also Klapper, *in* Ziegler (1975, p. 75-76) for additional comments and relations. For comparison with *Icriodus angustus obliquus,* see remarks for that taxon.

Material.—280 specimens.

Occurrence.—Fenestrate bryozoan-brachiopod zone and *Paraspirifer acuminatus* Zone of the Jeffersonville Limestone; Speeds, Silver Creek, and Beechwood Members of the North Vernon Limestone. For further discussion of occurrence, see section on Biostratigraphy.

Icriodus angustus obliquus n. subsp.
Fig. 8 G-L

Derivation of name.—*obliquus,* Latin, sloping; referring to the upper margin of the bladelike extension.

Holotype.—SUI 49334, the specimen illustrated on Fig. 8 J-L; from the Sellersburg Stone Company Quarry, sample SSQ-14, 0-10 cm above the base of the Speeds Member.

Diagnosis.—A subspecies of *Icriodus angustus* with a segminiscaphate element in which the posterior extension of the middle row of denticles is bladelike and is made up of about four to six laterally compressed bluntly to acutely pointed denticles. Of these, the anterior two to four denticles are relatively slender and subequal to gradually increasing in height posteriorly. The posteriormost one or two denticles are larger and gradually to distinctly higher than the preceding denticles of the bladelike extension. This extension begins near mid-length of the element.

Remarks.—*Icriodus angustus angustus* is distinguished from the new subspecies by a segminiscaphate element in which the posterior extension of the middle row of denticles is made up of one to four subequal denticles which, in most specimens, are abruptly higher than all other denticles on the platform. In some specimens, however, the denticles of the posterior extension increase gradually in height posteriorly as in one of the paratypes (Stewart and Sweet, 1956, Pl. 33, Fig. 4; also illustrated by Klapper, *in* Ziegler, 1975, *Icriodus*—Pl. 2, Fig. 6). In such specimens, however, the denticles of the posterior extension of the middle row are subequal in the anteroposterior dimension and are fewer in number than in the new subspecies.

Elements of *Icriodus obliquimarginatus* have posterior bladelike extension of the middle row of denticles similar to that of *I. angustus obliquus.* They can be distinguished from the new subspecies, however, by the outline of the basal cavity. In *I. angustus obliquus* the outline is like that of *I. angustus angustus,* in which the inner margin extends farther posteriorly than the outer margin and the two are connected by a diagonally oriented posterior margin. The outline of the basal cavity of *I. obliquimarginatus* is rounder and more expanded posteriorly than in the new subspecies. In addition, the posterior margin of elements of *I. angustus obliquus* is not inclined as strongly posteriorly, in lateral view, as in *I. obliquimarginatus,* and it may be vertical to inclined anteriorly as well.

One specimen assigned to the new subspecies from a sample from the Sellersburg Stone Company Quarry (SSQ-14) shows characteristics intermediate between *Icriodus angustus obliquus* and the nominal subspecies. It possesses a posterior extension of the middle row of denticles in which the anterior two dentiles are slender and subequal, as in *I. angustus obliquus,* but are followed by four abruptly larger denticles similar to those of *I. a. angustus.* Most of the other specimens of *I. angustus* recovered from this sample, however, clearly belong to the new subspecies.

Material.—23 specimens.

Occurrence.—North Vernon Limestone (all members). For further discussion of occurrence, see section on Biostratigraphy.

Icriodus brevis Stauffer, 1940
Fig. 12 P-R

Icriodus brevis Stauffer, 1940, p. 424, Pl. 60, Figs. 36, 43, 44, 52; Klapper, *in* Ziegler, 1975, p. 89-90, *Icriodus*—Pl. 3, Figs. 1-3; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 31-32, Pl. 5, Figs. 10-16, 21, 22 [see further synonymy].

Icriodus cymbiformis Branson and Mehl. Orr, 1964b, p. 70-71, Pl. 2, Fig. 5; Orr, 1971, p. 33-34, Pl. 2, Figs. 1-6.

Icriodus eslaensis Adrichem Boogaert, 1967, Pl. 1, Figs. 9-12; Norris and Uyeno, 1972, Pl. 3. Fig. 9; Huddle, 1981, p. B22, Pl. 4, Figs. 1-29 [see further synonymy].

Remarks.—Segminiscaphate elements assigned to *Icriodus brevis* are characterized by an extension of the middle row of denticles posteriorly beyond the lateral rows. The denticles of this extension stand at approximately the same height as the other denticles on the platform. Some specimens in the present collections have a longitudinal axis that is apparently more curved than that of the type material (Fig. 12 P-R) but are similar in other respects. See Klapper, *in* Ziegler (1975, p. 89) for further discussion of this species.

Material.—5 specimens.

Occurrence.—Beechwood Member, North Vernon Limestone.

Icriodus latericrescens latericrescens
Branson and Mehl, 1938
Fig. 8 V-AD

Icriodus latericrescens Branson and Mehl, 1938, p. 164-165, Pl. 26, Figs. 30-32, 34, 35 (only).

Icriodus latericrescens latericrescens Branson and Mehl. Klapper and Ziegler, 1967, p. 74-75, Pl. 10, Figs. 4-9, Pl. 11, Figs. 1-5 [see further synonymy]; Huddle, 1981, p. B22-B23, Pl. 5, Figs. 1-6; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 32, Pl. 4, Figs. 27-30 [see further synonymy].

Remarks.—This subspecies includes a scaphate pectiniform element, the diagnostic characteristics of which were given by Klapper and Ziegler (1967, p. 75). It is distinguished from the comparable element of *I. l. robustus* in that the main process tends to be slightly bowed with a more or less concave inner side and convex outer side. In *I. l. robustus,* the main process is generally straighter with a straight to convex inner side and convex outer side. The denticulation of the main process in the nominal subspecies consists of three longitudinal rows. The lateral rows are composed of discrete, round nodes, whereas the middle row nodes vary from subround to elongate to an irregular, discontinuous ridge. In *I. l. robustus,* the middle row nodes tend to be more nearly round, although in some specimens they are slightly elongate longitudinally. The lateral row nodes of *I. l. robustus* are generally round but tend to be more robust than those of the nominal subspecies. In some specimens, they appear crowded together, commonly becoming somewhat laterally elongate. In some large specimens of both subspecies, the middle row denticles may be much reduced or absent, in which case the distinction between the two subspecies is more difficult and must be based on the shape of the main process and the lateral row nodes.

Material.—151 specimens.

Occurrence.—Beechwood and upper part of the Silver Creek Members of the North Vernon Limestone.

Icriodus latericrescens robustus Orr, 1971
Fig. 8 M-U

Icriodus latericrescens robustus Orr, 1971, p. 37-38, Pl. 2, Figs. 14-17 [see further synonymy]; Uyeno, *in* Uyeno, Telford and Sanford, 1982, p. 32, Pl. 4, Figs. 1-6, 8-15, 19-22, 25, 26 31-38 (I elements) [see further synonymy].

Remarks—For diagnosis and description see Orr (1971, p. 37-38) and remarks for *Icriodus l. latericrescens* herein. Some of the specimens from the *Brevispirifer gregarius* Zone from the Falls of the Ohio (FOS) and Oak and Vine (OVS) localities have middle row denticles that are longitudinally elongate (e.g., Fig. 8 T). Although this feature is most characteristic of *I. l. latericrescens,* other features of these specimens are typical of *I. l. robustus,* and they are assigned to the latter subspecies. One specimen, which is complete except for the anterior tip, is typical of *I. l. robustus* but occurs in the highest sample of the Beechwood Member from the Sellersburg Stone Company Quarry (SSQ-2). Other latericrescid *Icriodus* from this sample belong to *I. l. latericrescens.*

Material.—530 specimens.

Occurrence.—*Brevispirifer gregarius* Zone, fenestrate bryozoan-brachiopod zone, *Paraspirifer acuminatus* Zone of the Jeffersonville Limestone and ?Beechwood Member of the North Vernon Limestone.

Icriodus retrodepressus Bultynck, 1970
Fig. 9 A-F

Icriodus retrodepressus Bultynck, 1970, p. 110-111, Pl. 30, Figs. 1-6; Ziegler, *in* Ziegler, 1975, p. 143-144, *Icriodus*—Pl. 8, Figs. 4, 5.

Icriodus nodosus (Huddle). Schumacher, 1971, p. 93-95, Pl. 9, Figs. 4-6 (only).

Icriodus corniger retrodepressus Bultynck. Weddige, 1977, p. 290-291, Pl. 1, Figs. 10, 11, ?12.

Icriodus aff. *I. retrodepressus* Bultynck. Uyeno, *in* Uyeno, Telford and Sanford, 1982, p. 33, Pl. 3, Figs. 16-18, 25-27 (only).

Remarks.—*Icriodus retrodepressus* is characterized by a segminiscaphate element with reduced or absent middle row denticles in the posterior part of the main process resulting in a distinct depression immediately anterior to the posteriormost middle row denticle. For further remarks and diagnosis see Bultynck (1970) and Ziegler, *in* Ziegler (1975). Uyeno, *in* Uyeno, Telford, and Sanford (1982), reported specimens of *Icriodus* with a posterior depression of the middle row denticles. He referred to these specimens as *I.* aff. *I. retrodepressus* and distinguished his material from *I. retrodepressus* sensu stricto by the more uniform longitudinal spacing of the lateral row nodes in the latter species. According to Klapper and Barrick (MS), some specimens of *I. retrodepressus* from the Couvinian Eau Noire sequence above and below the type stratum show greater longitudinal spacing of the lateral row denticles anteriorly than posteriorly. Specimens in the present collection may also show this feature and are considered within the range of variation of *I. retrodepressus.* See also *I.* sp. A, herein, for the distinction from *I. retrodepressus.*

Material.—46 specimens. (mature forms only.)

Occurrence.—North Vernon Limestone (all members). For further discussion of occurrence, see section on Biostratigraphy.

Icriodus n. sp. E. of Weddige, 1977
Fig. 9 G-I, cf. J-L

Icriodus n. sp. E Weddige, 1977, p. 299-300, Pl. 2, Figs. 23-25 [see further synonymy].

Remarks.—For diagnosis and remarks, see Weddige (1977). See also remarks for *Icriodus* sp. A, herein, for comparison of *I.* n. sp. E and *I. retrodepressus.*

Material.—280 specimens (mature forms only).

Occurrence.—Upper part of the *Brevispirifer gregarius* Zone of the Jeffersonville Limestone and all members of the North Vernon Limestone.

Icriodus sp. A
Fig. 9 cf. M-O, S-X

Icriodus nodosus (Huddle). Orr, 1964b, p. 77-78, Pl. 2, Fig. 16?, 24-26; Orr, 1971, p. 38-39, Pl. 2, Figs. 20-23; Schumacher, 1971, p. 93-95, Pl. 9, Figs. 1-3, 7-9?, 10-13, 15, 16 (only).

Icriodus sp. aff. *I. retrodepressus* Bultynck. Klapper and Johnson, 1980, p. 448, Pl. 3, Figs. 19-21, 22?, 23?

Icriodus aff. *I. retrodepressus* Bultynck. Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 33, Pl. 3, Figs. 19?, 23.

Remarks.—This species is to be described and named by Klapper and Barrick (MS). In upper view, the segminiscaphate element of this species is similar to that of *I.* n. sp. E of Weddige (1977), and *I. retrodepressus. I.* sp. A includes two morphotypes; one has a posterior depression of the middle row denticles as in *I. retrodepressus;* the other lacks such a depression and is similar to *I.* n. sp. E. *I.* sp. A, however, possesses a broader basal cavity posteriorly than either *I.* n. sp. E or *I. retrodepressus.* In the present collections, specimens considered intermediate between the three species have also been recognized. In addition, specimens have been recovered that have lateral row denticles that are rounder than is apparently typical of the above-mentioned species. These forms may also have two or three more or less well-developed middle row denticles posterior to the lateral rows, as opposed to the more typical, single, large, triangular denticle of the other forms. In other respects, these specimens are comparable to the three species discussed above (see Fig. 9 J-O). The rounder lateral row denticles and the two to three posterior middle row denticles are generally best developed in the smaller, possibly juvenile forms. If these are juvenile, it is often difficult or impossible to determine with which of the three mature forms they are associated. Faunas made up entirely of these smaller forms are common in the study material and have a stratigraphic range greater than that of the larger specimens. For the distribution of these "juvenile" forms relative to that of the mature forms, refer to Figs. 6 and 7.

Material.—347 specimens (mature forms only).

Occurrence.—Upper part of the *Brevispirifer gregarius* Zone of the Jeffersonville Limestone and all members of the North Vernon Limestone.

Icriodus? sp. B
Fig. 12 S-X

Remarks.—The specimens treated here in open nomenclature include scaphate elements with a narrow anterior primary process consisting of a single row of denticles that are round to laterally compressed in upper view. The denticles are numerous, subequal, discrete to fused, and bluntly pointed to round in lateral view. An outer lateral process extends at right angles to or is directed slightly posteriorly to the posterior end of the anterior primary process. The outer lateral process may have a narrow ridge running along its upper surface or may be weakly denticulate. A less well-developed inner lateral process or spur is also present. In lower view, the basal cavity is broadly flared posteriorly, becoming narrower anteriorly and pinching out slightly posterior of the anterior tip of the element.

The specimens considered herein are morphologically intermediate between *Icriodus* and *Pelekysgnathus*. Unfortunately, few specimens were recovered and all are fragmentary. A tentative assignment to *Icriodus* is based on the following considerations: (1) specimens of *Icriodus*? sp. B are notably similar in lower view to *Icriodus latericrescens latericrescens* with which this form co-occurs; (2) no specimens definitely assignable to *Pelekysgnathus* were recovered from any of the samples in this study; (3) Bultynck (1970, p. 111-112) reported a similar situation for *Icriodus regularicrescens*. In his faunas, he found specimens with well-developed lateral rows, with reduced lateral rows, and with only the middle row of nodes. In the present study, however, no forms were found showing any development of lateral rows of nodes. In addition, the denticulation of the anterior primary process of *Icriodus*? sp. B is unlike that of *Icriodus l. latericrescens* in both the shape and number of denticles. Definitive treatment of the form in question must await recovery of larger and better preserved faunas.

Material.—7 specimens.

Occurrence.—Beechwood Member of the North Vernon Limestone.

Polygnathus cf. *P. angusticostatus*
Wittekindt, 1966
Fig. 10 A-C, G-I

cf. *Polygnathus angusticostatus* Wittekindt, 1966, p. 631, Pl. 1, Figs. 15-18.

Remarks.—The specimens under consideration are all fragmentary carminiplanate elements, which are missing part or all of the free blade. Although platform development and ornamentation is apparently not as well developed as in the type specimen of *P. angusticostatus,* the present material appears closer to that species than to the similar and probably intergradational *P. angustipennatus*. Smaller specimens (see Fig. 10 A-C) tend to have more restricted platforms and appear to be closer to *P. angustipennatus*. For more detailed discussions on the similarities and differences between *P. angusticostatus* and *P. angustipennatus* the reader is referred to the papers by Klapper (1971, p. 65), Weddige (1977, p. 307), and Sparling (1981, p. 309-312).

Material.—21 specimens.

Occurrence.—*Brevispirifer gregarius* and *Paraspirifer acuminatus* Zones of the Jeffersonville Limestone and the Speeds and basal

Silver Creek Members of the North Vernon Limestone.

Polygnathus? caelatus Bryant, 1921
Fig. 10 S-U, cf. V, W

Polygnathus caelatus Bryant, 1921, p. 27, Pl. 13, Figs. 1-6, 8, 12, 13 (not Figs. 7, 9-11 = *Polygnathus collieri* Huddle, 1981).
not *Polygnathus caelata* Bryant. Bischoff and Ziegler, 1957, p. 86, Pl. 18, Figs. 18, 19.
Polygnathus beckmanni Bischoff and Ziegler, 1957, p. 86, Pl. 15, Fig. 25; Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson, 1976, Pl. 4, Figs. 22, 23; Bultynck and Hollard, 1981, p. 42, Pl. 8, Fig. 9.
Polygnathus aff. *P. beckmanni* Bischoff and Ziegler, Bultynck and Hollard, 1981, p. 42, Pl. 8, Fig. 1.
Polygnathus? caelatus Bryant. Huddle, 1981, p. B27, Pl. 11, Figs. 15-18, Pl. 12, Figs. 12-18, 22-24 (only), Pl. 13, Figs. 1-6, 12, 13.

Remarks.—Huddle (1981, p. B27) considered Bryant's original concept of *Polygnathus caelatus* to include two species. Specimens with an elongate, asymmetrical platform, ornamented by irregular ridges, and with little or no free blade, were referred to *Polygnathus? caelatus,* whereas the remainder of Bryant's specimens, characterized by a large free blade and smaller basal pit, were included in *Polygnathus collieri.* Huddle (1981, Pl. 13, Figs. 1-6, 12, 13) re-illustrated several of Bryant's original specimens and designated the specimen illustrated on Pl. 13, Figs. 6, 12, 13 (= Bryant, 1921, Pl. 13, Fig. 2) to be lectotype of *P.? caelatus.* In addition, he considered *P. beckmanni* and *P.? variabilis,* both of Bischoff and Ziegler, as junior synonyms of *P.? caelatus.*

Bischoff and Ziegler (1957, Pl. 15, Fig. 25 a,b) illustrated only an upper and lateral view of the holotype of *P. beckmanni. P.? caelatus* shows considerable variation in nature and strength of ornamentation and in shape of the platform in upper and lateral views. In this respect, the holotype of *P. beckmanni,* as well as the material in the present study, appears to be within this range of variation and assignment to *P.? caelatus* sensu Huddle, 1981, is adopted herein.

Material.—1 nearly complete and 10 fragmentary specimens.

Occurrence.—Beechwood and upper part of the Silver Creek Members of the North Vernon Limestone.

Polygnathus costatus costatus Klapper, 1971
Fig. 10 D-F, J-L

Polygnathus sp. nov. B Philip, 1967, p. 158-159, Pl. 2, Figs. 4, ?5, 8.
Polygnathus costatus costatus Klapper, 1971, p. 63, Pl. 1, Figs. 30-36, Pl. 2, Figs. 1-7; Klapper, *in* Ziegler, 1973, p. 347-348, *Polygnathus*—Pl. 1, Fig. 3 [see further synonymy]; Bultynck and Hollard, 1981, p. 42, Pl. 3, Figs. 7, 8; Klapper, *in* Johnson, Klapper, and Trojan, 1980, Pl. 4, Figs. 14, 15, 17; Sparling, 1981, p. 312-313, Pl. 1, Figs. 25-27 [P element] [see further synonymy]; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 28-29, Pl. 1, Figs. 11-13, 24, 25 [Pa element] [see further synonymy].

Remarks.—The specimens considered herein agree well with typical specimens of *Polygnathus costatus costatus.* For diagnosis and relations of *P. c. costatus,* see Klapper (1971, p. 63) and Klapper, *in* Ziegler (1973, p. 347-348).

Material.—79 specimens.

Occurrence.—Specimens confidently identified as *P. c. costatus* have been recovered, in this study, only from the *Paraspirifer acuminatus* Zone of the Jeffersonville Limestone at the Sellersburg Stone Company Quarry (SSQ) and from the Berry Materials Corporation Quarry (BMQ).

Polygnathus linguiformis klapperi
Clausen, Leuteritz, and Ziegler, 1979
Fig. 11 R-T

Polygnathus linguiformis linguiformis Hinde, epsilon morphotype Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson, 1976, p. 123-124, Pl. 4, Figs. 3, 12, 14, 24; Klapper, *in* Ziegler, 1977, p. 465, *Polygnathus*—Pl. 10, Figs. 5, 9, 10 [see further synonymy]; Bultynck and Hollard, 1981, p. 44, Pl. 7, Figs. 2-7, 9.

Polygnathus linguiformis klapperi Clausen, Leuteritz, and Ziegler, 1979, p. 32, Pl. 1, Figs. 7, 8.

Remarks.—*Polygnathus linguiformis klapperi* has a carminiplanate element with a flatter outer platform margin than that of the nominal subspecies. It can also be distinguished from *P. l. weddigei* by the poorer development of the tongue in the carminiplanate element of the latter subspecies. For a complete diagnosis and remarks, see Clausen, Leuteritz, and Ziegler (1979) or Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson (1976).

Material.—9 specimens.

Occurrence.—Basal Beechwood Member of North Vernon Limestone.

Polygnathus linguiformis linguiformis
Hinde, 1879
Fig. 11 O-Q

Polygnathus linguiformis Hinde, 1879, p. 367, Pl. 17, Fig. 15.

Polygnathus linguiformis linguiformis Hinde gamma forma nova Bultynck, 1970, p. 126-127, Pl. 11, Figs. 1-6, Pl. 12, Figs. 1-6.

Polygnathus linguiformis linguiformis Hinde. Weddige, 1977, p. 315-316, Pl. 5, Figs. 80-82; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 29-30, Pl. 2, Figs. 26-31 (Pa elements) [see further synonymy].

Polygnathus linguiformis linguiformis Hinde gamma morphotype Bultynck. Klapper, *in* Ziegler, 1977, p. 463-464, *Polygnathus*—Pl. 10, Fig. 2, *Polygnathus*—Pl. 11, Figs. 4, 7 (P element) [see further synonymy]; Bultynck and Hollard, 1981, p. 43-44, Pl. 7, Fig. 1.

Remarks.—*Polygnathus linguiformis linguiformis* has been divided into several morphotypes (Bultynck, 1970; Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson, 1976, p. 122-124; Klapper, *in* Johnson, Klapper, and Trojan, 1980, p. 102; Huddle, 1981, p. B30-B31). Most of these have since been treated as subspecies of *Polygnathus linguiformis* (Weddige, 1977, p. 312-316; Clausen, Leuteritz, and Ziegler, 1979, p. 30-33). Weddige (1977, p. 312-316) considered the gamma morphotype synonymous with the nominal subspecies and this opinion is followed in the present paper. Detailed diagnoses and descriptions of this form can be found in Weddige (1977); Klapper *in* Ziegler (1977), and Bultynck (1970).

Material.—943 specimens.

Occurrence.—Fenestrate bryozoan-brachiopod zone and *Paraspirifer acuminatus* Zone of the Jeffersonville Limestone and all members of the North Vernon Limestone.

Polygnathus linguiformis weddigei Clausen
Leuteritz, and Ziegler, 1979
Fig. 11 L-N

Polygnathus linguiformis linguiformis Hinde. Wittekindt, 1966, p. 635-636, Pl. 2, Fig. 11.

Polygnathus linguiformis linguiformis Hinde, delta morphotype, Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson, 1976, p. 123, Pl. 4, Figs. 4-8; Klapper, *in* Ziegler, 1977, p. 464-465, *Polygnathus*—Pl. 10, Figs. 1, 3; Bultynck and Hollard, 1981, p. 44, Pl. 7, Fig. 8.

Polygnathus linguiformis Hinde, delta morphotype, Ziegler and Klapper. Orchard, 1978, p. 944, Pl. 110, Figs. ?9, ?10, 21, 23, ?28, ?30.

Polygnathus linguiformis weddigei Clausen, Leuteritz, and Ziegler, 1979, p. 30-32, Pl. 1, Figs. 4, 9-12.

not *Polygnathus linguiformis linguiformis* Hinde, form delta Huddle, 1981, p. B30-B31, Pl. 15, Figs. 1-8.

(Text continues on page 108)

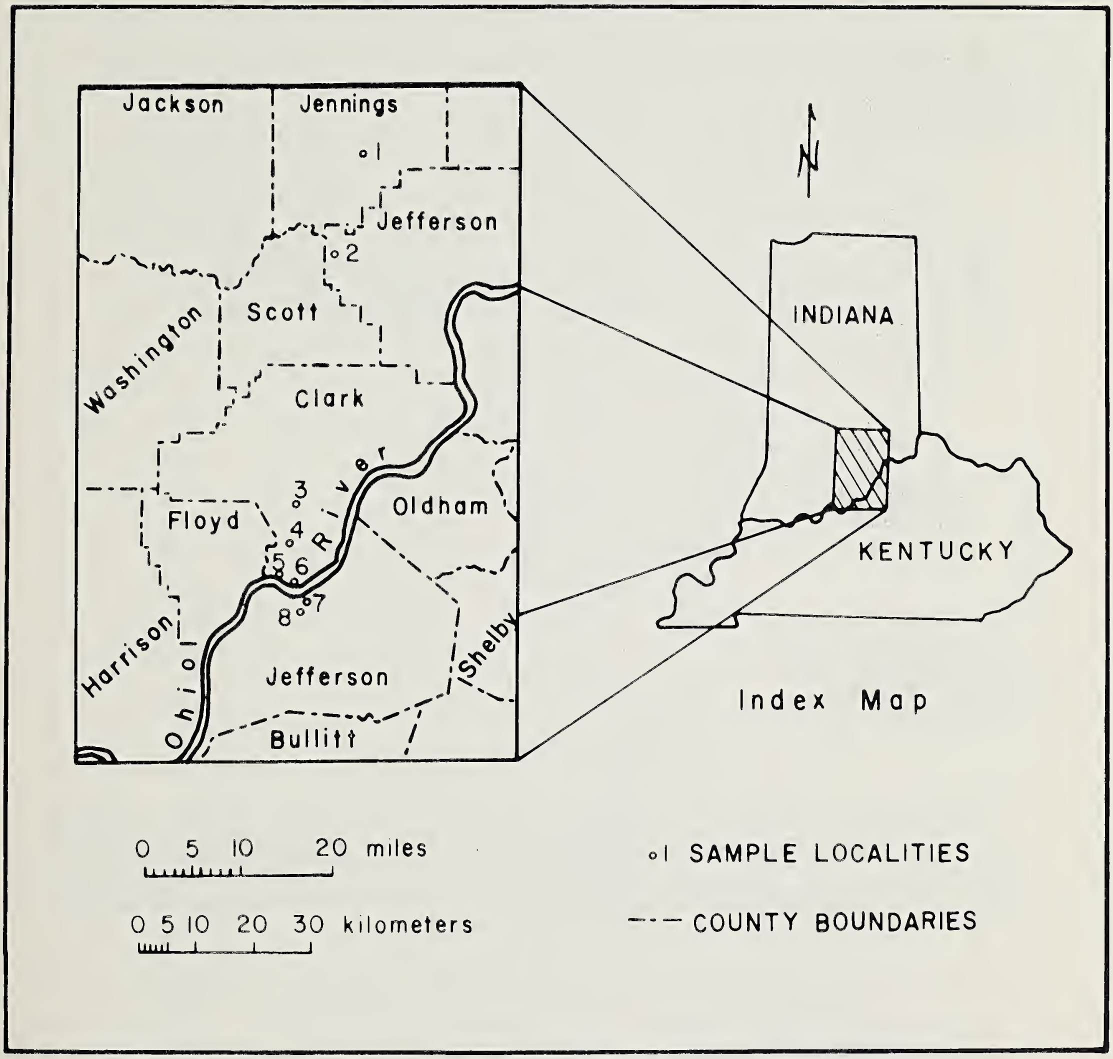

Fig. 1. Locality map for measured sections (see Appendix of Localities for precise locations).

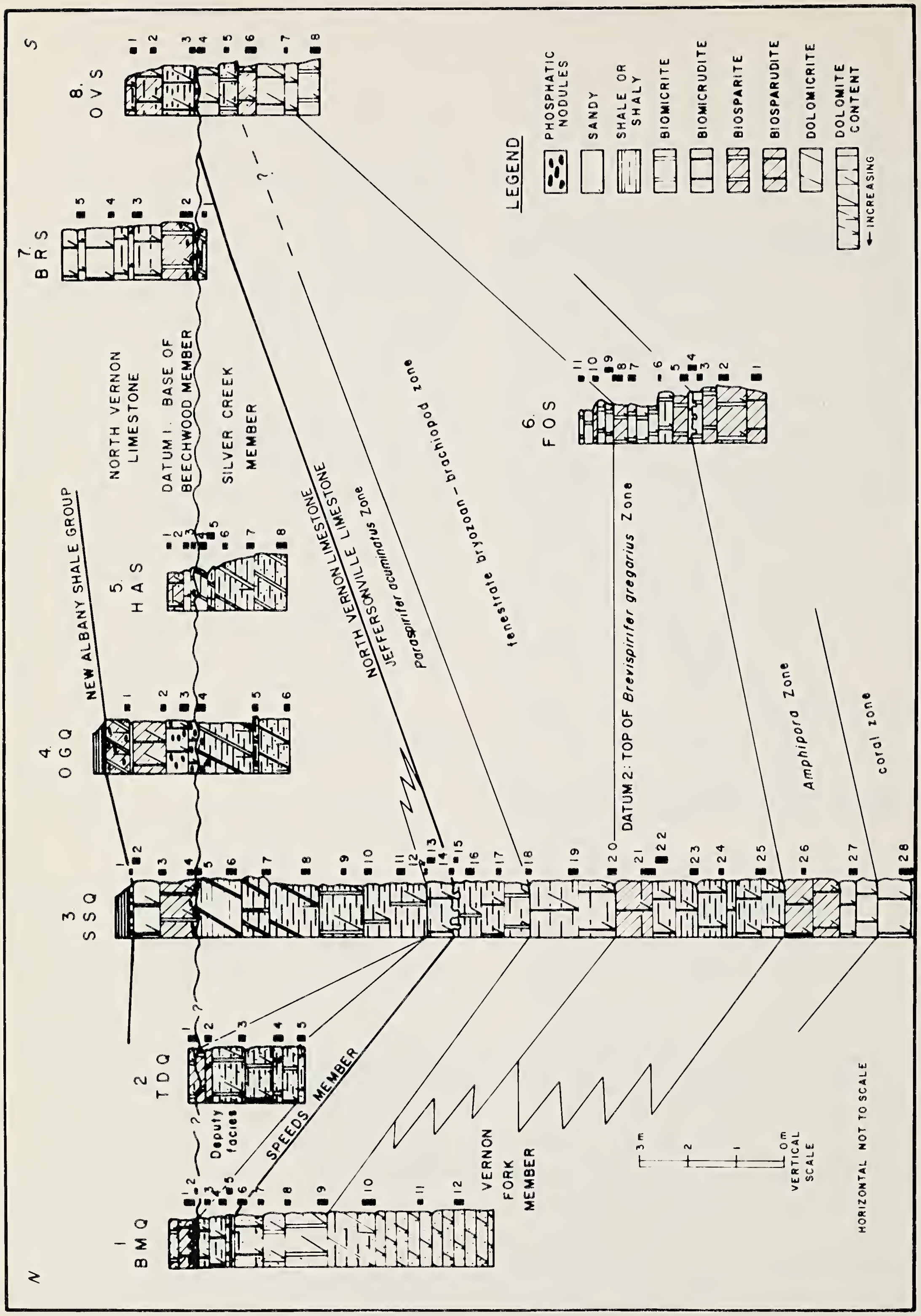

Fig. 2. Stratigraphy and conodont sample locations (numbered black rectangles) in the Muscatatuck Group, south-central Indiana and north-central Kentucky.

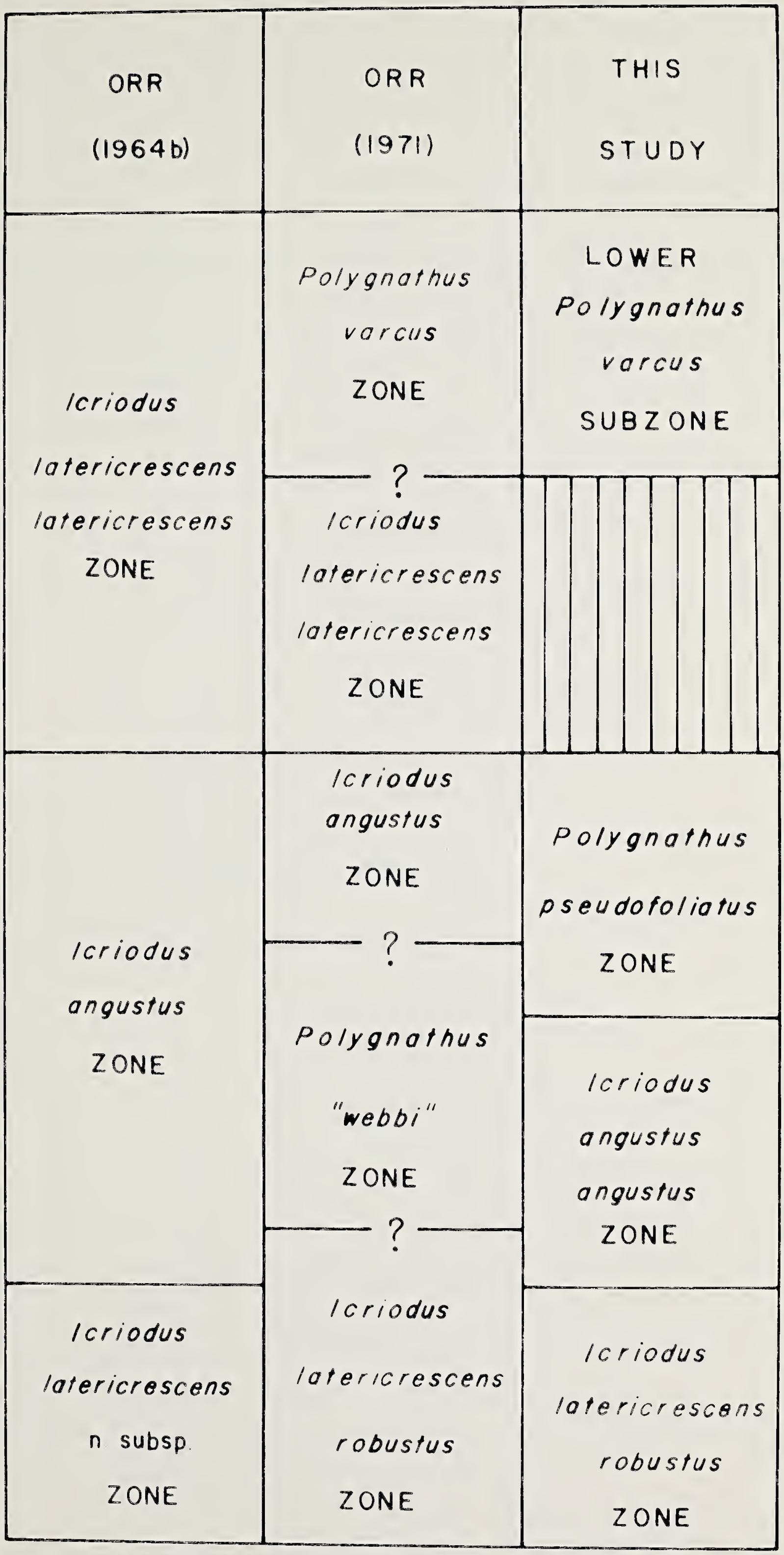

Fig. 3. Comparison of the conodont zonations of Orr (1964b), Orr (1971), and that of the present study.

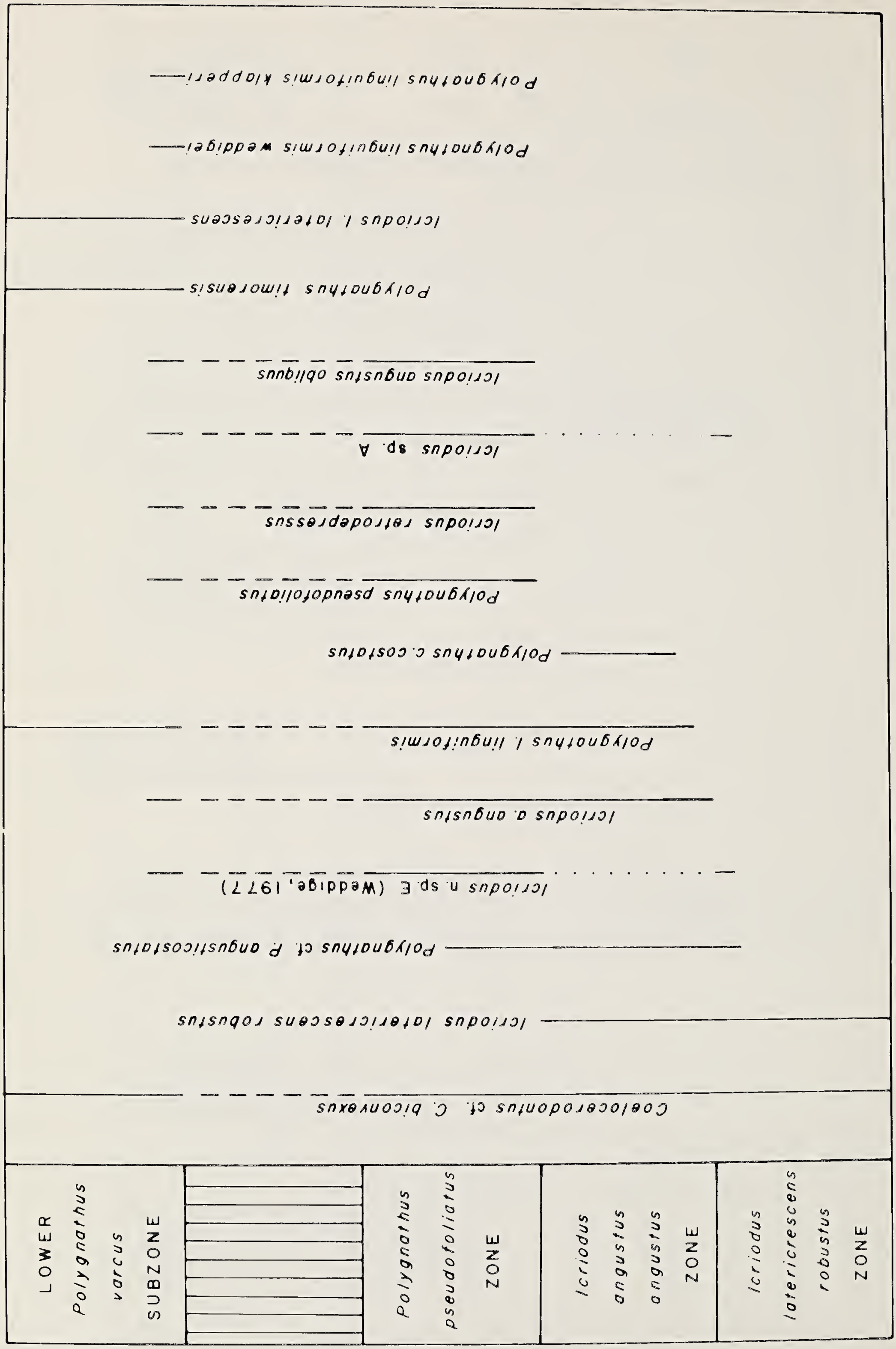

Fig. 4. Ranges of important conodont taxa in the Muscatatuck Group of south-central Indiana and north-central Kentucky.

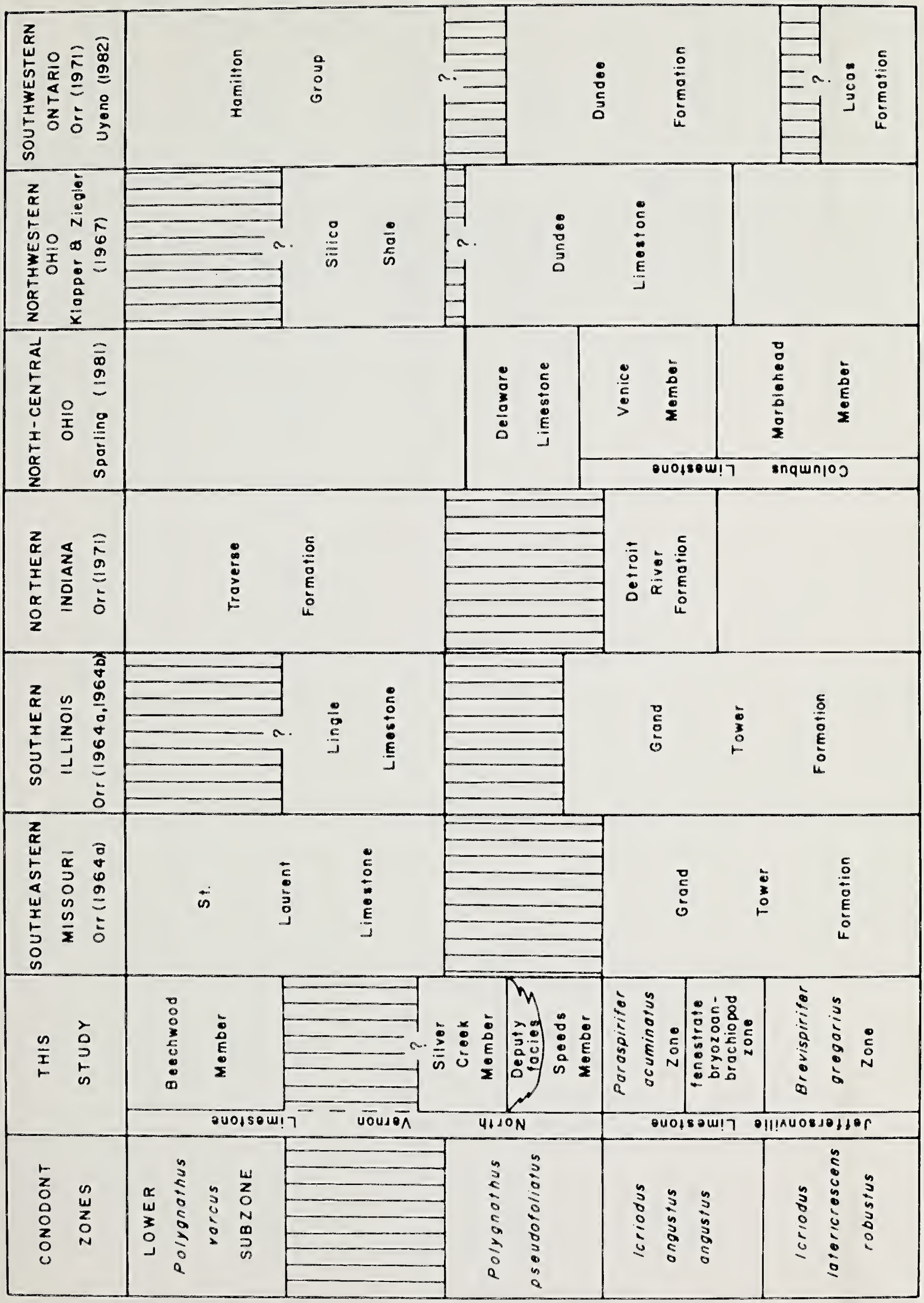

Fig. 5. Biostratigraphic correlations of Middle Devonian conodont zones in south-central Indiana, north-central Kentucky and surrounding areas.

SAMPLE NUMBER \ CONODONTS	*Belodella* cf. *B. resima*	*Coelocerodontus* cf. *C. biconvexus*	*Icriodus angustus angustus*	*I. angustus obliquus*	*I. brevis*	*I. latericrescens latericrescens*	*I. latericrescens robustus*	*I. retrodepressus*	*I.* n. sp. E of Weddige (1977)	*I.* sp. A	*I.?* sp. B	*Polygnathus* cf. *P. angusticostatus*	*P.? caelatus*	*P. costatus costatus*	*P. linguiformis klapperi*	*P. linguiformis linguiformis*	*P. linguiformis weddigei*	*P. pseudofoliatus*	*P. timorensis*	*Icriodus* "juveniles"	*Icriodus* sp. indeterminate	*Polygnathus* sp. indeterminate	genus & species indeterminate	alate elements	angulate elements	bipennate elements	cones (circular)	cones (compressed)	dolabrate elements	indeterminate ramiforms
SSQ-2	5	5				35	1cf.				4					2			25		76	3				2	3	3		2
SSQ-3		11				14															22		2				4	12		
SSQ-4	1	7				10							1cf.		1cf.	15		2	14	8	156	153	1	2	5	13	1	10	6	158
SSQ-5		17											1cf.			9			1	22	6					3	1	3	1	7
SSQ-6		24														9				36	6	8			2	6	3	18	5	11
SSQ-7		6														1				5				1		1	1	2		4
SSQ-8																1										1				1
SSQ-9																2				2						2				1
SSQ-10																														
SSQ-11		1														2				1								1		
SSQ-12	8	17	7	1				2	33	83		1				118		8		705	642	240		2	9	33	161	286	9	266
SSQ-13	6	10	1cf.					1	1	13										14	3						17	18		
*SSQ-14	1	11	2	15				8	20	94						115				452	184	57			3	7	48	47	4	47
*SSQ-15		2	7	1cf.				8	27	78						42		11		401	373	64			2	4	5	29	2	36
SSQ-16		14					37									20				90	18	17		2		12	20	47	7	30
SSQ-17	2	41					18							23		11				33	37	25		2	3	15	58	131	3	59
SSQ-18	2	51	9				147							34		72				186	146	14				9	228	182	7	75
SSQ-19	1	7					16									2				20	22					2	8	40	1	6
SSQ-20			1				1													1	11							1		
SSQ-21							1		2											2	10									
SSQ-22		1					5		1cf.											13	15						1	7		
SSQ-23		3					8													2	5						1	8		
SSQ-24			1cf.				9													10	16						2	6		
SSQ-25		2					6													3	5							1		
SSQ-26																														
SSQ-27																														
SSQ-28																														
OGQ-1	1	11			2	1							4			25			93	10	110	289			5	18	3	13	55	320
OGQ-2	1	6				16										2			6		37			1				8		
OGQ-3		2																			3	1								1
OGQ-4		3				1										4		1cf.		15	11	6			6	4		1	2	7
OGQ-5		6			2											6				15	4	3		2	5	4		3	4	6
OGQ-6	2	14			5											27				19	4	7		4	11	18	1	1	9	18
OVS-1	1																				5									
OVS-2						1																								1
OVS-3	4	2				3										4					3	1				1				1
OVS-4		26					11									9				23	12	8		1		4	9	22	7	13
OVS-5		15	1				30									32				83	58	5		1	1	9	2	15	4	12
OVS-6		19					45									19				46	17	5			3	7	1	25	2	8
OVS-7		5					27													9	12					1		8		1
OVS-8		1	1cf.				5		2	4										14	3							3		

Fig. 6. Distribution of conodonts in the Sellersburg Stone Company Quarry (SSQ), Old Gheen's Quarry (OGQ) and Oak and Vine Streets (OVS) sections. For discussion of *Icriodus* "juveniles," refer to remarks on *Icriodus* sp. A. Sample numbers preceded by an asterisk (*) indicate partial picking.

SAMPLE NUMBER \ CONODONTS	*Belodella* cf. *B. resima*	*Coelocerodontus* cf. *C. biconvexus*	*Icriodus angustus angustus*	*I. angustus obliquus*	*I. brevis*	*I. latericrescens latericrescens*	*I. latericrescens robustus*	*I. retrodepressus*	*I.* n. sp. E of Weddige (1977)	*I.* sp. A	*I.?* sp. B	*Polygnathus* cf. *P. angusticostatus*	*P.? caelatus*	*P. costatus costatus*	*P. linguiformis klapperi*	*P. linguiformis linguiformis*	*P. linguiformis weddigei*	*P. pseudofoliatus*	*P. timorensis*	*Icriodus* "juveniles"	*Icriodus* sp. indeterminate	*Polygnathus* sp. indeterminate	genus & species indeterminate	alate elements	angulate elements	bipennate elements	cones (circular)	cones (compressed)	dolabrate elements	indeterminate ramiforms
BMQ–1		5	5	3		10			3cf.							9		2cf		40	260	50			5	1	1	12	3	52
*BMQ–2		2	18	1		19		5	6	10					4	38		2cf.	3	263	803	149		2	3	2	3	41	3	135
BMQ–3		3	9					2	5	3										177	29					2	48	61		6
BMQ–4		17	68					10	5	13		5				4				543	330	21		4	3	5	56	175	4	50
BMQ–5		10	21					7	2	12						4				136	85	13			2	1	20	42		19
BMQ–6		16	1cf													4				108	44					4		9		9
BMQ–7		31	11				17							1		15				231	199	8		2	1	6	17	34	1	30
BMQ–8		36	3				18					3				2cf.				136	97			2		2	23	52		14
*BMQ–9		39	27				36							21		13				645	639	32		1	2	4	83	46	4	35
BMQ–10																														
BMQ–11																														
BMQ–12																														
TDQ–1		63						1	6	10										31		1					39	34		9
TDQ–2		13						1	6	10										9	9						1	16		
TDQ–3		16																		7	5	1					8	12		2
TDQ–4		17	2cf																	32	17						21	35		2
TDQ–5		11	83	2				1	26	15						68		4		476	289	42		1	3	22	12	109	8	40
HAS–1																					2							1		
HAS–2		1																												
HAS–3		8				23			139	2			5cf.		4	132	4	12	18	120	927	452		7	2	29		28	38	129
HAS–4		3														3				4	2	2			1	2		1	2	8
HAS–5		3														13				19	2			1	4	7		2	2	13
HAS–6		16														42				67	19	12				21	2	5	16	45
HAS–7																														1
HAS–8																1				2	1							3		1
FOS–11	1	5					25									10				58	42	1				7	2	20	1	11
FOS–10		15	3				28									5				55	19	1		2		3		24		2
FOS–9		1					5							1cf						1	7					1		5		
FOS–8		3					5													2	7							2		
FOS–7		1					2					1								3	4	1				1		2		
FOS–6		2					13													6	4							1		
FOS–5		10					15			2cf.										4	5							3		
FOS–4																														
FOS–3																														
FOS–2																														
FOS–1																														
BRS–5	5	1				3															4						4	6		
BRS–4																														
BRS–3																														
BRS–2	1	9				15			1cf							31	1	2cf.	1	3cf	38	47		1	3	7	3	16	2	37
BRS–1																2					1	1								4

Fig. 7. Distribution of conodonts in the Berry Materials Corporation Quarry (BMQ), Type Deputy Quarry (TDQ), Harrison Avenue (HAS), Falls of the Ohio (FOS) and Beechwood Reference (BRS) sections. For discussion of *Icriodus* "juveniles," refer to remarks on *Icriodus* sp. A. Sample numbers preceded by an asterisk (*) indicate partial picking.

Fig. 8. Conodonts from the Muscatatuck Group of south-central Indiana and north-central Kentucky. All figures approximately X40.

A-F *Icriodus angustus angustus* Stewart and Sweet, 1956. A, B, C, upper, lower and lateral views of SUI 49331, TDQ-5. D, E. F, upper, lower, and lateral views of SUI 49332, BMQ-4.

G-L *Icriodus angustus obliquus* n. subsp. G, H, I, upper, lower, and lateral views of paratype SUI 49333, TDQ-5. J, K, L, upper, lower, and lateral views of holotype SUI 49334, SSQ-14.

M-U *Icriodus latericrescens robustus* Orr, 1971. M, N, O, lower, upper, and lateral views of SUI 49335, FOS-6. P, Q, R, upper, lower and lateral views of SUI 49336, OVS-6. S, T, U, lower, upper, and lateral views of SUI 49337, OVS-6.

V-AD *Icriodus latericrescens latericrescens* Branson and Mehl, 1938. V, W, X, lower, upper, and lateral views of SUI 49338, BRS-2, Y, Z, AA, upper, lower, and lateral views of SUI 49339, OGQ-2. AB, AC, AD, lower, upper, and lateral views of SUI 49340, BRS-2.

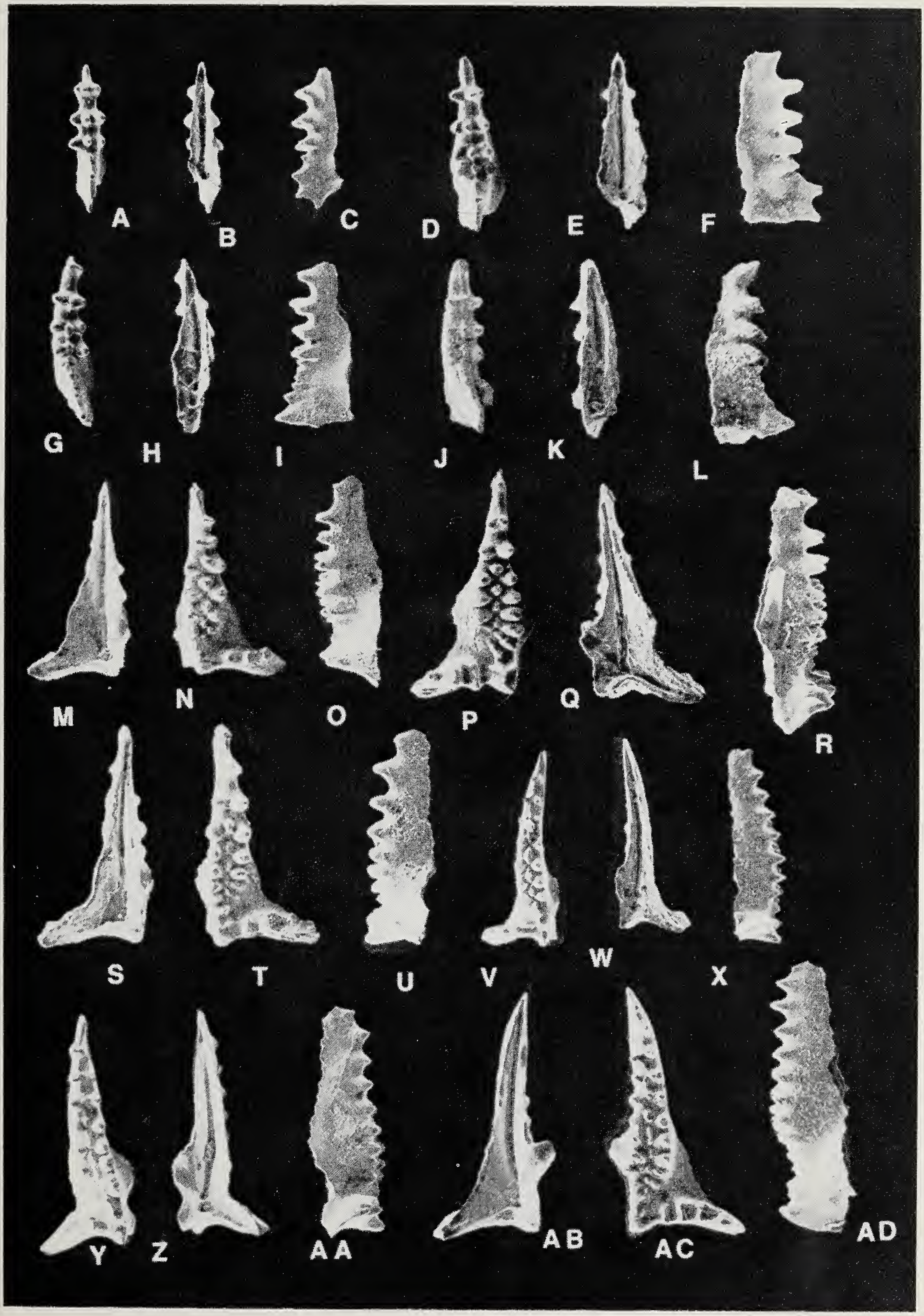
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Fig. 9 Conodonts from the Muscatatuck Group of south-central Indiana and north-central Kentucky. All figures approximately X40.

A-F *Icriodus retrodepressus* Bultynck, 1970. A, B, C, upper, lower, and lateral views of SUI 49341, BMQ-4. D, E, F, upper, lower, and lateral views of SUI 49342, BMQ-4.

G-I *Icriodus* n. sp. E of Weddige, 1977. Upper, lower, and lateral views of SUI 49343, BMQ-2.

J-L *Icriodus* cf. *I.* n. sp. E of Weddige, 1977. Upper, lower, and lateral views of SUI 49344, OVS-6.

M-O *Icriodus* cf. *I.* sp. A. Upper, lower, and lateral views of SUI 49345, FOS-5.

P-R *Icriodus* n. sp. E of Weddige, 1977 → *Icriodus* sp. A. Upper, lower, and lateral views of SUI 49346, BMQ-4.

S-X *Icriodus* sp. A. S, T, U, upper, lower, and lateral views of SUI 49347, TDQ-5. V, W, X, upper, lower, and lateral views of SUI 49348, BMQ-4.

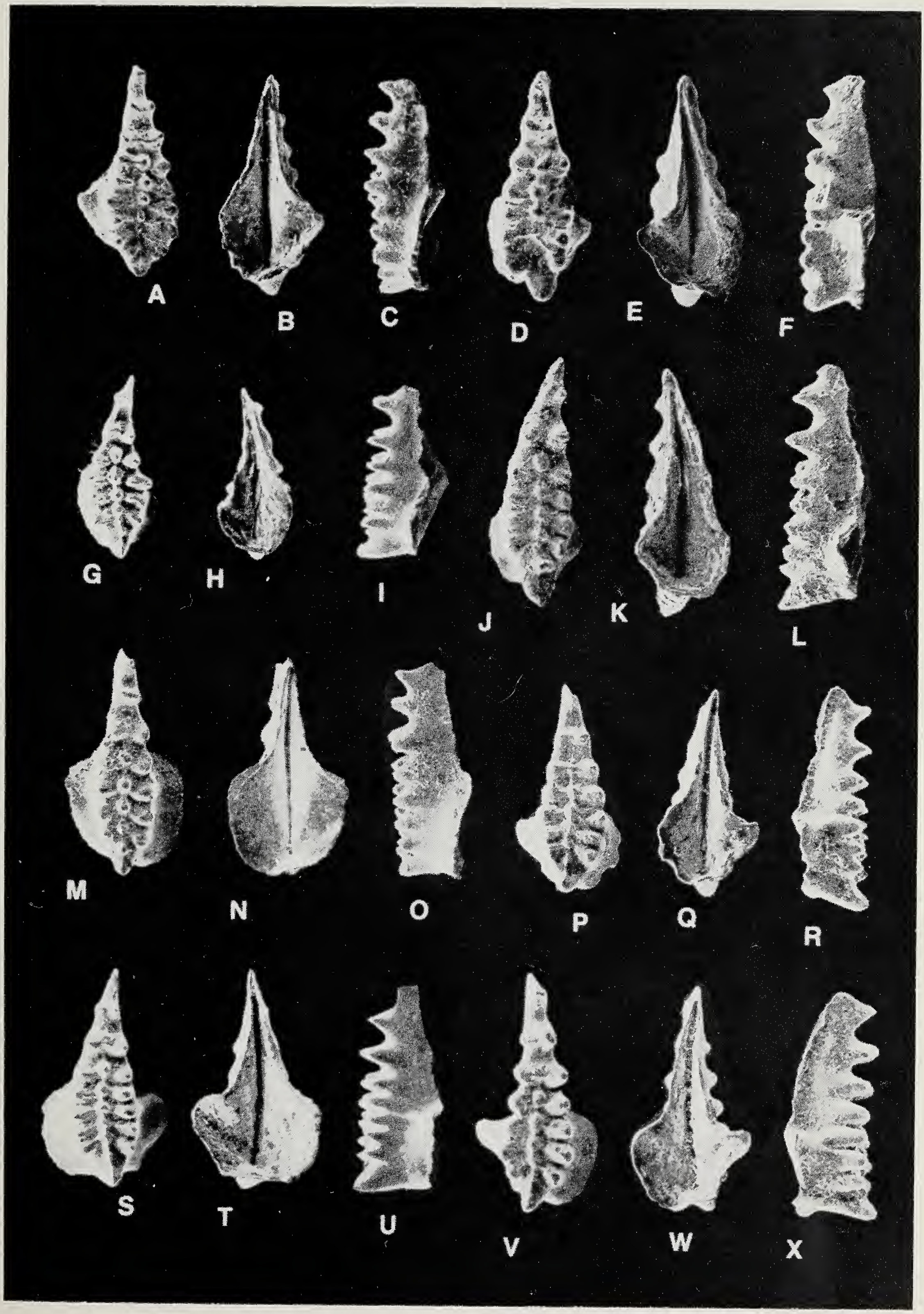
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Fig. 10. Conodonts from the Muscatatuck Group of south-central Indiana and north-central Kentucky. All figures approximately X40.

A-C *Polygnathus* cf. *P. angusticostatus* Wittekindt, 1966. Upper, lower, and lateral views of SUI 49349, BMQ-1. Specimen missing most of free blade.

D-F *Polygnathus costatus costatus* Klapper, 1971. Upper, lower, and lateral views of SUI 49350, SSQ-17.

G-I *Polygnathus* cf. *P. angusticostatus* Wittekindt, 1966. Upper, lower, and lateral views of SUI 49351, SSQ-15. Specimen missing free blade.

J-L *Polygnathus costatus costatus* Klapper, 1971. Upper, lower, and lateral views of SUI 49352, SSQ-18.

M-R *Polygnathus pseudofoliatus* Wittekindt, 1966. M, N, O, upper, lower, and laterial views of SUI 49353, SSQ-15. P, Q, R, upper, lower, and lateral views of SUI 49354, SSQ-15. Specimen missing most of free blade.

S-U *Polygnathus? caelatus* Bryant, 1921. Upper, lower, and lateral views of SUI 49355, OGQ-1. Specimen missing anterior tip.

V,W *Polygnathus?* cf. *P.? caelatus* Bryant, 1921. Upper and lower views of SUI 49356, HAS-3. Fragmentary specimen missing anterior portion and posterior tip.

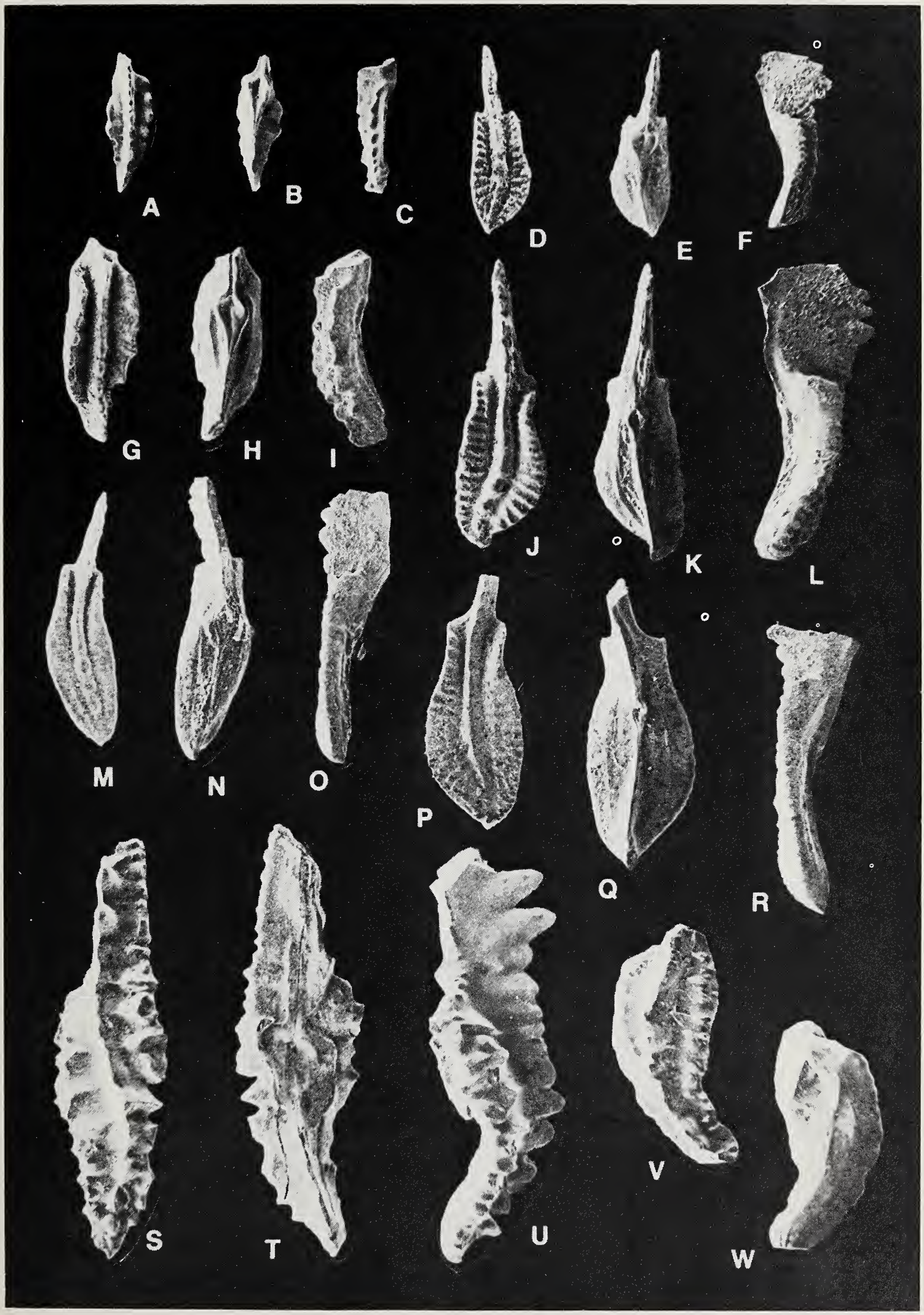
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Fig. 11 Conodonts from the Muscatatuck Group of South-central Indiana and north-central Kentucky. All figures approximately X40.

A Bipennate element. Inner lateral view of fragmentary specimen, SUI 49357, FOS-10.

B-E Dolabrate elements. B, inner lateral view of SUI 49358, OGQ-1. C, D, E, inner lateral, outer lateral, and lower views of SUI 49359, HAS-5.

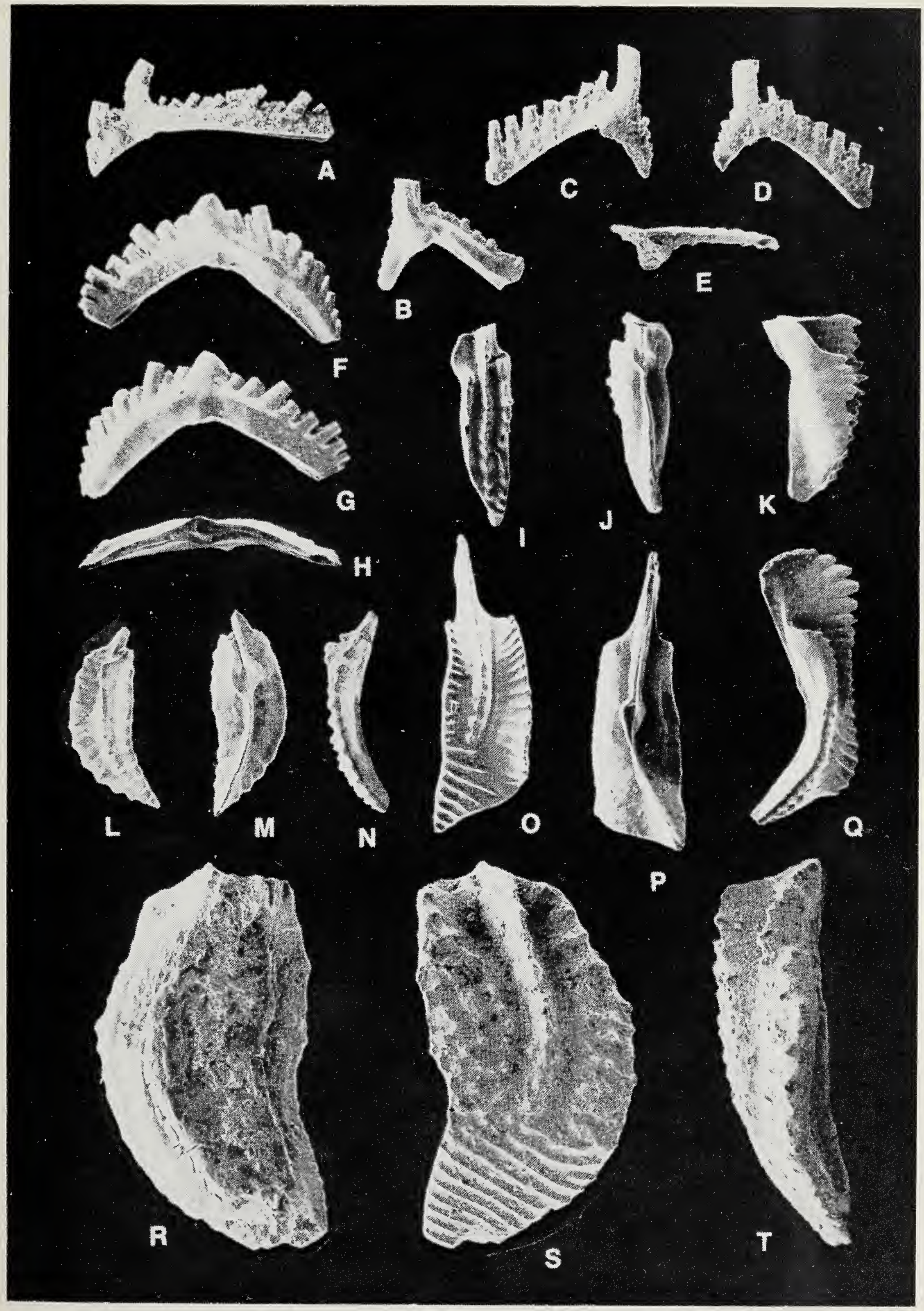
F-H Angulate element. Inner lateral, outer lateral, and lower views of SUI 49360, TDQ-5.

I-K *Polygnathus timorensis* Klapper, Philip, and Jackson, 1970. Upper, lower, and lateral views of SUI 49361, OGQ-1.

L-N *Polygnathus linguiformis weddigei* Clausen, Leuteritz, and Ziegler, 1979. Upper, lower, and lateral views of SUI 49362, BRS-2.

O-Q *Polygnathus linguiformis linguiformis* Hinde, 1879. Upper, lower, and lateral views of SUI 49363, SSQ-4.

R-T *Polygnathus linguiformis klapperi* Clausen, Leuteritz, and Ziegler, 1979. Lower, upper, and lateral views of SUI 49364, BMQ-2.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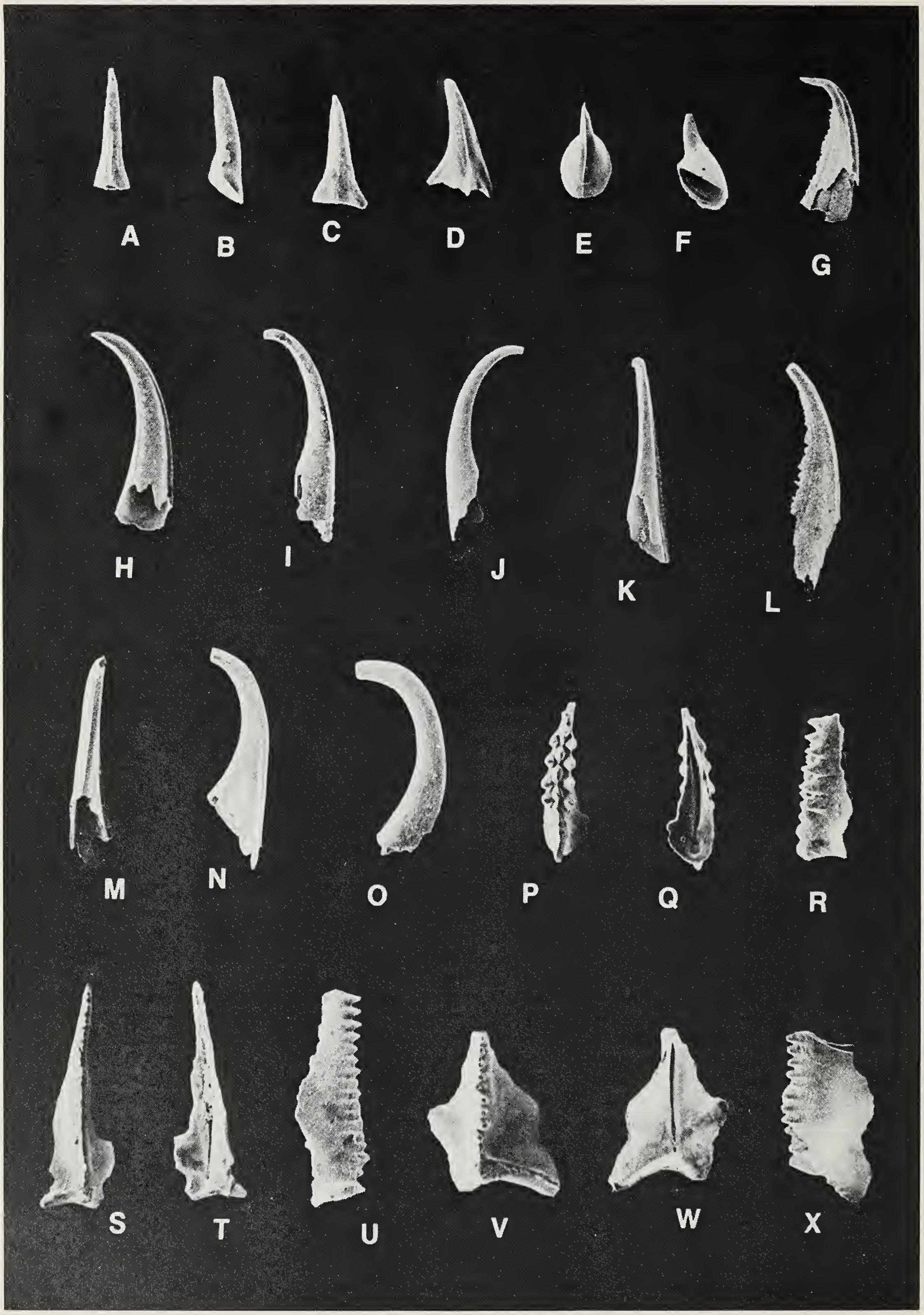
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Fig. 12 Conodonts from the Muscatatuck Group of south-central Indiana and north-central Kentucky. All figures approximately X40.

A-D Coniform elements. A, SUI 49365, OGQ-1; B, SUI 49366, TDQ-5; C, SUI 49367, BRS-2; D, SUI 49368, SSQ-3.

E,F Genus and species indeterminate. Upper and lateral views of SUI 49369, SSQ-4.

G *Belodella* cf. *B. resima* (Philip, 1965). Lateral view of SUI 49370. OVS-3.

H-K *Coelocerodontus* cf. *C. biconvexus* Bultynck, 1970. H, posterolateral view of SUI 49371, SSQ-3; I, J, K, inner lateral, outer lateral, and posterolateral view of SUI 49372, TDQ-5.

L *Belodella* cf. *B. resima* (Philip, 1965). Lateral view of SUI 49373, SSQ-4.

M-O *Coelocerodontus* cf. *C. biconvexus* Bultynck, 1970. M, N, posterior and lateral views of SUI 49374, SSQ-3. O, lateral view of SUI 49375, OGQ-1.

P-R *Icriodus brevis* Stauffer, 1940. Upper, lower, and lateral views of SUI 49376, OGQ-1.

S-X *Icriodus?* sp. B. S, T, U, upper, lower, and lateral views of SUI 49377, SSQ-2. V, W, X, upper, lower, and lateral views of SUI 49378, GHE-2.

Remarks.—*Polygnathus linguiformis weddigei* is distinguished from the nominal subspecies by the flatter platform, the poorly developed tongue, and a carina that extends to, or nearly to, the posterior tip in the former. For a detailed diagnosis, see Clausen, Leuteritz, and Ziegler (1979) or Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson (1976). *P. l. weddigei* is a rare form in the present faunas and was recovered from only two samples.

Material.—5 specimens.

Occurrence.—Basal part of the Beechwood Member of the North Vernon Limestone.

Polygnathus pseudofoliatus
Wittekindt, 1966
Fig. 10 M-R

Polygnathus n. sp. Ziegler. Flajs, 1966, p. 232-233, Pl. 23, Figs. 5-7.

Polygnathus pseudofoliata Wittekindt, 1966, p. 637-638, Pl. 2, Figs. 20-23 [non Fig. 19 = *P. eiflius*].

Polygnathus pseudofoliatus Wittekindt. Klapper, 1971, p. 63-64, Pl. 2, Figs. 8-13 [see further synomymy]; Klapper, *in* Ziegler, 1973, p. 375-376, *Polygnathus*—Pl. 1, Figs. 8, 9 [see further synonymy]; Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson, 1976, Pl. 3, Figs. 2, 3, 12, 13; Weddige, 1977, p. 317-318, Pl. 4, Figs. 68-70 [see further synonymy]; Bultynck and Hollard, 1981, p. 45, Pl. 5, Figs. 13, 14.

Polygnathus cf. *P. pseudofoliatus* Wittekindt. Pedder, Jackson, and Ellenor, 1970, Pl. 15, Fig. 26.

Remarks.—For diagnosis and description of *Polygnathus pseudofoliatus,* see Wittekindt (1966, p. 637-638). For amended diagnosis see Klapper, *in* Ziegler (1973, p. 375). *P. pseudofoliatus* includes a carminiplanate element that may have a platform outline similar to that of *P. c. costatus.* In *P. pseudofoliatus,* however, the platform tends to be shallower with shallower adcarinal troughs, especially in the posterior part of the platform. The ornamentation of *P. pseudofoliatus* is less strongly developed than in *P. c. costatus* and consists of transverse rows of nodes to weakly developed to broken transverse ridges. Rare specimens in the present study have unusually elongate platforms (see Fig. 10, M-O) but otherwise agree with specimens considered herein as *P. pseudofoliatus.*

Material.—44 specimens.

Occurrence.—North Vernon Limestone (all members).

Polygnathus timorensis
Klapper, Philip, and Jackson, 1970
Fig. 11 I-K

Polygnathus varca Stauffer. Bischoff and Ziegler, 1957, Pl. 18, Fig. 34 (only).

Polygnathus varcus Stauffer. Kirchgasser, 1970, p. 351-352, Pl. 66, Figs. 9-11; Orr, 1971, p. 53-54, Pl. 5, Figs. 4-8.

Polygnathus cf. *decorosa* Stauffer. Matthews, 1970, Pl. 1, Fig. 10.

Polygnathus timorensis Klapper, Philip, and Jackson, 1970, p. 655-656, Pl. 1, Figs. 1-3, 7-10; Klapper, *in* Ziegler, 1973, p. 385-386, *Polygnathus*—Pl. 2, Fig. 3; Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson, 1976, p. 125, Pl. 2, Figs. 27-32; Orchard, 1978, p. 949, Pl. 112, Figs. 13-15, 17, 18, 25, 28, 32, 35; Bultynck and Hollard, 1981, p. 45, Pl. 6, Figs. 8-14; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 30, Pl. 2, Figs. 7, 8, 13-16 (Pa elements).

Polygnathus rhenanus marijae Huddle, 1981, p. B32, Pl. 17, Figs. 10-12, 19-27 (only), Pl. 18, Figs. 1, 2, 5 (only).

Remarks.—For diagnosis and remarks, see Klapper, Philip, and Jackson (1970) and Ziegler and Klapper, *in* Ziegler, Klapper, and Johnson (1976).

Material.—161 specimens.

Occurrence.—Uppermost part of the Silver Creek Member, and the Beechwood Member of the North Vernon Limestone. See section on Biostratigraphy for comments on occurrence in the Silver Creek Member.

Genus and species indeterminate
Fig. 12 E, F

Remarks.—Three, slightly asymmetrical, nongeniculate coniform elements of uncertain affinities have been recovered from two of the examined samples. These elements have a broad, circular to elliptical basal margin. The thin-walled base occupies the lower three-fourths to four-fifths of the specimen. The cusp is proclined, oval in cross-section, and bluntly pointed apically. A low, narrow keel runs along the anterior margin from the apex to the basal margin; otherwise, the elements are smooth. These specimens bear some resemblance to *Coelocerodontus* cf. *C. biconvexus* in the development of the deep, thin-walled base. Paucity of material and restricted distribution, however, obscure the relationship, if any, with that species.

Material.—3 specimens

Occurrence.—Beechwood Member, North Vernon Limestone.

Coniform Elements
Fig. 12 A-D

Remarks.—Proclined coniform elements that are generally either compressed or nearly circular in cross-section are common to abundant in many of the examined samples. Similar coniform elements have been included in multielement reconstructions of species of *Icriodus* (see, e.g., Klapper and Philip, 1971, p. 446; Johnson and Klapper, 1981, p. 1242; Clark et al., 1981, p. W125; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, p. 32). The comparable distributions of the segminiscaphate elements of *Icriodus* and of the simple cones, in the present study, support those reconstructions (refer to Figs. 6 and 7). No similar reconstructions are attempted in this paper, however, because of the diversity of the simple cones and of species of *Icriodus*.

Material.—Compressed: 1,955; circular: 978.

Occurrence.—Brevispirifer gregarius Zone; fenestrate bryozoan-brachiopod zone; *Paraspirifer acuminatus* Zone and Vernon Fork Member of the Jeffersonville Limestone; Speeds, Silver Creek and Beechwood Members and Deputy facies of the North Vernon Limestone.

Ramiform and Angulate Elements
Fig. 11 A-H

Remarks.—Ramiform and angulate elements are common constituents of many of the conodont faunas examined. Preservation tends to be poor, however, with most specimens being fragmentary. Whenever possible, specimens were placed into the various shape categories (alate, bipennate, dolabrate, and angulate). Elements belonging to these shape categories have been included in reconstruction of species of *Polygnathus* (see, e.g., Klapper and Philip, 1971, p. 431-433; Sparling, 1981, p. 308-309; Clark et al., 1981, p. W162-W164; Uyeno, *in* Uyeno, Telford, and Sanford, 1982, Pl. 2). The comparable distribution of the carminiplanate elements of *Polygnathus* and the ramiform and angulate elements in the present study support these reconstructions.

Material.—Alate elements: 51; bipennate elements: 367; dolabrate elements: 235; angulate elements: 117.

Occurrence.—Brevispirifer gregarius Zone; fenestrate bryozoan-brachiopod zone; *Paraspirifer acuminatus* Zone and Vernon Fork Member of the Jeffersonville Limestone; Speeds, Silver Creek and Beechwood Members and Deputy facies of the North Vernon Limestone.

Conclusions

Conodont faunas from the Middle Devonian Muscatatuck Group of south-central Indiana and north-central Kentucky contain few species diagnostic of the standard conodont zonation. Consequently, a zonation consisting of three local zones and one standard subzone has been adopted. By means of this local zonal scheme, a correlation of the Middle Devonian strata of the study area and surrounding areas can be established. A late Emsian to early Givetian age is suggested for the Muscatatuck Group

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APPENDIX

Localities

Three distinct methods (Federal System of Rectangular Surveys, Clark Military Grants, and Carter Coordinates) have been used to survey the land in the study area. For the sake of consistency, locations are given in terms of latitude and longitude.

1) Berry Materials Corporation Quarry (BMQ), Lat. 39°00′53″ N, Long. 85°37′07″ W, Butlerville 7.5′ Quadrangle, Jennings County, Indiana (type locality of North Vernon Limestone).
2) Deputy Quarry (TDQ), Lat. 38°46′50″ N, Long. 85°38′18″ W, Deputy 7.5′ Quadrangle, Jefferson County, Indiana (type locality of Deputy Limestone of Campbell, 1942).
3) Sellersburg Stone Company Quarry (SSQ), Lat. 38°23′24″ N, 85°46′54″ W, Charlestown 7.5′ Quadrangle, Clark County, Indiana.
4) Old Gheen's Quarry (OGQ), Lat. 38° 21′27″ N, Long. 85°44′30″ W, Jeffersonville 7.5′ Quadrangle, Clark County, Indiana (type area of Silver Creek Member).
5) Harrison Avenue Section (HAS), Lat. 38°17′17″ N, Long. 85°46′39″ W, New Albany 7.5′ Quadrangle, Clark County, Indiana.
6) Falls of the Ohio Section (FOS), Lat. 38° 16′20″ N, Long. 85°45′45″ W, New Albany 7.5′ Quadrangle, Clark County, Indiana (type locality of Jeffersonville Limestone).
7) Beechwood Reference Section (BRS), Lat. 38°15′13″ N, Long. 85°42′53″ W, Jeffersonville 7.5′ Quadrangle, Jefferson County, Kentucky (reference section of Beechwood Member).
8) Oak and Vine Streets Section (OVS), Lat. 38°14′08″ N, Long. 85°43′46″ W, Louisville East 7.5′ Quadrangle, Jefferson County, Kentucky.

ADDRESSES OF CONTRIBUTORS TO K. G. NELSON MEMORIAL VOLUME OF THE *TRANSACTIONS* WISCONSIN ACADEMY, 1983

Dr. Rachel K. Paull
Department of Geology and Geophysics
University of Wisconsin-Milwaukee
Milwaukee, WI 53201

Dr. Brian Witzke
Iowa Geological Survey
123 N. Capitol St.
Iowa City, Iowa 52242

Dr. Donald Mikulic
Illinois State Geological Survey
615 E. Peabody Dr.
Champaign, IL 61820

Ms. Joanne L. Kluessendorf
Illinois State Geological Survey
615 E. Peabody Dr.
Champaign, IL 61820

Mrs. Susan M. Siemann-Gartmann
Route 1, Box 152A
Bush, LA 70481

Mr. Curtis R. Klug
Department of Geology
University of Iowa
Iowa City, IA 52242

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TRANSACTIONS

of

the Wisconsin Academy of Sciences, Arts & Letters

Volume 71
Part 2
1983

TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

Volume 71, Part 2, 1983

Co-editors
PHILIP WHITFORD
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WISCONSIN ACADEMY

Established 1870
Volume 71, Part 2, 1983

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Fairwater, WI 53931

LORINE NIEDECKER: A LIFE BY WATER

WAYNE MEYER
Department of Library Service
Ball State University
Muncie, Indiana

The Wisconsin poet Lorine Niedecker (1903-1970) is easily overlooked, and usually has been overlooked. The short entry in *Contemporary Authors,* the only standard reference work in the libary in which I could find her listed, seems, as I expected, quite unremarkable, especially in the sections for "Education" and "Career": "Beloit College, student for 2½ years" and "formerly employed in a library and hospital and at Radio Station WHA, Madison."[1] According to hometown sources in Fort Atkinson, Wis.,[2] Niedecker's mother became deaf and a virtual invalid during Lorine's stay at Beloit, and so the daughter, an only child, felt needed at home and thus left college. She was called "assistant librarian" for a few years during the late 1920's at the Dwight Foster Public Library in Fort Atkinson. Some sort of script writing job for WHA radio in Madison evidently lasted just a brief time during the early 1940's. During the period 1944-50 she worked in Fort Atkinson as a stenographer and proof reader at Hoard's where the well-known journal *Hoard's Dairyman* is published & printed. Her working life outside the home, as we now say, ended with a stint at the Fort Atkinson Memorial Hospital from 1957 to 1962, the year of her marriage (which was actually her second marriage) to Al Millen, a housepainter from Milwaukee. Her job description at the hospital was "dietary position, cleaning."

Her style of life would not have attracted much attention, except perhaps—if anyone had cared to notice—by virtue of its extreme simplicity. The meager living conditions that were hers during most of her life are referred to quite often in the poetry. But when I looked around in the two-room cabin that she lived in alone during many years before her 1962 marriage, I was still impressed by how gaunt and cramped it seemed. The privy and hand pump close by the cabin were still there, too. I especially noticed them because the arrival of indoor plumbing is specifically mentioned in a couple of poems, including the following:

> Now in one year
>   a book published
>   and plumbing—
> took a lifetime
>   to weep
>   a deep
>   trickle

(Incidentally, that book of poems, which arrived along with the plumbing, was most likely a collection dated 1961.)

This typically short, terse poem reveals several qualities that are typical of Niedecker and that will be important for this essay. First, note how the poet's life and art are described in water imagery. Also, there are rather typical attitudes expressed of humility, and some humorous self-deprecation, combined with strict honesty, in regard to her hard life and work—with the result of reinforcing the emotional impact of that honesty. Alliteratively juxtaposed to plumbing, her poetic output, so modest in quantity, is a mere "trickle." But there is indeed real depth to it, and the price paid for it was high—a whole "lifetime" and with considerable weeping involved.

In regard to material comfort, her childhood, too, evidently fit into this pattern.

This essay is based upon a presentation to the Conference on Wisconsin Writers, held at Lawrence University, Appleton, Wisconsin, September 12, 1980.

According to some of Niedecker's own words, in *Paean to Place:*

Seven years the one
dress
for town once a week
One for home
   faded blue-striped
as she piped
her cry

In adulthood her attitude towards the material was quite firm and expressed again in water imagery:

O my floating life
Do not save love
   for things
      Throw things
to the flood

ruined
by the flood

Nor did this woman attract any attention by "getting around" much. She spent the great majority of her days in a few different dwellings on Blackhawk Island, which is actually a small spur of land jutting out toward Lake Koshkonong between marshland on one side and the Rock River on the other (close to where the Rock empties into the lake). The previously mentioned cabin is thirty or so yards from the river shore. Maybe a quarter mile down the single blacktop road heading toward the tip of the Island is her parents' former home, where Niedecker was born and spent much of her time as a child (with some stints at relatives' homes in town which were closer to school) and, just across the road and right on the river bank, a rambling frame building which was a kind of combination tavern and bait shop operated originally by her maternal grandfather and then by her father, who was also a commercial fisherman. Finally, back on Niedecker's own cabin lot is the more comfortable ranch-style house, right on the river bank again and thus with a nice view of the Rock and Lake Koshkonong beyond, where she lived with her husband after her 1962 marriage. So she was always somewhat removed, even in a geographical sense, from the community of Fort Atkinson a couple of miles away.

Only rarely during her life did she venture out of her native Fort Atkinson region. The chief exceptions, it seems, were those years in Beloit and Madison and then, after her marriage in 1962, some winters spent in Milwaukee. But in "Fort," today a town of about 9,000, very few people could claim to know her well. Most never heard of her. To put it mildly, Lorine Niedecker did not cut a large figure in the world.

As already mentioned, her poetry is small in volume. The "Writings" section of *Contemporary Authors* lists six different book titles, which actually turn out to be five successive new editions of the slowly growing body of poems, plus one posthumous collection called *Blue Chicory*—all from a few small presses.[3] In all, her poetry fills about 200 pages. The first two books, both quite small (and, almost needless to say, almost entirely overlooked by the literary world) were published in 1946 and 1961, when the poet was, respectively, 43 and 58 years old. The next three books, larger collections of her work, were published during the last three years of her life, 1968-1970. The posthumous collection came out in 1976. As I have noted, few people in her home town knew her at all; fewer still knew of her poetry. But her poetic reputation, though not large, was international, and her acquaintance among poets, very select. Louis Zukofsky she called her mentor over the years, dating back to 1931. She also had some correspondence with William Carlos Williams, Basil Bunting, Jonathan Williams, and especially Cid Corman, her literary executor, a few of whom sought her out for a rare personal visit in Wisconsin. The striking thing is that, although to a very large degree isolated from and neglected by the literary world, she so devotedly kept at her task of writing poems that in form and style were among the more progressive—perhaps even the *avant garde*—of their day. Most significant of all, much of her poetry is simply excellent.

The title given to the most nearly complete collection of Niedecker's poems is *My Life By Water: Collected Poems 1936-68.* The title *My Life By Water* has a perfectly obvious, literal meaning that I have already discussed: Niedecker spent almost her whole life on Blackhawk Island. (For that matter, even those few periods away from her native place were also spent by water: a few miles downstream on the Rock River in Beloit, in the so-called City of the Four Lakes, Madison, and in the Lake Michigan port of Milwaukee. As Niedecker wrote in a letter to a friend, "I love . . . all water."[4]) But it is in perfect keeping with her style of writing that upon closer inspection, other and deeper meanings can be added to the obvious meaning of the terribly simple words of that title. Because as with Lorine Niedecker, the plain-looking and plain-living person, so her poetry, to repeat, is and has been easily overlooked; but careful study and attentiveness can reveal its true and estimable worth. So in this essay I want to explicate that title and explore its implications.

Clearly suggested by living by water is the importance of nature in Niedecker's poetry, which indeed is full of natural sights and sounds, plants and animals (especially birds), of lake and river, marsh and shore. Delving a little deeper, one notices how often and how easily—almost, it seems, automatically—the poet speaks of herself in the poems in natural and particularly in water imagery. And further exploration of that title, *My Life By Water,* will reveal, or will suggest at least, certain circumstances that exerted great influence upon this poet and certain important choices she made during her life. These circumstances and choices are reflected in key themes in the poetry, and they also bear directly upon the question of why and how this poet, with so little encouragement, and at very significant personal sacrifice, kept at her work. To clarify, I am not claiming that all the meanings that I

Fig. 1. Lorine Niedecker beside Rock River near her home. Photo taken by Gail H. Roub of Fort Atkinson in summer of 1967.

discern in the title *My Life By Water* are intended by the poet. But concentrating on that title and its implications will help us understand the poems and will also help us appreciate the high price paid for this particular life of poetry as well as the rare and precious benefits gained from it.

To preview this discussion with a bit of very colloquial figurative language, Niedecker was not "high and dry" during much of her life. Rather, the one practical everyday concern that seems most often mentioned in her poems and also in letters to her friends is the recurrent spring flooding on the Island. According to one concise autobiographical image,

My life is hung up
on the flood
  a wave-blurred
    portrait

Again, flooding was important enough to warrant quite a few lines in *Paean to Place,* the rather long poem which Niedecker referred to as her autobiography. (The *he* and *she* in these lines refer to her father and mother.)

> River rising—flood
> Now melt and leave home
> Return—broom wet
> naturally wet
>
> Under
> soak-heavy rug
> water bugs hatched—
> no snake in the house
> Where were they?—
> she
>
> who knew how to clean up
> after floods
> he who bailed boats, houses
> Water endows us
> with buckled floors

Repeated flooding was hard on buildings and people on Blackhawk Island. This unreliability of nature, this business of not being able to take your next step on "buckled floors" for granted, was just one way in which Niedecker's life was separated from the ordinary, and one form of loss that, I submit, she in her circumstances chose to incur, more or less willingly, but with self-awareness and sometimes doubt and sometimes with a real sense of loss. Why did she make this choice? Because of a deep, strong attachment to that place, is the beginning of the answer—and because of other values also implied in living by water. That is what I want to explore.

In part, then, this paper will be an exercise in how biographical knowledge can enrich our understanding of the poetry. But I do agree, incidentally, with the standard New Critical viewpoint that literary works must stand alone with regard to their *basic* meaning and worth. The excellence of Niedecker's poems is our primary reason for being interested in her life in the first place. For these reasons, I'll take a detailed look at some of the poems as I go along.

Niedecker valued her deep roots in her native place and also took an interest in the history of that region, an interest expounded in several early poems. The waterways of Wisconsin were of course very important to the Indians and traders and early settlers, and probably no historical figure is more closely associated with the Rock River than the famous Sauk chief Black Hawk. One of the last great Indian uprisings in the old Northwest Territory is known now as the Black Hawk War of 1832. The cause of the uprising was, predictably, property or territory, as set forth in Niedecker's poem on the subject.

> Black Hawk held: In reason
> land cannot be sold,
> only things to be carried away,
> and I am old.
>
> Young Lincoln's general moved,
> pawpaw in bloom,
> and to this day, Black Hawk,
> reason has small room.

It is typical of a Niedecker poem to demand a lot of the reader. In this case some knowledge of this chapter in regional history is required.[5]

In 1804 a Fox chief and an earlier Sauk chief had ceded their lands east of the Mississippi, in what is now Illinois and Wisconsin, to the United States. Black Hawk, then a rising war chief, always claimed that this treaty had been made with no tribal authority and that the two chiefs were in fact induced to sign it while drunk. In 1816 Black Hawk himself actually signed a document confirming the treaty of 1804, but afterward he claimed he was ignorant of the terms of the agreement. The Black Hawk of Niedecker's poem explains his philosophy of property in the first three lines; perhaps it could be called a philosophy of stewardship of the earth, as maintained by a minority of Christians in European and American history. In another Niedecker poem called

"Pioneers," a somewhat similar claim is made upon some other Indians' behalf:

> Winnebagoes knew nothing
> of government purchase of their land,
> agency men got chiefs drunk
> then let them stand.

Historians tell us that it was after many years of brooding over the loss of Sauk and Fox lands east of the Mississippi that Black Hawk in 1831 and again in 1832 led a band of warriors and their families back across the river in a determined but ultimately futile attempt to regain their ancestral lands. His increasingly pathetic struggle to rally support from other Indians and to keep evading the white men's armies took him as far east as "the widening of the Rock River known as Lake Koshkonong."[6] His band paused there but still escaped, for a while longer, the pursuing U.S. Army regulars led by General Henry Atkinson. Hence the name "Blackhawk Island." (This historical event is now annually commemorated in the town of Fort Atkinson with a Fort Festival and Black Hawk Pageant.)

In the first line of the poem, "Black Hawk held"—with its strong, delayed stress on the third word, further emphasized through alliteration—means, primarily, that Black Hawk reasoned or argued in this manner on the question of land ownership, but with a suggestion, too, of "held" in the sense of "took a stand" and refused to be pushed around any longer. Thus, it is not surprising that this particular word is not found in Niedecker's source for the rest of these first three lines, namely, Black Hawk's autobiography, which he dictated a few years after his capture. The key passage follows:

> My reason teaches me that *land cannot be sold.* The Great Spirit gave it to his children to live upon, and cultivate, as far as is necessary for their subsistence; and so long as they occupy and cultivate it, they have the right to the soil—but if they voluntarily leave it then any other people have a right to settle upon it. Nothing can be sold, but such things as can be carried away.[7]

The characteristic simplicity of Niedecker's diction does not lead us to suspect that her lines are a kind of borrowing. Of course the extreme conciseness and paring things down to their minimum essentials are also typically Niedecker. Next, Black Hawk himself does not make mention of his age at this point in his story, and we should look closely at that extremely, deceptively simple line, "and I am old." So what? one may ask. First of all, perhaps the beliefs and arguments of an older person, and an experienced and wise leader, should be given special attention, should indeed be listened to and heeded—or such is the practice, anyway, among many so-called primitive societies. Similarly, Black Hawk might also be asking straightforwardly for a bit of sympathy, since, in the opinion of some again, the elderly deserve it. Also, I think that Black Hawk means that he has grown too old and weary to keep on fleeing the white men and their army and too old to endure further deracination, and thus he intends to "hold," to take his stand, here and now.

Finally, there is a meaning to his words not intended by Black Hawk, most likely: he is part of and, as it turns out, one of the very last truly notable representatives in this territory of an old and dying way of life, a civilization that is steadily and irretrievably being pushed out by a new one.[8] Thus, the youth of Lincoln and the identity of Lincoln himself as a famous representative—and, note, a sympathetic figure—of the new civilization are important in the next line, in addition to the historic fact that young Abe was among the volunteer Illinois militiamen who joined with the U.S. Army regulars to pursue Black Hawk and crush the rebellion during the spring and summer of 1832. Furthermore, the springtime of the year is associated with the advance of white civilization, again in contrast to the age of Black Hawk.

Fig. 2. Dust jacket of *My Life by Water* showing fishermen's map of Lake Koshkonong. From original loaned by Gail H. Roub.

But the way springtime is identified in the poem, in the line "pawpaw in bloom," relates to the question of title to the land. Here is one example, the tree called pawpaw, among many that could be cited, of American Indian names for plants and animals being adopted by the newcomers, the white men. Whose land, indeed, is this? Well, never mind the reasonable answer, because "to this day . . . reason has"—as Black Hawk in 1832 had—"small room."

It's not hard to understand that a person who composed lines such as these would not leave, easily or for very long, her native place. Niedecker was also concerned with maintaining the roots of her family in their life by water. Her father's occupation—or that particular occupation, among the several that he followed, which the daughter preferred to recall and which gets mentioned in one context or another many times in the poetry—was that of commercial fisherman —"he seined for carp to be sold." Notable, too, is the dust jacket of *My Life By Water* which shows a fisherman's map of Lake Koshkonong (Fig. 2), a map, one former neighbor of Niedecker told me, that used to be posted on the wall of her father's tavern on Blackhawk Island. Just listen to the opening lines of "Paean to Place":

> Fish
>   fowl
>   flood
>   Water lily mud
> My life
>
> in the leaves and on water
> My mother and I
>   born
> in swale and swamp and sworn
> to water

Her attachment to river and lake, marsh and shore, and the plants and animals there is hard to overestimate and simply permeates the poetry. The two closest friends of the late poet that I had a chance to talk to in Fort Atkinson could be categorized as one person interested in art and poetry and another with whom Lorine took long walks on the Island in order to watch the birds. As with her parents, so the daughter, too—albeit in a different way—took much of her living from the water.

But what about Niedecker's life on land, which we've already previewed as to some degree out of the ordinary? What about, first of all, her place not in the natural but the local human community? A couple of her best poems directly address this subject. Here is my favorite:

> The clothesline post is set
> yet no totem-carvings distinguish the
>   Niedecker tribe
> from the rest; every seventh day they wash:
> worship sun; fear rain, their neighbors eyes;
> raise their hands from ground to sky,
> and hang or fall by the whiteness of their all.

As with many of the nature poems, the poet finds her material in the middle of her humble surroundings and its most ordinary details, and then, as distanced observer and critic (in addition to, it's made clear, a participant), works an artistic transformation upon it. In this poem the poet's identity and roots in the local community are acknowledged—the "post is *set*" and the Niedeckers are definitely there as one among the other tribes—and then a bit of weekly routine is solemnly mythologized, and simultaneously of course the whole business is rather gently, playfully undercut.

In place of real tribal identity there is conformity. There is, from the highly original perspective of this poetic observer, the appearance of watery ritual and elemental sacrament in the behavior and particularly the physical movements of the villagers. And note how the terse parallel phrases and their abrupt rhythm very effectively suggest this: "worship sun; fear rain." But these are not totem poles, and in reality there is only human interaction, of the most petty and trivial kind. In a very characteristic play upon words, a little pivotal pun, the literal hanging *up* of the laundry becomes, when juxtaposed to "fall," the figurative maintaining of face among the neighbors, being able to hold up one's head, thereby very quickly alluding to "ring around the collar" and all such TV commercial idiocy aimed at the contemporary housewife. The ironic undercutting is also conveyed in the same verb "hang" when it is applied to the victorious launderers—or, more likely, laundresses—almost as if to say, "Give them enough clothesline and white laundry and they will successfully hang themselves." This compactness is indeed typical of Niedecker at her best. Note, too, how the phrase "their all" at the very end playfully alludes, I think, to the white underwear included among all the other laundry and thus, again, to the villagers' inane washday rivalry and fear of "exposure." Lorine Niedecker was *in* this same community, as we know, almost all her life, but she was definitely not entirely *of* it.

In another poem jobs and the workaday world form the context for exploring the poet's place in the community, and again her distance from it. Though containing an element of admiration, the portrait of the community has grown more harsh, just as the poet's detachment from it now seems greater. Incidentally, the poem clearly alludes to Niedecker's job at Hoard's during 1944-50, which is in accord with the reference to "the bomb" in the first line.

> In the great snowfall before the bomb
> colored yule tree lights
> windows, the only glow for contemplation
> along this road
>
> I worked the print shop
> right down among em
> the folk from whom all poetry flows
> and dreadfully much else.
>
> I was Blondie
> I carried my bundles of hog feeder price lists
> down by Larry the Lug,
> I'd never get anywhere
> because I'd never had suction.
> pull, you know, favor, drag,
> well-oiled protection.
>
> I heard their rehashed radio barbs—
> more barbarous among hirelings
> as higher-ups grow more corrupt.
> But what vitality! The women hold jobs—
> clean house, cook, raise children, bowl
> and go to church.
>
> What would they say if they knew
> I sit for two months on six lines
> of poetry?

The "folk" of the community, as they're called, are associated with the mundane and gauche commercialism and, in turn, with the militarism of their society, which are in such contrast to the meaning of Christmas, the holiday which these people publicly try to celebrate.

The first stanza merely alludes, it seems, to the glare or "glow" of an atomic bomb explosion because the reality of it is too awful to *contemplate.* At least there is a gesture toward peace in the observance of Christmas. Christianity—specifically the old hymn called the Doxology—is also alluded to in the second stanza: blessings, in the form of poetry, flow from the folk—"and dreadfuly much else." Note how the rhythm and stress and colloquial diction capture so simply, but so precisely, both the speech of the folk and the poet's feelings in regard to working "right down among em."

The rhythm and diction of the third section get rougher to convey the poet's feeling of being defiled, it almost seems, as well as embittered by contact with that society, although some of the bitterness seems to reflect back upon the poet herself. Then, in contrast to the ordinary women's vitality, she sits "for two months on six lines/of poetry." So the poet does acknowledge how much of ordinary life she is missing out on for the sake of these lines of poetry, and she doesn't seem altogether confident or pleased about her choice. And the poet knows—or definitely thinks she knows—the unfavorable kind of thing "they" would say if "they" knew, and so, it's quite clear, she ends the poem more resolute in her distance and even isolation from her community.

In a third poem dealing with the poet's relationshp to her community, some of the earlier humor returns, for a while, but the judgement of that community and its way of life remains harsh.

> I rose from marsh mud,
> algae, equisetum, willows,
> sweet green, noisy
> birds and frogs
>
> to see her wed in the rich
> rich silence of the church,
> the little white slave-girl
> in her diamond fronds.
>
> In aisle and arch
> the satin secret collects
> United for life to serve
> silver. Possessed.

The poet starts out on a mock self-deprecating note, picturing herself almost as some kind of muddy monster rising from the deep. But the poem soon turns, in effect, into a defense of her life by water, by attacking the life of the town at one of its key points, the honorable institution of marriage. The poet is in touch, literally, with some of the most basic elements of her natural surroundings, such as the simple plants, algae and equisetum, whereas the young bride is surrounded with richness, with diamonds and satin. Vitality in the form of water, earth, greenness and noise is located this time in the poet's realm, contrasting to the silence and whiteness around the bride. Note how the simple alliterative patterns—the *d* and thick *ch* sounds of the second stanza, the *t* and hissing *s* sounds of the third stanza—reinforce a sinister and stealthy atmosphere surrounding the wedding. The suggestion of white slavery with reference to the bride actually seems, to me, more harsh and unsubtle than is characteristic of Niedecker. And the "satin secret" is the unpleasant truth about marriage commonly known (especially by the women, perhaps) but not confessed. That is, the innocent bride is not forewarned. She will *serve from* silver, maybe. But more important, she will be a lifelong *servant to* silver, she will be dominated by domestic routine and social convention and be possessed by her possessions—with maybe even a hint of madness in the forecast for her future. "Possessed."

This poem and its discussion of marriage brings us again to the subject of Niedecker's personal life—which turns out to be quite a sensitive area indeed. First let us go back to Niedecker's parents and the model of domestic life that they provided. It's her parents' lives in the out-of-doors, you'll recall, that Niedecker liked to remember and celebrate in the poems. Their life indoors was simply not very happy, not at least during those many years when the mother was an invalid, a pitiable figure, deaf and finally blind. Several poems express the sometimes nagging burden felt by the only child in caring for her mother. A couple of poems allude to the drunkenness and philandering that are known to be part of her father's reaction to the situation. In an early poem the mother, speaking of course through the poet, gives a kind of mournful summation of her own version of a life by water, and an important final line helps to define the daughter's status in this family.

> Well, spring overflows the land,
> floods floor, pump, wash machine
> of the woman moored to this low shore by deafness.
>
> Good-bye to lilacs by the door
> and all I planted for the eye.
> If I could hear—too much talk in the world,
> too much wind washing, washing
> good black dirt away.
>
> Her hair is high.
> Big blind ears.
>
> I've wasted my whole life in water.
> My man's got nothing but leaky boats.
> My daughter, writer, sits and floats.

Note that terse but unmistakable note of scorn and accusation in the last line: in the mother's opinion, the daughter doesn't really *do* much, she is not involved enough, her calm is interpreted as cool, distant detachment. But more than this is conveyed in the brief watery metaphor for the poet's way of life—"floats." In reality, the quiet floating is a kind of victory of survival for the daughter and in sharp contrast to the mother, who is "moored to this low shore by deafness." The mother was both right and wrong about her daughter: in order to write so powerfully and yet so subtly about this relationship, she had to feel, intensely, along with the mother, as well as distance herself, deliberately, to compose delicate lines such as these.

And what of Niedecker's own experience with marriage? Her first marriage to Frank Hartwig, described as a "road contractor" in the local weekly, the *Jefferson County Union,* took place in 1928 when Lorine was twenty-five years old.[9] After just four years they agreed to separate. According to the records in the Jefferson County courthouse, Niedecker eventually filed for divorce in 1942. Let us turn at this point to the poem called "Wild Man."

You are the man
You are my other country
and I find it hard going

You are the prickly pear
You are the sudden violent storm
the torrent

to raise the river
to float
the wounded doe

The usual kind of subtle artistry seems lacking in this poem. Still, form follows content in a straightforward, unrestrained rush of feeling. To repeat, her life by water —or in the terms of the last section, *in* water—was not always nice. Some people seem to think that Niedecker's late marriage (from 1962 till her death in 1970) to Al Millen was the personal basis for this and a few other grim poems on marriage published posthumously in the volume called *Blue Chicory.* I strongly suspect that a basis might be found as well in the first marriage, not to mention the backdrop of the senior Niedeckers' marriage. In any case, following her mother's death in 1951 and her father's death in 1954 came the long period of near isolation in that gaunt, green-painted two-room cabin on Blackhawk Island.

Property, community life, marriage and family—an awful lot of the ordinary sources of satisfaction were, evidently, not very available to her. She did have her poetry.

I wish, now, to look at another deceptively simple poem, which is also the title poem of Niedecker's second collection.

My friend tree
I sawed you down
but I must attend
an older friend
the sun

I recall my reaction upon first reading this poem. It seemed a rather clear statement, incidental yet arresting, about the necessity of making choices and of suffering losses. Simple devices of rhyme, diction, and rhythm give that impression some force. But so concisely, in just sixteen words. Typically Niedecker. After studying the other poetry more and especially after learning more about her life, my impression after rereading the poem much later I would have to describe as shock.

My friend tree
I sawed you down
but I must attend
an older friend
the sun

How much indeed did this woman have to give up—or anyway decide that she had to give up—in order to live her life by water and to practice her craft and art, so carefully and so devotedly, over those many decades? But she simply had to get down to the real *essentials* of her life, and note how the image of the sun and its associations with vision and illumination and the source of all vitality can suggest poetry, of course, among many other meanings. Further, when a bit of literary success and a bit of material comfort did come to her, they evidently did not always seem commensurate with the personal prices that she had paid.

> Now in one year
> a book published
> and plumbing—
> took a lifetime
> to weep
> a deep
> trickle

Reflecting upon her life and work, one is drawn powerfully to the conclusion that here was a life of great integrity. The spare and lean, hard yet delicate quality of her style of life that formed a simple, polished case for character of great depth is matched by the identical quality of her polished verses that release profound meaning and impact to the attentive reader.

Almost all commentators on Lorine Niedecker have drawn a comparison with Emily Dickinson. Certainly there are ample grounds for such comparisons, including the shy sensitivity of the women's personalities, their suspicion of, and relative seclusion from, their contemporary societies, some personal and family misfortunes, and, of course, the starting point of such comparisons—their concise, delicate, complex though seemingly simple, and often powerful poetry. In both cases, I think, there is a temptation to create a kind of legend of a victim-heroine poetess driven to—or forced rather reluctantly into—a higher dedication to poetry and personal release through art.[10] I submit, though, that there is a strong likelihood that both of these women deliberately and knowingly chose and accepted their ways of life as the very conditions which made their poetry possible. Look at this excerpt from Niedecker's long poem called "Wintergreen Ridge":

> Nobody, nothing
> ever gave me
> greater thing
>
> than time
> unless light
> and silence
>
> which if intense
> makes sound

Here we have a kind of personal commentary, I believe, on the so-called quiet life. It's not that the poet must be satisfied with just the simplest gifts in life—time, light, and silence. Rather, seclusion and quietude and alert attentiveness, raised to a high enough "intensity," become the very conditions for a precious, magical transformation into "sound." And certainly there is an implied identification of this sound with the poet's own voice speaking, her very special poetry. According to the review of her work by the critic Michael Heller, "what Miss Niedecker has achieved, and this is what makes her work distinguished, is not to become the poet-victim of her condition but its agency, singing the song of her world and herself *through* herself."[11]

Surely, then, Lorine Niedecker did finally, confidently, realize the great benefits that she had reaped from her life by water. And surely we are now all her beneficiaries.

Notes

[1] *Contemporary Authors, Permanent Series: A Bio-bibliographical Guide to Current Authors and Their Works,* Vol. 2 (Detroit: Gale Research Co., 1978), p. 389.

[2] For most of the biographical data in this paragraph I am relying on Jane Knox, "Biographical Notes: Lorine," *Origin,* 4th Series, no. 16 (July, 1981), pp. 3-23. Mrs. Knox is the wife of William D. Knox, President of W. D. Hoard and Sons Co., Niedecker's former employer.

Also in regard to hometown soures of information, this seems a good time to acknowledge my debt to Mr. Gail Roub of Fort Atkinson, former neighbor and close friend of the late poet, who generously gave me a couple days of his time in August 1980—very memorable days for me. Mr. Roub shared with me many recollections of and much information about Niedecker along with some manuscripts, letters and other material of hers, showed me Niedecker's former residences and the environs of Blackhawk Island, and introduced me to Mr. Al Millen, husband of LN, and also some of her former neighbors on the Island.

[3] The following comprise the published collections of Niedecker's poetry:

New Goose (Prairie City, Ill.: Decker Press, 1946);
My Friend Tree (Edinburgh, Scotland: Wild Hawthorn Press, 1962);
North Central (London: Fulcrum Press, 1968);

T & G: The Collected Poems (1936-1968) (Penland, North Carolina: Jargon Society, 1968);

My Life By Water: Collected Poems 1936-1968 (London: Fulcrum Press, 1970);

Blue Chicory (New Rochelle, N.Y.: Elizabeth Press, 1976).

All quotations from her work in this essay are based on the text of *My Life By Water,* with the exceptions of a poem quoted from *Blue Chicory* and an excerpt quoted from the poem "Pioneers" in *New Goose.*

[4] Quoted in Knox, p. 7.

[5] A good, brief account of the Black Hawk War that I've relied on here is Odie B. Faulk, "Black Hawk," *The McGraw-Hill Encyclopedia of World Biography,* 1973.

[6] Alice E. Smith, *From Exploration to Statehood,* The History of Wisconsin, Vol. 1 (Madison: State Historical Society of Wisconsin, 1973), p. 137.

[7] *Black Hawk: An Autobiography,* Donald Jackson, ed. (Urbana: University of Illinois Press, 1955), p. 114.

[8] It is interesting in this connection to note one authority's estimation of Black Hawk's autobiography as "a unique document, for it narrated from an Indian point of view the tale of frustration, bewilderment, and desperation of a dispossessed people, striving to retain the only way of life they knew against the oncoming rush of a different civilization." Smith, *From Exploration to Statehood,* p. 140.

[9] *Jefferson County Union,* 7 December 1928, p. 11.

[10] For a discussion of this tendency in the criticism and biography of Dickinson, see chapter 1, "Legend and Life," of Paul J. Ferlazzo, *Emily Dickinson* (Boston: Twayne Publishers, 1976).

[11] Michael Heller, "I've Seen It There," *Nation,* April 13, 1970, p. 444. This review is reprinted in *truck,* no. 16 (Summer 1975), edited by David Wilk. This special issue of the little magazine is devoted in its entirety to LN: a selection of her poems and letters; reviews, reminiscences, and appreciations; and thirteen poems dedicated to LN by fellow poets.

THE VILLAGE REVISITED: THE SPIRIT OF PLAY IN AMERICAN FICTION

MARJORIE P. PIECHOWSKI
Marquette University

A number of fictional works appearing early in the twentieth century seriously scrutinized life in small-town America. In general, the books were written by natives of these towns who examined the mores and inhabitants of the villages with the double vision of the provincial who has escaped to a more sophisticated urban existence. From Hamlin Garland's *Main-Travelled Roads* to Sinclair Lewis's *Main Street,* these books depicted life in the provinces as barren, ugly and boring, a situation in which the only real future for a sensitive, creative individual lay in escape of some sort. Hence the phrase "revolt from the village," often used to describe these writings, referred to an attitude as well as a physical journey. Usually the portrayal of village life in these books suggested that small American towns were built from a master plan of calculated architectural mediocrity and populated with dour, hardworking inarticulates. The heroes of these works escaped the village principally because it offered no scope for creative interests. Usually the initial discontent began with the hero's awareness that recreation, spontaneity, fun, a spirit of play, were of little importance in small-town America compared with the serious business of making a living.

Many causes exist for the growth of such an attitude, particularly in rural America. The Puritan tradition encouraged hard work while at the same time repressing festivity. Furthermore, the simple necessity for physical labor in expanding the American nation certainly contributed to this attitude. But recognition of the equal necessity of play as a human activity has seldom been absent from any civilization, primitive or sophisticated. Plato in his *Laws* points out the vital role of play, and philosophers of every ideology have included play as a necessary element of humanity ever since. In an influential modern study of this subject, Johan Huizinga observes, ". . . genuine, pure play is one of the main bases of civilization."[1]

The term one uses—play, leisure or celebration— is not as important as the attitude itself. In *Leisure the Basis of Culture* Joseph Pieper defines this attitude: "Leisure, it must be clearly understood, is a mental and spiritual attitude . . . it is not the inevitable result of spare time, a holiday, a weekend or a vacation."[2] Huizinga further defines the importance of the play element for humans:

> As a regularly recurring relaxation, however, it becomes the accompaniment, the complement, in fact an integral part of life in general. It adorns life, amplifies it and is to that extent a necessity both for the individual—as a life function—and for society by reason of the meaning it contains, its significance, its expressive value, its spiritual and social associations, in short, as a culture function. The expression of it satisfies all kinds of communal ideals.[3]

Closely related to an individual's play spirit is the relationship with the community. Every human being has moments of private play when celebrating a personal relationship with the world. Appreciation of nature, physical exercise, musical performance, in fact, most esthetic creations, necessarily comprise individual acts of play. Richard Rupp describes them as moments of "mystery and wonder, a silent celebration of one's own unique identity."[4] But it is in shared leisure that most human bonds are defined, "revealing significant shared social and personal values, uniting separate individuals into a momentary but transcendent identity.''[5] It is to commemorate the important moments of human existence that most social events have evolved. Such communal celebration ''organizes patterns of private and public behavior in conformity to an image of personal and corporate identity.''[6]

The presence of a spirit of play and festivity ''links us to a world of memories, gestures, values, and hopes that we share with a much larger community.''[7] The absence of this spirit ''as an essential ingredient in human life,'' Harvey Cox observes, ''severs man's roots in the past and clips back his reach toward the future. It dulls his psychic and spiritual sensibilities.''[8] Cox could well be describing the Village Virus which afflicted Lewis's Main Street or explaining George Willard's reasons for leaving Winesburg, Ohio, or Ethan Frome's unexpressed despair over his bleak future. Significantly, the lack of play and festivity appears as an underlying motif in a number of fictional works which describe the revolt from the village. A comparative study of the significance of play in village life might provide fresh illumination on motives for this revolt and also illustrate differences in scope and stance of the five authors on this theme.

The choices for this study include *Main-Travelled Roads* (1891, revised 1922), by Hamlin Garland; *Ethan Frome* (1911) by Edith Wharton; *My Antonia (1918) by Willa Cather; Winesburg, Ohio* (1919) by Sherwood Anderson; and *Main Street* (1920) by Sinclair Lewis. Spanning thirty years and five states, these books provide ample opportunity to examine Richard Rupp's contention, ''Celebration is an ingrained quality in American literature.''[9]

Evidence of the spirit of play or festivity in these books assumes many forms, both public and private. These include meals, weddings, courtship rituals, parties, holiday observations, funerals, games and contests, jokes, initiation rites, clubs, sports, hunting, travel, theater, concerts, lectures, movies, even religious services—whatever activities pleasurably fill leisure hours. It is important to recognize that play is not always frivolous or superficial. It can be solemn, even profound: for example, George Willard's moment of illumination, Ethan and Mattie's single shared dinner, and Jim Burden's reunion with Antonia. Much of the joy of the moment, in fact, is its release or culmination of earlier strain or insecurity: ''To dare, to take risks, to bear uncertainty, to endure tension—these are the essence of the play spirit,'' Huizinga notes.[10] As a consequence, however, ''The play-mood is one of rapture and enthusiasm, and is sacred or festive in accordance with the occasion. A feeling of exaltation and tension accompanies the action, mirth and relaxation follow.''[11]

Of the eleven stories collected in *Main-Travelled Roads,* seven deal specifically with leisure and play—or their absence. The reader is warned by Garland's preface, however, that ''the main-travelled road of life'' is ''long and wearyful.''[12] Two stories, ''Up the Coulee'' and Mrs. Ripley's Trip,'' both from 1891, illustrate Garland's handling of this theme. In common with other revolt from the village stories, ''Up the Coulee'' shows a young ex-farmer, Howard, who ''had been wonderfully successful'' (p. 59) as a New York actor. But he ''retained through it all a certain freshness of enjoyment that made him one of the best companions in the profession'' (p. 60). His sentimental response as he drives through his former village is ''sweet and stirring somehow, though it had little of aesthetic charm at the time'' of his youth (p. 58).

Similar ironic juxtaposition is developed through the story as Garland describes the elegantly dressed Howard, ''a man associating with poets, artists, sought after by brilliant women'' (p. 72). The more he contemplates the grimness of his brother's farm, ''with all its sordidness, dullness, triviality, and its endless drudgeries, the lower his heart sank. All the joy of the homecoming was gone'' (p. 61).

At the welcoming party given by neighbors of Grant (the brother), Garland illustrates profusely the role of festivity and play in this country setting. Detailed descriptions of the party's activity and guests reveal the rarity of celebration in this village. Unsure how to act, the people "were all very ill at ease. Most of them were in compromise dress—something between working 'rig' and Sunday dress" (p. 83). Instinctively segregated by sex, the men discussed crops and farms, while the women

> forced Howard more and more into talking of life in the city. As he told of the theater and the concerts, a sudden change fell upon them; they grew sober, and he felt deep down in the hearts of these people a melancholy which was expressed only elusively with little tones or sighs. Their gaiety was fitful (p. 85).

A few more examples document the almost atrophied play spirit in these people. Inspired by Howard's description of city revelry, a woman guest proposes dancing: "By an incredible exertion she got a set on the floor, and William got the fiddle in tune. . . . After two or three sets had been danced, the company took seats and could not be stirred again" (p. 87). To Howard's chagrin, the party evokes a bitter confession from his sister-in-law: "'I hate farm life. . . . It's nothing but fret, fret and work the whole time, never going any place, never seeing anybody but a lot of neighbors just as big fools as you are. I'm sick of it all'" (p. 89). To Howard, the dreary lack of ornament in the house contributes further to this attitude. He was disturbed that there "were no books, no music, and only a few newspapers in sight —a bare, bleak, cold, drab-colored shelter from the rain, not a home" (p. 92). Alongside such vignettes Garland continually contrasts Howard, who appears hedonistic and over-indulgent to the dour villagers.

Both Garland's comments and Howard's reflections restate almost to excess the impossibility of change for this community. In a vain attempt to placate his farmer brother, Howard explains, "Circumstances made me and crushed you. That's all there is about that. Luck made me and crushed you" (p. 96). The last words are given to Grant, who expresses a resignation about his provincial existence which would probably be shared by his entire community: "'I'm a dead failure. I've come to the conclusion that life's a failure for ninety-nine per cent of us. You can't help me now. It's too late'" (p. 97). Though Garland provides ample description and justification for the lack of festivity in these rural lives, he overstates his case in this story. Occasionally sentimental, sometimes ironic, always profuse, Garland points out repeatedly the contrast between Howard's abundance of play (even making his living at play-acting) and its dearth in the lives of the community he left behind.

The pattern is reversed in "Mrs. Ripley's Trip," with a country woman traveling to an Eastern city for a nostalgic visit. Here Garland portrays a lighter, more credible situation, though a sixty-year old woman who "ain't been away t'stay overnight for thirteen years" (p. 183) has clearly had little leisure in her life. The home, as small and barren as that described in "Up the Coulee," nevertheless resounds with Uncle Ripley's violin and his affectionate though gruff jesting. Further manifestations of a play spirit emerge in Mrs. Ripley's dry humor with a gossiping neighbor and her dramatic revelation of a mitten full of carefully hoarded coins. Furthermore, Mr. Ripley has a "kindly visage. Life had laid hard lines on his brown skin, but it had not entirely soured a naturally kind and simple nature" (p. 188). Thus he can understand that "the old woman needed a play spell. . . . 'I calc'late I c'n get enough out o' them shoats to send her" (p. 187).

In their mutual surprises the Ripleys acknowledge the importance and rarity of this trip. But it satisfies Mrs. Ripley's need for play: "'I've had my spree, an' now I've got to get back to work. They ain't no rest for such as we are'" (p. 193). Her final analysis of the trip reveals a keen insight into the nature of the play spirit: "'Them folks in the big houses have Thanksgivin' dinners every day uv their lives, and men an' women in splendid clo's to wait on 'em, so't Thanksgivin' don't mean anything to 'em'" (p. 193). As Harvey Cox observes, in a more eloquent restatement of Mrs. Ripley's words, ". . . the reality of festivity depends on an alternation with the everyday schedule of work, convention, and moderation."[13]

The balance of Garland's stories describe further uses and misuses of leisure, on farms and in villages. None of the remaining works repeats the extreme of "Up the Coulee," although "A Day's Pleasure" and "A Branch Road" show young married women almost dead from overwork and no recreation. In both stories Garland illustrates the restorative power of play. Agnes in "A Branch Road" leaves the rigorous farm life to marry her former lover, enticed by his promise to "have a piano and books, and go to the theater and concerts" (p. 50). Less dramatically, Delia Markham spends an afternoon in town, entertained by tea, piano music and refined conversation with a young lawyer's wife, who ". . . through it all . . . conveyed the impression that she, too, was having a good time" (p. 181). Celebration and festivity occur in Garland's stories but more often in the breech than in the observance. It is accurate to conclude that a healthy spirit of play is not a consistent trait in his characters. In some it has never been developed, while in others it is nearly atrophied.

In the case of *Ethan Frome,* Edith Wharton traces a newly developed spirit of play into its eventual distortion and loss. Starkfield, Ethan's New England village, offers little opportunity for recreation except a coasting-ground and infrequent church dances. When Mattie Silver enters Ethan's life, recreation assumes a new importance for Frome as he begins escorting her home "on the rare evenings when some chance of amusement drew her to the village."[14] During these walks with Mattie he learns that "one other spirit had trembled with the same touch of wonder" (p. 34). Their growing love occurs almost totally during a few buggy rides and the walks, where they discover a mutual love of nature. Ethan ponders the miracle of these new feelings of joy:

> The fact that admiration for his learning mingled with Mattie's wonder at what he taught was not the least part of his pleasure. And there were other sensations, less definable but more exquisite, which drew them together with a shock of silent joy: the cold red of sunset behind winter hills, the flight of cloud-flocks over slopes of golden stubble, or the intensely blue shadows of hemlocks on sunlight snow (p. 34).

Other than their shared attitude of joy, Ethan and Mattie have few chances to indulge in a spirit of play until the end. Their brief courtship has only one festive event, the dinner Mattie prepares on Zeena Frome's overnight absence. This shared meal produces in Ethan a "sense of being in another world, where all was warmth and harmony and time could bring no change" (p. 88). Their celebration, more implied in ritualistic gestures than spoken, is marred by the accidental breaking of Zeena's pickle dish. This red dish serves as an ironic reminder of Zeena's own distorted spirit of play. Considering the dish too good to use, she keeps it hidden away until there will be a suitable festive occasion. Such an event, of course, has never occurred in her life.

Zeena's discovery of the broken dish and her determination to send Mattie away intensify Ethan's brief taste of happiness with Mattie: "The inexorable facts closed in on him like prison-warders handcuffing a convict. There was no way out—none. He was a prisoner for life, and now his one ray of light was to be extinguished" (p. 134). The final irony of the book is that Ethan's most intense experience of play leads to his own destruction. Driving Mattie to the station, he laughs and holds her hand, "passing the site of a summer picnic, one of the few that they had taken part in together: a 'church picnic' which, on a long afternoon of the preceeding summer had filled the retired place with merry making" (p. 153). For both, this last ride is a reminder of their earlier shared pleasures. ". . . That was all; but all their intercourse had been made up of just such inarticulate flashes, when they seemed to come suddenly upon happiness as if they had surprised a butterfly in the winter weeds. . . ." (p. 154).

The sound of passing sleigh bells and the sight of an abandoned sled inspire Ethan's final, but ultimately tragic, act of real play. Flying down the hill with Mattie arouses in him a "strange exaltation of his mood" (p. 163). For the first and last time in Ethan's life he experiences true play as Hugo Rahner defines it:

> To play is to yield oneself to a kind of magic, to enact to oneself the absolute other, to pre-empt the future, to give the life to the inconvenient world of fact. In play earthly realities become, of a sudden, things of the transient moment, presently left behind, then disposed of and buried in the past; the mind is prepared to accept the unimagined and incredible, to enter a world where different laws apply, to be relieved of all the weights that bear it down, to be free, kingly, unfettered and divine.[15]

The intensity of the sled ride "made the other vision more abhorrent, the other life more intolerable to return to" (p. 166). Thus Ethan's decision to use the instrument of happiness as a death weapon is initially shocking but becomes natural and appropriate to his purpose. What the sled ride kills, ironically, is love, happiness and the nascent spirit of splay in Ethan and Mattie. Ethan's attempt to misuse a form of play produces only physical crippling and permanent stifling of the play spirit, rather than the release Ethan sought in their attempted deaths. The end result is a whining, crippled Mattie, an embittered Ethan, and an almost smug Zeena comtemplating the results of Ethan's aborted death-wish.

Thus the characters in Wharton's bleak narrative effectively contrast natural and unnatural attitudes toward play. Starkfield, an aptly named village, offers only slight chances for festivity, whether public or private. Zeena enjoys only housework and her hypochondria, rejecting any social life not directly related to these concerns. Until Ethan meets Mattie, his own life is similarly devoid of pleasure. But Mattie's natural zest for life and her aesthetic interests ("She could trim a hat, make molasses candy, recite 'Curfew shall not ring tonight,' and play 'The Lost Chord' and a pot-pourri from 'Carmen'") (p. 59), meager though they are, inspire Ethan to revive his own lost spirit of play. His attempts, too feeble and too late to have any lasting effect on his life, suggest that a sense of play must grow naturally and continually throughout life. It is as impossible to impose as to stifle, without serious consequences.

Willa Cather's *My Antonia* offers among its many characters several otherwise creative indivduals who find difficulty in expressing their spirit of play. In various ways Mr. Shimerda, Jim Burden and Lena Lingard find Black Hawk too confining for their aesthetic fulfillment. Most pathetic is Shimerda, Antonia's father. Antonia attempts to explain her father's discontent and sadness:

> My papa sad for the old country. He not look good. He never make music any more. At home he play violin all the time; for weddings and for to dance. Here never. When I beg him for play, he shake his head no. Some days he take his violin out of his box and make with his fingers on the strings, like this, but never he make the music. He don't like this kawntree.[16]

It is not only *this* country but country life itself which is distasteful to Shimerda. A city-bred tailor, he is totally unfit for Nebraska homesteading. White, well-shaped hands and a silk scarf, "carefully crossed and held together by a red coral pin" (p. 27), along with his violin, are poignant reminders of the sophisticated life he left behind in Bohemia. His suicide is no surprise. Overwhelmed by the reality and grimness of a Nebraska winter, he characteristically plans a ceremonial, almost festive, death. Shaving and dressing carefully, ". . . he was always sort of fixy, and fixy he was to the last" (p. 110).

Lena Lingard, equally fixy and unsuited for homesteading, is driven rather than destroyed by these qualities. The difference lies in Lena's ability to turn her frustrated spirit of play into aesthetic fulfillment and financial security. As a successful dressmaker, first in Lincoln and later in San Francisco, Lena delights in having the money to dress well, attend plays, and provide luxuries for her family. It is tempting to accept Jim Burden's uncritical response to Lena's apparent spirit of play: "Lena had left something warm and friendly in the lamplight. How I loved to hear her laugh again! It was so soft and unexcited and appreciative—gave a favorable interpretation to everything" (p. 306).

What Jim does not perceive is Lena makes no distinction between her work and her play. She rather calculatedly uses her stylish appearance and attendance at social events to advertise her professional dressmaking skills. Although Jim believes that Lena's passionate interest in good clothes and good times arises from childhood deprivation, he is unaware that her resolution never to marry arises from the same source: "She remembered home as a place where there were always too many children, a cross man, and work piling up around a sick woman" (p. 330). Thus, a strain of hardness and self-interest permeates much of Lena Lingard's approach toward life, revealing an attitude inimical to a true spirit of play and festivity.

For Jim Burden the spirit of play assumes many forms, which are periodically redefined during phases of his maturation. As a boy living in the country, he finds immense joy in the prairie itself. Lyrical passages describe his response to the change of seasons: "There was only—spring itself; the throb of it, the light restlessness, the vital essence of it everywhere; in the sky, in the swift clouds, in the pale sunshine, and in the warm, high wind—rising suddenly, sinking suddenly, impulsive and playful like a big puppy that pawed you and then lay down to be petted" (p. 137).

During his adolescence in Black Hawk he first is satisfied, then stifled, by the local recreational opportunities. Finally, like George Willard in *Winesburg, Ohio* and Carol Kennicott in *Main Street,* he begins "to prowl about, hunting for diversion" (p. 247). These diversions, in a prairie town abundant in social activity, are carefully described by Cather. Maxwell Geismar notes that

> in the daily patterns of pioneer activity—the colorful weddings, dances, and costume parties, the all-night gatherings to the tune of a *dragharmonika* or a fiddle, the games, choral societies, and family readings that accompanied the axe, the plow and the Bible,—Miss Cather very early suggested the resources of that frontier life which was to seem so harsh and sterile to a subsequent generation of western rebels and expatriates.[17]

Listing the saloon, drug store, cigar factory and depot as his available distractions, Jim Burden finds these "resources" insufficient for satisfying his newly emerging needs. Seeking a wider source of satisfaction, he leaves Black Hawk for Lincoln. In Black Hawk Jim feels repressed and bored:

> This guarded mode of existence was like living under a tyranny. People's speech, their voices, their very glances, became furtive and repressed. Every individual taste, every natural appetite, was bridled by caution. The people asleep in these houses, I thought, tried to live like the mice in their own kitchens; to make no noise, to leave no trace, to slip over the surface of things in the dark. The growing piles of ashes and cinders in the back yards were the only evidence that the wasteful consuming process of life went on at all (p. 250).

Like Lena, Jim thrives at Lincoln. Tennis, reading, and long walks with a Latin teacher add to the richness of his life: "I shall always look back on that time of mental awakening as one of the happiest in my life. Gaston Cleric introduced me to the world of ideas; when one first enters that world everything else fades for a time, and all that went before is as if it had not been" (pp. 291-2). Jim Burden's scope of play is further widened when James O'Neill's touring *Count of Monte Cristo* "introduced the most brilliant, worldly, the most enchantingly gay scene I had ever looked upon" (p. 309). After this experience Jim presumably continues to explore these same pleasures, first at Harvard and then as a New York attorney. Cather omits description of twenty years of Jim Burden's life, ending the book with a reunion between him and Antonia.

Finally, there is Antonia: in her exuberance, enjoyment, her healthy acceptance of the light and shadow of life, Antonia has perhaps the finest realization of a true spirit of play and festivity of any in this study. Describing the harmonious relationship between Antonia and her employer, Cather writes, "Deep down in each of them was a kind of hearty joviality, a relish of life, not over-delicate, but very invigorating" (p. 205).

Antonia endures a life of almost melodramatic hard work and emotional pain, aging her almost beyond Jim's recognition. Misinterpreting Antonia's physical deterioration as a sign of similar emotional weariness, Jim muses, "If, instead of going to the end of the railroad, old Mr. Shimerda had stayed in New York and picked up a living with his fiddle, how different Antonia's life might have been!" (p. 254). But Jim fails to grasp Antonia's innate satisfaction and delight in her life. Not only has Antonia successfully maintained her healthy acceptance of the fullness of life, but she has reproduced in her dozen children "a veritable explosion of life out of the dark cave into the sunlight" (p. 382). Meeting the exuberant family, Jim is overwhelmed: "It made me dizzy for a moment" (p. 382). Antonia's instinctive awareness of a play spirit has caused her to marry "a humorous philosopher who had hitched up one shoulder under the burdens of life, and gone on his way having a good time when he could" (p. 402). A wonderful complement to Antonia, Anton Cuzak "seemed to think it a joke that all these children should belong to him" (p. 404).

Jim Burden's eventual recognition of Antonia and Anton Cuzak's capacity for enjoying life occurs in separate observations: "I knew so many women who have kept all the things that she had lost, but whose inner glow has faded. Whatever else was gone, Antonia had not lost the fire of life" (p. 379). Jim's final comment on the Cuzaks aptly illustrates his recognition of the real play spirit engendered and represented by Anton: "There were enough Cuzaks to play with for a long while yet. Even after the boys grew up, there would always be Cuzak himself! I meant to tramp along a few miles of lighted streets with Cuzak" (pp. 417-418). Thus, in Antonia and Anton Cuzak one sees a mature and developed spirit of play which has also been communicated to their children. Even the worldly, sophisticated Jim Burden recognizes that he can benefit from a man like Cuzak who has so fully integrated his spirit of play into his entire life.

The miles of lighted streets which Jim Burden hopes to walk with Anton Cuzak represent a similar enticement for George Willard to leave Winesburg, Ohio, as a youth. With George's escape, however, Sherwood Anderson leaves little opportunity for play and celebration by the town's inarticulate "grotesques," for whom George was often the only social contact. Each of these characters is presented in a social relationship with George Willard in separate short stories. Generally these characters have a distorted or unfulfilled sense of play, finding the community unable or unwilling to meet these needs. Though *Winesburg, Ohio* begins and ends with a note of celebration, Anderson juxtaposes a solitary nonparticipant in both stories.

The story "Hands" continually contrasts Wing Biddlebaum's solitary life with the conviviality of the berry pickers he hears. Sounds and detailed setting skillfully illustrate Wing's social isolation: "Across a long field that had been seeded for clover but that had produced only a dense crop of yellow mustard weeds, he could see the public highway along which went a wagon filled with berry pickers returning from the fields. The berry pickers, youths and maidens, laughed and shouted boisterously."[18] A man socially isolated from the town for twenty years, Biddlebaum once possessed a rare power "to carry a dream into the young minds" (p. 32) of his students. When one recalls that the Latin *ludus* means both *play* and *school,* Biddlebaum's intensity and joy in teaching can validly be seen as still another manifestation of a sprit of play. To Biddlebaum, teaching was his life, and his students his only pleasure. Such a delicate, pure interest in his students can never be restored after his brutal lynching for a false accusation of homosexuality, but his later attempt to inspire George Willard's ambition indicates that the spirit has not been totally killed.

Another teacher in Winesburg, Kate Swift, has almost too much spirit of play for the town to understand: "She became inspired as she sometimes did in the presence of the children in school. A great eagerness to open the door of life to the boy, who had been her pupil and who she thought might possess a talent for the understanding of life, had possession of her" (p. 164). So intense is her zeal to encourage George's interest in writing and participating fully in life that she soars right over his head. After their conversation, George dimly realizes, "I have missed something. I have missed something Kate Swift was trying to tell me" (p. 166). The incident illustrates the impossibility of giving one's own spirit of play or joy to another, no matter how keenly felt. Eventually George Willard will be ready for such revelations, but Kate Swift's use of him as an outlet for her own suppressed zeal blinds her to George's incapacity to benefit from her insight.

Alice Hindman in "Adventure" has more self-knowledge than Kate Swift but an equal intensity in her responses to life. Again, however, Anderson pictures a character who attempts desperately and futilely to share this awareness: "Not for years had she felt so full of youth and courage. She wanted to leap and run, to cry out, to find some other lonely human and embrace him" (p. 119). To Alice's credit, although she began "trying to force herself to face bravely the fact that many people must live and die alone, even in Winesburg," (p. 120), she determines to fight her loneliness, participating in Winesburg's available social life.

Other stories explore the participation of the "grotesques" in village play and celebration, usually revealing their failure or ineptness. Joe Welling in "A Man of Ideas" cannot converse normally. Only when he establishes a winning baseball team and courts Sarah King does the town begin to respect him, although his verbosity is still out of control. But the town perceives his play activities as normal or at least as a balance to his conversational eccentricity.

Louise Hardy in "Godliness" also tries too hard and uses the wrong means to break out of her unhappiness:

> It seemed to her that between herself and all the other people in the world, a wall had been built up and that she was living just on the edge of some warm inner circle of life that must be quite open and understandable to others. She became obsessed with the thought that it wanted but a courageous act on her part to make all of her association with people something quite different, and that it was possible by such an act to pass into a new life as one opens a door and goes into a room (p. 91).

Unfortunately she chooses studying as her courageous act, never really learning that play would have served better to enhance her social acceptance. Turning to sex as another potential solution, she learns that it is equally ineffective without love. Both acts, studying and sex, are aspects of a private kind of play, exhilarating when they are performed with a positive attitude and genuine interest, but destructive when performed in Louise's pattern.

Elizabeth Willard also expect marriage to supply "something she sought blindly, passionately, some hidden wonder in life" (p. 224). Anderson pictures a girl full of zest, stage-struck and restless. Finding no real outlet for her energy in Winesburg, she hopes that sexual fulfullment and marriage can replace her unsatisfied spirit of play. In George she relives her hopes and dreams, ecstatic when he announced his decision "to go away and look at people and think" (p. 48). George never shares her delight: "she wanted to cry out with joy, because of the words that had come from the lips of her son, but the expression of joy had become impossible to her" (p. 48).

One of the final scenes shows George wandering alone at the Winesburg County Fair, as "an American town worked terribly at the task of amusing itself" (p. 233). Anderson skillfully parallels George's solitary reflections with the frivolity of the crowd. Unlike that in "Hands," this pairing of isolation and festivity is positive and desired. George's decision to leave Winesburg, shared with Helen White at the now-empty fairgrounds, produces a spontaneous outburst of genuine play. "In some ways chastened and purified by the mood they had been in, they became, not man and woman, not boy and girl, but excited little animals. It was so they went down the hill. In the darkness they played like two splendid young things in a young world" (p. 242). This incident clearly bears out Huizinga's observation, "The play-mood is one of rapture and enthusiasm, and is sacred or festive in accordance with the occasion. A feeling of exaltation and tension accompanies the action, mirth and relaxation follow."[19]

Throughout *Winesburg, Ohio* Anderson illustrates the crippling effects of a stunted spirit of play but offers little remedy. The grotesques, deficient in a personal sense of play, fail to participate in public play and celebration as well. George Willard, their only social contact, leaves Winesburg. The grotesques remain, inarticulate and alone.

No such loose ends occur in *Main Street,* a highly complex illustration of the American spirit of play, public and private, rural and urban, thwarted and successful. Packing the book with enough detail for a sociology study, Sinclair Lewis examines Carol Kennicott's movement toward a genuine and mature spirit of play. Her inward growth is both caused and illustrated by physical movement from St. Paul to Gopher Prairie to Washington, D.C. and back again to Gopher Prairie. Reared in a family "self-sufficient in their inventive life, with Christmas a rite full of surprises and tenderness, and 'dressing-up parties' spontaneous and joyously absurd," Carol assumes the universality of that particular spirit of play.[20] Her uncritical acceptance of this belief is occasionally threatened in college but "credulous, plastic, young, drinking the air as she longed to drink life," (p. 7) Carol is finally forced to examine her assumptions when she marries Will Kennicott and moves to Gopher Prairie.

The book is structured by Carol's varied attempts to reconcile her concept of the play spirit with Gopher Prairie's theory and practice of play. Though Will has courted her with play and promises of continued opportunity for fun in Gopher Prairie, Carol fails to note his stress on work and progress. As a result, her famous walk through Main Street reveals the overwhelming dominance of work in Gopher Prairie. Only a small movie theater, a few saloons, a tobacco shop, a pool room and several lodges even suggest the possibility of play opportunities. Introducing the first of many parallel scenes, Lewis uses another newly arrived resident, the cleaning woman Bea Sorenson, to reverse the perspective. To Bea, Gopher Prairie fulfills all her emotional and recreational needs: "What did she care if she got six dollars a week? Or two! It was worthwhile working for nothing, to be allowed to stay here'' (p. 43).

Four specific stages emerge in Carol's attempt to realize her spirit of play in Gopher Prairie. Eventually recognizing that the community has a highly structured social life, she struggles to fit. But a welcoming party makes Carol ''embarrassed by the heartiness of the cheering group'' (p. 31). Her own social offering produces equal discomfort for the guests as she plans a profusion of activity in place of the traditional gossip and stunts. Failure is almost guaranteed by her attitude: '''I don't know that I can make them happy, but I'll make them hectic''' (p. 76). In describing the nature and significance of play, Huizinga cautions against an attitude such as Carol's: ''First and foremost, then, all play is a voluntary activity. Play to order is no longer play: it could at best be but a forcible imitation of it.''[21] It takes Vida Sherwin's blunt but accurate observations to begin Carol's reassessment of the meaning of play: '''After all, Gopher Prairie standards are as reasonable to Gopher Prairie as Lake Shore Drive standards are to Chicago. And there's more Gopher Prairies than there are are Chicagos. Or Londons''' (p. 96). Still, Carol suspects that ''in their debauches of respectability they had lost the power of play as well as the power of impersonal thought' (p. 77). Vida's balancing perspective gives Carol further insight: '''They think you're too frivolous. Life's so serious to them that they can't imagine any kind of laughter except Juanita's snorting''' (p. 96).

Temporarily abandoning her attempts to reform Gopher Prairie's established patterns of play, Carol enters her second stage. ''She had tripped into the meadow to teach the lambs a pretty educational dance and found the lambs were wolves'' (p. 100). Carol then begins the dual process of redefining her own spirit of play and establishing individual but genuine social relationships. Finally she has perceived that she has been ''taking herself too seriously'' (p. 101). In this effort Carol is more successful. Vida Sherwin, Bea Soderstrom, Miles Bjornstam, Erik Valborg, Guy Pollock and several elderly couples give Carol some experiences of real shared pleasure. She also begins to delight in solitary country walks.

Still, she cannot suppress her zeal in bringing more communal play to Gopher Prairie. She organizes skating, swimming, tobogganing, amateur theater parties for the community, which politely samples and then abandons Carol's offerings. In an attempt to define Gopher Prairie's apparent resistance to play, Carol speculates,

> It is contentment . . . the contentment of the quiet dead, who are scornful of the living for their restless walking. It is negation canonized as the one positive virtue. It is the prohibition of happiness. It is slavery self-taught and self-defended. It is dullness made God. A savorless people, gulping tasteless food, and sitting afterward, coatless and thoughtless, in rocking chairs prickly with inane decorations, listening to mechanical music, saying mechanical things about the excellence of Ford automobiles, and viewing themselves as the greatest race in the world (pp. 257-8).

Will Kennicott offers an equally blunt assessment of Carol's attempts: '''Carrie, you always talk so much about getting all you can out of life, and not letting the years slip by, and here you deliberately go and deprive yourself of a lot of real good home pleasure by not enjoying people unless they wear frock coats and trot out—to a lot of tea parties''' (p. 171). Of Kennicott's own spirit of play Lewis writes, ''Kennicott had five hobbies: medicine, land-investment, Carol, motoring, and hunting. It is not certain in what order he preferred them'' (p. 191). Adding the movies and his card club, Will finds Gopher Prairie more than fills his needs. Carol, however, begins to look beyond the personal and local implications of an attitude toward play: ''There are two races of people, only two, and they live side by side. His calls mine 'neurotic;' mine calls his 'stupid.' We'll never understand each other, never; and it's madness for us to debate'' (p. 284).

This stand-off with Will and Gopher Prairie produces Carol's third stage in redefining her concept of play. Because she now feels ''alone, in a stale pool'' (p. 275), Carol widens her examination, first in a trip to Minneapolis, then in extensive travel in the west, and finally, in a move to Washington, D.C. Despite Will's pledge that ''everything'll be different when we come back'' (p. 387) and his giving ''promise of learning to play'' (p. 389), Carol ''could discover no more pictures nor interesting food nor gracious voices nor amusing conversations nor questing minds'' (p. 401) on her return to Gopher Prairie. Hence she decides that her moving to Washington would give her the necessary perspective to define herself and her relationship to Gopher Prairie: '''Do you realize how big a world there is beyond Gopher Prairie where you'd keep me all my life? It may be that some day I'll come back, but not till I can bring something more than I have now''' (p. 405).

And the move is salutary. In ''a Washington which did not cleave to Main Street'' (p. 410) Carol learns and changes. ''Her days were swift, and she knew that in her folly of running away she had found the courage to be wise'' (p. 409).

What is Carol's newly acquired wisdom? For the first time she recognizes that ''the only defense . . . is unembittered laughter'' (p. 413). For the first time, too, Carol recognizes that it is she who must change. To Will, visiting Washington to woo her home, she confesses, '''I know it must have been pretty tiresome to have to live with anybody as perfect as I was''' (p. 419). Carol has finally synthesized her outward play activity with a genuine sense of humor and proportion, vital to the play spirit. Until Washington showed Carol how to play naturally and freely, she was just as deficient in a real play spirit as those Gopher Prairie inhabitants whom she once scorned. '''I can laugh now and be serene . . . I think I can,''' (p. 424) a confident, relaxed Carol muses, on her way home. But change is not so easily or quickly accomplished. ''She laughed at herself when she saw that she had expected to be at once a heretic and a returned hero; she was very reasonable and merry about it; and it hurt just as much as ever'' (p. 429).

Varied though the five books are in defining and illustrating a spirit of play in rural America, several strains reappear. Play or festivity, if it has any meaning, must be totally integrated into a person's and a community's life. Ideally there must be a private commitment as well as a public manifestation of festivity and celebration. Real play will grow out of its environment spontaneously and naturally. It cannot successfully be imposed or forced. At the same time, however, it cannot become obsessive or exaggerated. In both cases it ceases to be play. Further deadening of the play spirit occurs when play becomes rigid and stylized instead of spontaneous.

Does a spirit of play exist in these fictional villages? Certainly. Sometimes natural, more often forced, stifled, or feeble, seldom as spontaneous, free and developed as it should be, this spirit of play, both negatively and positively, is a strong influence on the revolt from the village.

Notes

[1] Johan Huizinga, *Homo Ludens: A Study of the Play Element in Culture* (Boston: Beacon Press, 1955), p. 5.

[2] Josef Pieper, *Leisure the Basis of Culture,* trans. Alexander Dru (New York: Pantheon Books Inc., 1952), pp. 51-2.

[3] Huizinga, p. 9.

[4] Richard H. Rupp, *Celebration in Postwar American Fiction 1945-1967* (Coral Gables: University of Miami Press, 1970), p. 66.

[5] Rupp, p. 159.

[6] Rupp, pp. 27-8.

[7] Harvey Cox, *The Feast of Fools: A Theological Essay on Festivity and Fantasy* (Cambridge: Harvard University Press, 1969), p. 26.

[8] Cox, p. 110.

[9] Rupp, p. 211.

[10] Huizinga, p. 51.

[11] Huizinga, p. 132.

[12] Hamlin Garland, *Main-Travelled Roads* (New York: New American Library Inc., 1962), p. 12. Further references are indicated by page numbers in the text.

[13] Cox, p. 23.

[14] Edith Wharton, *Ethan Frome* (New York: Charles Scribner's Sons, 1911), p. 31. Further references are indicated by page numbers in the text.

[15] Hugh Rahner, *Man at Play* (New York: Herder & Herder, 1967), p. 65.

[16] Willa Cather, *My Antonia* (Boston: Houghton Mifflin Co., 1918), p. 102. Further references are indicated by page numbers in the text.

[17] Maxwell Geismar, *The Last of the Provincials: The American Novel, 1915-1925* (Boston: Houghton Mifflin Co., 1947), p. 161.

[18] Sherwood Anderson, *Winesburg, Ohio* (New York: The Viking Press, 1958), p. 27. Further references are indicated by page numbers in the text.

[19] Huizinga, p. 132.

[20] Sinclair Lewis, *Main Street* (New York: New American Library, Inc., 1961), p. 12. Further references are indicated by page numbers in the text.

[21] Huizinga, p. 7.

INCREASE A. LAPHAM'S PIONEER OBSERVATIONS AND MAPS OF LAND FORMS AND NATURAL DISTURBANCES

John R. Dorney
Department of Botany
University of Wisconsin-Milwaukee

Increase Allen Lapham, Wisconsin's first natural historian, lived in Wisconsin from 1836 until his death in 1875 and traveled extensively throughout the state, recording his observations about Indian mounds, vegetation, weather, mineral resources, water and other natural phenomena. He was a prolific writer and, in 1846, published the earliest book on Wisconsin geography, geology, and natural history. Lapham's extensive observations of wind and fire in Wisconsin vegetation provide valuable historical evidence of natural disturbance before European settlement caused large-scale environmental alteration.

Disturbance has long been recognized as an important factor in ecosystem dynamics. Recent studies include Lorimer (1977) on fire and wind in the presettlement forests of northeastern Maine, Zackrisson (1977) on forest fires in the Swedish boreal forest, Brewer and Merritt (1978) on windthrow and tree replacement in a beech-maple woods in Michigan, and Forman and Boerner (1981) on fire in the New Jersey Pine Barrens. Earlier studies include those of succession in canopy gaps created by windthrown trees (Bray 1956), windfalls in northern Wisconsin (Stearns 1949) and effects of hurricanes on northern hardwood forests in the northeastern U.S. (Stephens 1955). Lorimer (1977) in Maine, Canham (1978) in Northern Wisconsin, Dorney (1981) in southeastern Wisconsin and Lindsey (1973) in Indiana all used notes made by early land surveyors to construct vegetation maps showing areas of wind and/or fire damage. White (1979), in a comprehensive review of the subject, concluded that disturbance and cyclic succession are recurrent events affecting vegetation structure; whereas traditional succession (the sequential replacement of tree species) occurred without disturbance. Ecologists generally agree that disturbance is important in determining species dispersal, community structure, and the rate of community change.

Historical documentation of disturbance has received less attention. White (1979) mentions Raup as an early proponent of the subject with publications dating from 1941. Interest in disturbance in Wisconsin vegetation dates from Norman Fassett, John T. Curtis and their students at UW-Madison from the 1930's to 1950's. While settlers and travelers often noted the effect of fire on Wisconsin vegetation, especially in prairie and savanna (e.g., Beltami 1828, Haight 1907), less attention was given to the effect of wind.

Lapham in an undated note (probably from the 1850's) in his collected work at the Wisconsin State Historical Library, stated:

> "The condition of the country now entraced within the limits of Wisconsin, five hundred years ago may have been quite different from the present. It is quite certain that the prairies then covered a much larger portion of the state than at present. The largest trees are probably not more than 500 years old. Large tracts are now covered with forests of young trees, where there are no traces of an antecedent growth. The state is subject to sudden gusts of wind sweeping through the forest, turning up the trees by the roots. The earth turned up with the roots falls upon the decay of the roots forming an elongated mound by the side of the depression at the place where the tree stood. Now as there has been no change of climate, it is clear that this process must have been repeated from time to time and in course of ages the whole

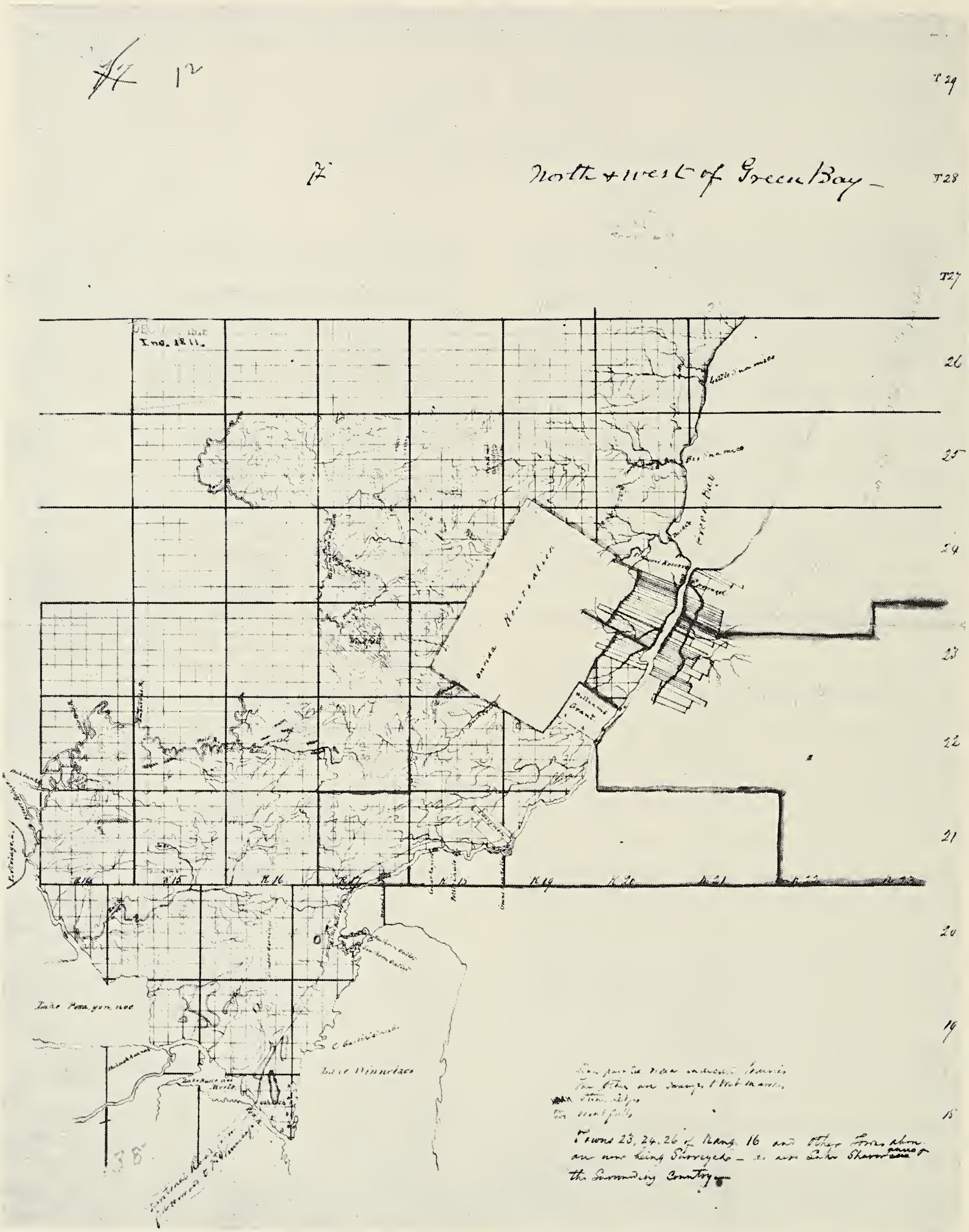

Fig. 1. Area North and West of Green Bay showing windfalls (≡≡), rock ledges (xxxxxxxx), swamps (⬭) and prairies (⬭). State Historical Library-Map Collection Number GX902 L31 Sheet 6P.

> surface would be dotted with these small hillocks. The paucity of the 'tree mounds' may be deemed evidence of the recent origin of the forests."

Further, in a letter from Mayville, Wisconsin, dated October 18, 1851, Lapham stated that:

> "Every year the high winds prostrate a great number of forest trees, and the earth adhering to the roots form upon their decay a little mound. Now if this process had been continued from a very early period, it is to be presumed that these mounds, made by successive growths of trees, would be very numerous."

In 1855, Lapham published his survey of Indian mounds in "The Antiquities of Wisconsin." After describing the mounds and their location in the state, he discussed the issue of windfalls and restated his earlier views about the presence of tree mounds, fire and the age of southern Wisconsin forests. He said "Whether the greater extent of treeless country in former times was owing to natural or artificial causes, it is now difficult to determine . . . but the country was at least kept free from trees by the agency of man." Lapham referred directly to Indian-caused fires when he stated that the annual fires in oak savanna were "often kindled on purpose by the Indians on their hunting excursions." He also mentioned the ". . . deep shady woods where fires do not so often penetrate . . ." (1846). Lapham described a first-hand experience near Pewaukee in 1850. He was visiting an oak savanna and said "At the time of our visit, a fire was raging through the woods about us, consuming the dry leaves and brush and filling the air with smoke. . . . The peculiar noise made by the fire as it entered the marsh . . . was very great." Lapham's speculation that fire had maintained prairie in southern Wisconsin was corroborated when Curtis (1959), after examining the accumulated evidence, concluded that Indian fires were the major reason for the persistence of prairie and savanna in Wisconsin.

Lapham also seems to have been the first naturalist to employ the General Land Office (GLO) surveyors' notes for the construction of detailed maps of land forms and vegetation. Such maps were made possible because, in addition to establishing section and township lines, the GLO surveyors were required to note the agricultural value of the land and locations of streams, rivers, prairies, rough land, swamps and windfalls. A portion of one of Lapham's maps based on surveyors' notes was published in his 1855 report but the map is reproduced here in its entirety for the first time (Fig. 1). A century after Lapham had drawn his maps Bourdo (1956) reviewed the use of the GLO notes to prepare vegetation maps and suggested that they be widely used for this purpose.

Lapham's first map (Fig. 1) was a preliminary sketch of the area from the Fox River and Green Bay to the Wolf River and Lake Butte des Morts. It covers about 1000 square miles including portions of the present Brown, Outagamie, Winnebago, Oconto and Shawano counties. The lots along the Fox River were notable. These lots, laid out by the early French settlers in the 1700's lay perpendicular to the river with narrow river frontages. This pattern, largely lost with the imposition of the GLO grid system, is still observable along parts of the Fox River in the City of Green Bay.

Lapham's map presented detail on streams and rivers in the region. Swamps and wet marshes tended to be parallel to rivers or to occur in isolated patches. Lapham also noted stone ledges along the Wolf River and its tributaries. Several sawmills are shown on the Wolf, and Little and Big Suamico Rivers as well as a tannery on the Big Suamico River, but the chief area of settlement on the Wolf was at Oshkosh. The major rapids on the Fox River were noted as was the Oneida Indian Reservation west of Green Bay.

Prairies and an oak opening were mapped near Lake Butte des Morts and Oshkosh. Prairie was unusual this far north in Wisconsin (Finley 1976). On the east side of Green Bay, the surveyors also noted areas of oak savanna that were associated with Potawatomi Indian village sites and were probably maintained by fire.

Of special interest are the eight windfalls shown on the map. They occurred at various places throughout the region but were concentrated mostly west and north of the city of Green Bay. These windfalls appear to be of two types. Narrow windfalls, such as the one south of the Big Suamico River, were about one-quarter mile wide and several miles long and appear to be tornado tracks similar to those reported by Lindsey (1973) in Indiana. Larger areas tend to be about one mile wide and several miles long like those west of the Oneida Reservation. These may have been caused by downbursts such as those that occurred in northern Wisconsin on July 4, 1977 (Fujita 1977). In northern

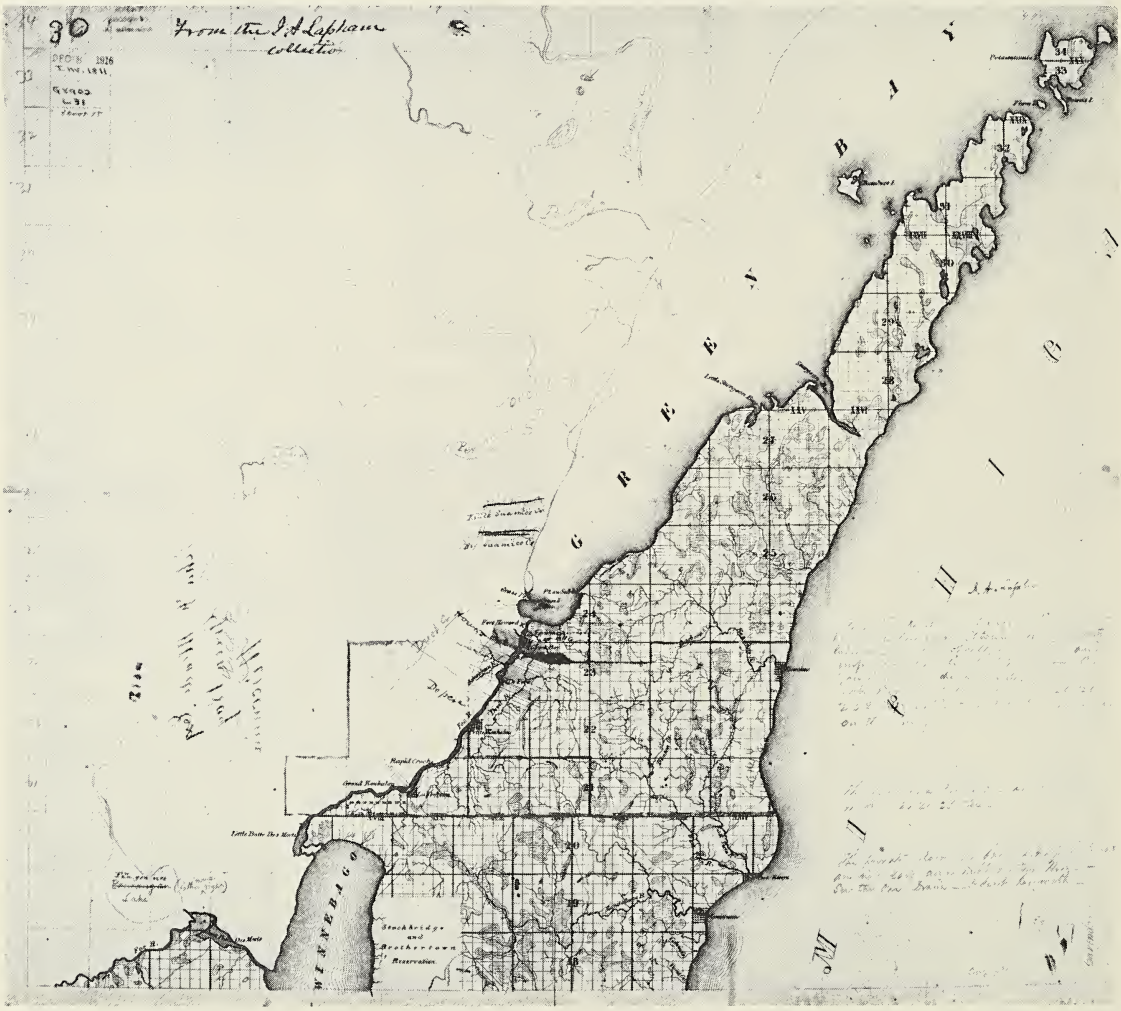

Fig. 2. Door and Kewaunee Counties and parts of Brown, Calumet, Manitowoc, Winnebago, Waushara and Outagamie Counties showing marshes ( ), and stone ledges ( ). State Historical Library-Map Collection Number GX 902 L31 Sheet 15.

Wisconsin, other large windfalls were shown in the GLO notes (Canham 1978). Winds associated with downbursts may flatten trees in large patches.

Lapham also prepared a map of the area east of the Fox River from Lake Winnebago to Door County (Fig. 2). On this map, he showed swamps, rivers, stone ledges and settlements but for some unknown reason, ignored the oak openings and prairies along the east shore of Green Bay (Finley 1976).

Lapham speculated on the age of forests in southern Wisconsin which he estimated to be less than 500 years old and occupying land which previously had been prairie. It is certainly true, as Lapham noted, that windfalls create pit and mound relief. Stone (1975) examined the effect of windfalls on microrelief in forests in New York state. Estimates of the area affected by uprooted trees in his stands varied from 14 to 48% of the land surface. In Pennsylvania, Denny and Goodlett (1965) found that this microrelief was common in old growth forests and concluded that 250 to 300 years of erosion could reduce the height of these mounds to one foot. Stephens (1955) used tip-up mounds in the Harvard Forest to date the windfalls and describe the effect of hurricanes on the vegetation. Such mound and pit microtopography is characteristic of forested landscapes and Lapham was correct in noting that their absence from a forested site suggests recent invasion by trees.

Other evidence also indicated that prairies were more widespread before settlement. Based on pollen stratigraphy, Bryson and Wendland (1967) decided that Wisconsin's climate was drier and cooler around 1200 A.D., which was a period of prairie invasion into central Wisconsin. A gradual change to a wetter climate had occurred by 1850. Also, King (1981) points to pollen evidence from northern Illinois which indicated a trend toward cooler temperatures that began between 900 and 400 years ago. Thus, Lapham's observation that forests in southern Wisconsin were young and occupied sites which previously had been prairie appears well founded.

Lapham was aware of the impact of natural events on vegetation, particularly wind and fire. In his pioneering observations, he commented mostly on the physical damage caused by wind on trees and soil but apparently did not describe the effect of wind on tree species or plant succession. This is not surprising since plant succession as a process was not well defined in the United States until the work of Cowles and Clements about 50 years later (Oosting 1950). Lapham's observations and records of wind and fire disturbance, and his pioneering use of GLO surveyors' records for mapping original vegetation and early settlement patterns, are important to both historians and ecologists.

Acknowledgments

I would like to thank F. W. Stearns, R. S. Dorney and L. C. Dorney for their helpful editorial suggestions.

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THE GEOMETRIC STYLE IN ART: A BRIEF SURVEY FROM THE PALEOLITHIC TO THE TWENTIETH CENTURY

Sally Hutchison Ceely
Madison, Wisconsin

The geometric style is perhaps the oldest in history. Beginning in the Upper Paleolithic, the geometric style is still vital in the twentieth century. This brief survey attempts to show how the geometric style may have originated, how it has contributed to the evolution of new art forms, and most important, how it has been an essential instrument in the development of human consciousness.

The geometric style began during the Paleolithic era, about 20,000 years ago. We find it expressed both in mobiliary art (portable art) and in parietal, or cave art. Next to the paintings or engravings of deer, bison, and other animals found in caves or rock shelters from Spain to Southern Russia are painted squares, rectangles, circles, dots, and tectiforms (shapes composed of these geometric elements). Some scholars believe that since these geometric forms are not found in nature they must have a religious meaning. Others feel that these geometric shapes may depict elementary forms of architecture such as the trap, pitfall, or hut. But it is in the mobiliary art that we gain a clearer insight into the meaning and function of the geometric in the Upper Paleolithic era. Some of the carved mobiliary pieces represent animals and fertility goddesses. Others, animal bones and stones, bear incised carvings of plants and animals as well as geometric repeated motifs. Such carved repeated motifs range from simple straight lines to triangles to more complex arrangements of geometric shapes. These incised bones and stones were transported about for long periods of time, as is shown by evidence of wear. The goddesses and incised animals were probably used in fertility cults, and may also have been appreciated as art objects. The same may be said of the small bones with almost decorative geometric designs. These have been found in large numbers and must have occupied a place of great importance in the Upper Paleolithic, from about 20,000 to 10,000 B.C.

In his book *The Roots of Civilization* (McGraw-Hill, 1972), Alexander Marshack states that mobiliary art with geometric markings may have had an important function in the lives of the Cro-Magnon, the inhabitants of Europe during Upper Paleolithic times. He believes these objects to be notational. They originated, he says, out of a necessity to record time and sequence, so that the Cro-Magnon hunters could survive the Ice Age in Europe. They were not merely curious objects with geometric repeat designs. On the contrary, Marshack's innovative analysis of these mobiliary pieces points toward a lunar notational function. Under a powerful microscope, it can be seen that the carving or incising was done at different intervals using different tools, which means they must have been done over a definite time period for a particular reason, perhaps having to do with gestational or seasonal or migrational patterns. Further, Marshack writes, "In order to record and act upon his lunar observations, he (Cro-Magnon-Ice Age) must have had a spoken language of great range and expressiveness. His notations on stone and bone clearly foreshadow writing. He was becoming a master of art and symbol." Clearly, the geometric may have its origins in basic intellectual development, and in basic perceptual development as well. (Fig. 1)

That geometrical markings on mobiliary art may have been notational, calendrical, and a prelude to writing, removes it from the realm of the merely decorative. And yet, the

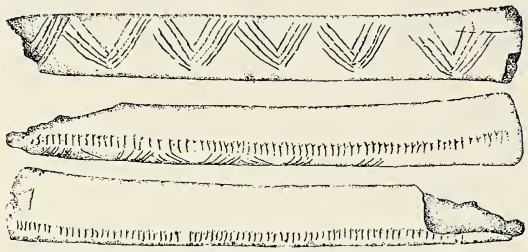

Fig. 1. Three faces of an engraved eagle bone, 4½″ or 11 cm., from the site of Le Placard. Middle Magdalenian. Adapted from a photo by Alexander Marshack in *The Roots of Civilization.*

geometric as a purely decorative device constitutes an important visual development in the history of art. Mobiliary art with geometric incising or with naturalistic seasonal imagery (animal and plant forms) represents an entirely new schema, or visual concept in art. This schema was presented on the limited surface that the stone or bone provided. For the first time we encounter the portable surface in art. This feature of mobiliary art separated it conceptually from the cave paintings. Cave art was neither centered or framed and certainly not portable, and in many cases, it was almost inaccessible. The schema of the small, portable surface utilizing naturalistic and geometric motifs first developed during the Upper Paleolithic. However, beginning in the European Mesolithic era, the schema finds new surfaces, or a new surface will effect the schema in a new way.

During the Mesolithic (roughly 10,000 to 5,000 B.C.) the ice receded in Europe. Forests spread over much of the continent, eliminating the vast grasslands and causing the great herds to disappear. The Cro-Magnon peoples dispersed into small groups of hunters and gatherers. It is perhaps because of this scattering that fewer of their artifacts have been found. Or perhaps, because more time was spent in food aquisition, less time was available for the production of art. Fortunately, however, small, portable, carved artifacts and tools of amber, stone, bone, and antler have been found well preserved in Denmark from the Mesolithic Maglemose Culture. Of great interest is a ceremonial axe made from a reindeer antler which bears organized, variegated rows of repeated geometric shapes incised into the surface of the bone. Alexander Marshack has subjected this ceremonial axe to lunar notational analysis and found the incisions on the axe could be notational for a time span of a year and a half. This could be a seasonal span or perhaps a religious or ceremonial cycle. Whatever its notational function, the geometric schema on the surface has become more organized and sophisti-

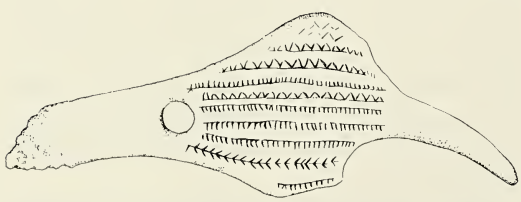

Fig. 2. Ceremonial axe or "antler mattock," engraved in a "geometric pattern," 16″ to 20″ in length. Adapted from photo by Alexander Marshack in *The Roots of Civilization.*

Fig. 3. Engraved amber from the Maglemose culture (North Sea Region) with two bands of birds riding on schematized water angles. 2¾″ long. Adapted from an illustration by Alexander Marshack in *The Roots of Civilization.*

cated. The antler axe has a particular, well integrated and pleasing geometric design which has been transferred directly from the Upper Paleolithic. This same design will be transferred again to a new surface in the Neolithic era in Europe. (Figs. 2, 3) Another artifact found in the Maglemose Culture that is evidence of direct transference of decorative schema is an amber piece incised with water angles (triangles) and bands of geometricized waterbirds. This is a seasonal image, according to Marshack. This image would be directly transferred to a new surface, pottery: on a Neolithic pot found in Russian Carelia near Finland, Marshack points out that the same imagery is incised in the surface, an example of the fact that mobiliary art pieces were definitely an early source for the decorative impulse on utilitarian and ceremonial objects. (Figs. 4, 5)

Because of its durability and plentiful supply, pottery or ceramics, the "master fossil," enables prehistorians to follow migrations and discover origins of cultures all over the world. The Neolithic period in Europe (roughly 5,000 to 3,000 B.C.) was the agrarian "settling-down" time, during which pottery became the impermeable and rodent-proof container for water and grains, and a receptacle for ashes of the dead. Here was a surface that invited a painted or incised decoration. Weaving and basketry shared pottery's practical and artistic functions using geometric motifs to organize and "measure" surface areas into bands and units of rectilinear as well as curvilinear design. It is possible that weaving, with its basic grid form influenced land organization in early agriculture. Land tended to be divided into grids and units of enclosure to accommodate crop and stock-raising. The geometric provides a measuring not only of time, but now in the Neolithic, a measuring of space (land).

During the Neolithic, different styles of the geometric were evolving in different areas of Europe. One style was curvilinear (spirals, whorls, circles); the other was rectilinear and severe (squares, triangles, rectangles). The geometric curvilinear appears ubiquitously, first in southeastern Europe, where it later disappeared only to re-emerge in Crete during the Bronze Age after 2000B.C. The geometric rectilinear ap-

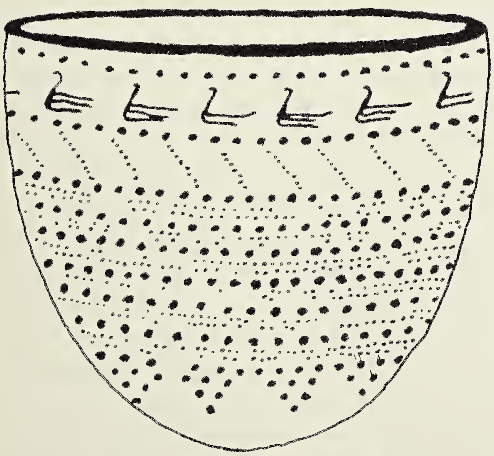

Fig. 4. Comb and pit marked pot with a frieze of swimming water birds from Carelia. (6″ high) Adapted from an illustration in *The Stone Age Hunters,* Grahame Clark.

Fig. 5. Pottery from bell beaker culture (6″ or 7″ high) adapted from a photo in *Prehistoric European Art* by Walter Torbrugge.

parently originated in southwestern Europe and expanded eastward toward Northern Italy, to the Balkans, and eventually into Greece, effecting the art forms of that area, which in turn profoundly influenced all of European art. Even now, folk arts in Europe perpetuate this same rectilinear geometric tradition that originated in Neolithic times. We can see this especially in folk weaving and pottery. Although the two types of geometric traveled in different directions, there was a constant overlapping and alternation of the two forms in pottery decoration as well as in other art forms.

The Neolithic settlements in Thessaly, north of mainland Greece, provide examples of this overlap of the curvilinear and rectilinear. During the 4th millenium B.C. the early Sesklo peoples and the later Dimini painted and incised pottery with both rectilinear and curvilinear decoration. The curvilinear was composed of spirals and whorls. (This form of the curvilinear traveled from the Balkans to Crete via the Dimini culture).

Because the island of Crete and the other Aegean settlements were open to all areas of Europe and the Mediterranean, it becomes important in this survey to focus on these areas, especially Greece. We must trace the influences bearing upon these areas which stimulated the production of pottery, in many ways became the most prominent art form.

During the Bronze Age, which lasted until about the 12th century B.C., the Helladic culture on the Greek mainland developed a so-called Matt-painting technique for ceramic vessels, in which the painted motifs were of a rectilinear geometric nature. This development was the result of an integration of the Balkan and eastern Mediterranean traditions of rectilinear geometric. However, this style was suppressed as the Mycenaean civilization, overcoming the Greek Helladic civilization, asserted itself. The Mycenaeans differed from their conquered subjects in that they had adapted the Cretan style of naturalistic and curvilinear design. (And in an unsuccessful manner according to some investigators.) The Mycenaean civilization collapsed around the 11th century, as a consequence of internal dissensions within the Mediterranean sea-trading civilizations, combined with invasions from the north by less civilized peoples looking for land and plunder. During this period Central and Northern Europe were asserting themselves with the new weapons, and they were carrying off art and artisans to the north where their skills were most needed. In Mycenaean Greece the time known as the "Dark Ages" began; little is known of the events of this period.

From the "Dark Ages" emerged Geometric Greece, a period which lasted from about 1075 to 700 B.C. A visual and intellectual evolution took place, especially in Athens, during which decoration on pottery or vases paved the way for a new concept in art. Eventually the geometric was to yield some of its dominance of surface area, to make room for a figurative, naturalistic, and narrative presentation of art. The geometric, in effect, became a frame for a naturalistic picture.

In Bernhard Schweitzer's book *Greek Geometric Art* (Phaidon Press, 1969), the author states, "The post-Mycenaean Greeks were the first and only people to develop a Geometric art which spread through all art forms." And, "For the first time artists are seeking the real nature of Geometric form . . . out of the basic elements of geometry." The curvilinear naturalistic Creto-Mycenaean style is gradually replaced by a rectilinear geometric style. Although some scholars disagree, it is thought that the Greek Geometric style of vase and utensil decoration evolved gradually through the stylistic elements of Helladic, Balkan, and post-Mycenaean. Even the Dorian invaders, themselves Greek, settling on the Greek mainland contributed to the re-emergence of the rectilinear.

The rectilinear did not emerge and dominate immediately, however. In Athens, in the 10th century B.C., it was preceded by the Protogeometric vase style. This was a style of concentric circles accurately painted which evolved from the post-Mycenaean curvilinear spiral vase decorations. Located on the belly or shoulder of the vases, depending upon the location of the handles, these concentric circles floating on the vase surface became like icons or mandalas to guide the people of Greece from the poverty of the "Dark Ages" to prosperity. These concentric circles and sometimes half circles were painted on the vase surface with the aid of a compass. The compass and later, the ruler, became the new instruments used to articulate geometric development. The circle, a primary geometric shape like the sun, and completely symmetrical from all directions, was the form that most challenged the Greek vase painters of the Protogeometric era.

About 900 B.C. a geometric rectilinear decorative style of triangles, chequers, and meanders began to dominate. These elements were organized in rows of separate bands, encircling the vase. During this period in Geometric Greece, the meander became the dominating motif on the vases. From its origin in the Paleolithic onward the meander, a rectilinear geometric design, was symbolic of water, perhaps because of its resemblance to waves, lightening, and rivers. The meander was adapted, or perhaps reinvented and made more complex by the vase painters of Athens. Rectilinear decorations of meanders, triangles, and rectangles, soon covered the vase, like a mesh or mosaic design, becoming one with the vase itself. The shape of the vase was influenced by the design and became more sculptural and architectonic.

During the 8th century B.C. in Athens, the neck and shoulder of the vases were areas of special interest. Here, panels containing geometric elements such as solitary circles, diamonds, and zigzags, were enclosed, or framed, by other geometric elements, often a small meander band. The panel was thus framed in the area between the handles of the vases, resulting in an almost anthropomorphic effect of back and front. Another development during this time was the Dipylon style funeral amphoras. These vases were sometimes over 5 feet tall. They were set up as memorials on tombs. The panel of special geometric motifs was replaced by a panel framed by geometric designs, leaving the panel itself free for the depiction of a special scene. This was often a funerary scene of mourners. Although the figures of the mourners and dead person were geometricized and although the compositions still resembled the panels of the ornamental compositions of the earlier vases, the funeral scene was a pictorial innovation that opened

Fig. 6. Amphora adapted from Kerameikos Museum, Athens. (1,55 M. high) Photo found in *Greek Geometric Art* by Bernhard Schweitzer.

the way for the narrative, figurative portrayal of the heroes of Greek mythology. The shape and very large size of the funerary vase also contributed to the development of the "picture," presenting the vase painter with a larger, flatter, and framed rectangular surface. This new planar surface brought about new aesthetic considerations for the Athenian artist. (Fig. 6)

From the 6th century B.C. onwards, first in the Black-Figure amphoras, and then in the Red-Figure amphoras, Athenian vase painters depicted the Gods and legendary heroes of Homer and other epic poets. The geometric was reduced to a framing band around the narrative scene, which now dominated the surface of the vase. Because the pictures were placed in areas between the handles on the front and on the back, the result was that in certain ways the vase became conceptually a two-dimensional object, a portable vehicle for a composed, planar, framed narrative picture. This was an object which every Athenian citizen could possess. The geometric had made space for the picture on the vase surface. Soon the picture would be released to a new non-utilitarian surface emerging as a free picture without a connection to any utensil, vase or building architecture.

Although in Greece the geometric was on the wane in vase painting it continued to function and develop in another realm, architecture. In his book *Greek Geometric Art,* Bernhard Schweitzer writes, "All the sources of Greek temple architecture are to

Fig. 7. Russion Icon, *Our Lady of the Sign.* " × 34-3/4".
Courtesy of the Elvehjem Museum, Madison, WI.

be found in the Geometric period." This may be true of all architecture to follow.

After the artistic explosion the geometric caused in Greece, from 1075 to 800 B.C., the geometric as a primary visual form receded for many centuries into other forms relating to decoration and ornamentation. European peasant art, for example, stressed geometric motifs of triangles, meanders, and circles. In religious art the geometric retained its primary forms of rectangles, squares and circles in the shapes of the icons, within which saints and dieties were portrayed, Europe thus retained the geometric, but in a subtler form. The dormant geometric was to erupt again in Europe, especially in Russia, a "backward" country ripe for both political and artistic revolution.

At the turn of the century in 1900 A.D., Russia was a place of great artistic freedom. The constricting bonds of the French and German schools of art, established in Russia since the 18th century, were being shattered. The patrons of the arts were no longer the nobility, but wealthy industrialists eager to sponsor new and innovative Russian cultural movements in theatre, dance, opera, poetry and the visual arts. This movement looked toward many sources in its attempt to identify the true Russian culture.

In the early 1800's with the help of the wealthy Stroganoff family, Russian scholars had begun to study the history of Russian icon painting. These small medieval paintings with their religious subject matter, having been overpainted for centuries, began to be restored to their original brilliant colors and purity of line. Finally, in 1913, an exhibition of these restored icons in Moscow entitled "Ancient Russian Painting," influenced many of the leading Russian artists of the day, profoundly impressing them by the richness of color and the geometric "flatness" of composition. The image that this portable little painting liberated was to join with certain artistic forces already afoot in Russia in the early 1900's. (Fig. 7)

Another vehicle for artistic liberation in Russian was the peasant art. Almost intact in some rural areas since the Neolithic, these peasant cultures became the source of a new 'Primativistic' style of painting in the early years of the 20th century in Russia. With the Russian peasant recognized as the new national hero, the popular arts of weaving, woodcarving, and embroidery became a source of inspiration for this primativistic movement in Russian culture. Although a great many artists as well as poets and musicians participated, the painters Natalia Goncharova, Vladimir Tatlin, and Kasimir Malevich emerged as the most important innovators during the early 20th century. The folk arts with their schematized and geometricized figures and designs influenced these painters towards flatness, directness and simplicity of composition, opposing the naturalism prevalent in Europe. The icon painting and the folk arts promoted and nurtured this artistic direction, but there were other forces as well which influenced this development. (Fig. 8)

Not only did the artists look to the past for inspiration, but developments in mathematics and science also stimulated the formulation of new artistic concepts and new visual materials. Einstein's "theory of relativity" published in 1905 had a profound effect on concepts of imagery. It denied the existence of "absolute space" and "absolute time." It proposed that measure-

Fig. 8. Russian folk embroidery on end of towel in design known as "Cavaliers and Ladies." Adapted from illustration in Camilla Gray's, *The Russian Experiment in Art.*

ments of space and time were "relative" to some arbitrarily chosen frame of reference. From this moment on, the universe was to be viewed in a different way. Artists such as Kasimir Malevich set about creating an appropriate image to reflect this new concept. Images could no longer exist in 19th century time and space.

The scientific discoveries opened new avenues of thought but also brought about a crisis in religion, not only in Russia but in Europe. Spiritual movements emerged to ease the void and replace the traditional religions. The Theosophical movement was one such movement that inspired many artists toward a non-objective image: God was no longer conceived in Man's image but as an idea or a transcendental spiritual force. The spiritual movements stimulated the search for a new 20th century image. Malevich, like his countryman Kandinsky and the Dutch artist Mondrian, believed that the function of art was to serve as a reflection of cosmic order. Artists turned toward the abstract, toward the non-objective, and with Malevich, toward the geometric.

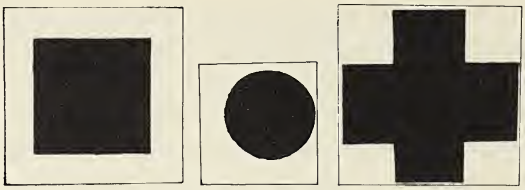

Fig. 9. Primary forms including *The Black Square*. Adapted from illustrations of Malevich's book, *Suprematizm, 34 Drawings,* Unovis Vitebsk, 1920. These were found in *Kasimir Malewitsch* by Antonina Gmurzynska.

Lifting the primary geometric shapes of the circle, square, and rectangle directly

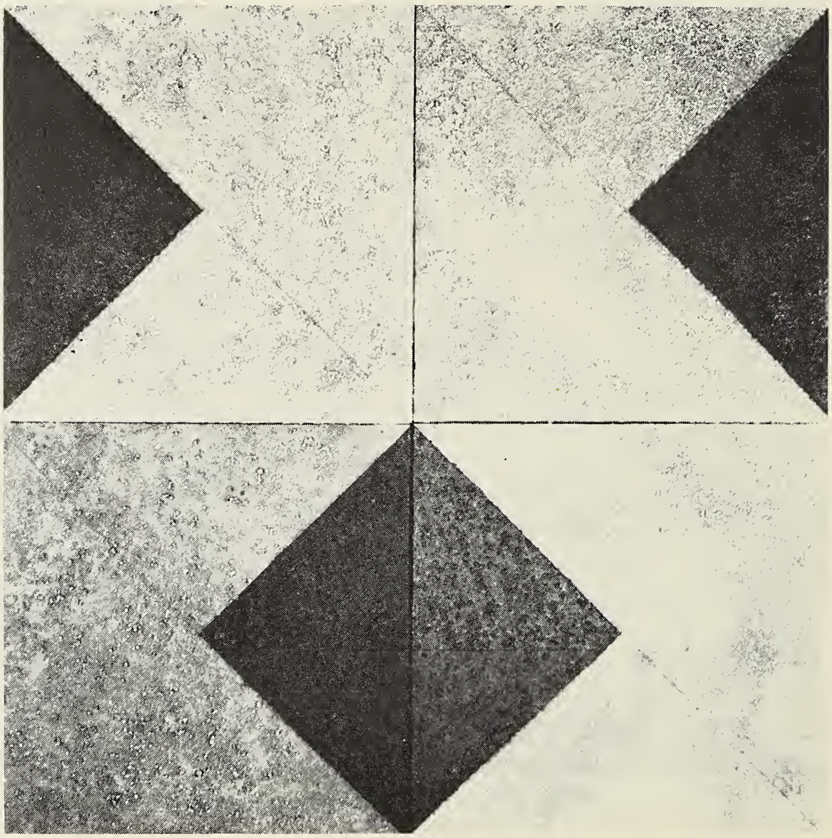

Fig. 10. Painting by Sally Hutchison Ceely (48" x 48") *untitled*. Made of our identical units, which form an image of an enlarged weaving segment.

from the Medieval Russian religious icons, and from peasant decoration, Malevich offered a new modern concept of painting to artists all over the world. The Suprematist Movement had begun. The *Black Square,* one of Malevich's first Suprematist paintings, was hung in a corner of his room, the corner being the place reserved for religious icons. This 1913 painting of a black square on a white ground was what it was. It was not related to, or imitative of nature. Though he received much opposition and criticism for his stance, Malevich revitalized the geometric in art. (Fig. 9)

The Russian poet, Khlebnikov, a close friend of Malevich, sums up the feelings of the time in his essay, "To the Painters of the World." In it he writes about a common language, accessible to all through "mute geometric signs" as the fundamental units of comprehension. Thus, the Russian artists attempted to re-establish the geometric which had begun in the Paleolithic. They attempted to offer concepts which would bring about stability and universality in a time of great upheaval and change.

Malevich in his Suprematist system not only proposed new artistic concepts to the visual artist, he influenced industrial design and architecture as well. His series of three-dimensional idealized architectural drawings done in 1915 were a forecast of what would become the International Style of architecture of the mid-century. As the geometric created the architecture of Greece in 700 B.C., so too the geometric artists of the 20th century paved the way for the modern architecture of today.

The geometric concept of abstraction continues to evolve in contemporary art. The simple primary shapes, alone or combined in repeated forms, provide an untiring and effective imagery. Just as Malevich resurrected the geometric from its subservient decorative function and gave it new life, I hope to find new ways to present the geometric in art. The geometric served admirably during Paleolithic times. It is waiting to be reclaimed by the artist of today. (Fig. 10)

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COLOR MIXTURE IN COMPUTER GRAPHICS

Kenneth Paul Fishkin
University of Wisconsin-Madison

Abstract

Digital control of color television monitors has added precise control of a large subset of human colorspace to the capabilities of computer graphics. This subset is the set of colors spanned by the red, green, and blue electron guns exciting their respective phosphors. A color can be represented as a triple of numbers between zero and one, representing the excitement levels of the respective guns. This capability allows the creation of new and the testing of old mathematical formulae regarding color mixture.

This paper presents the three basic models of color mixture (additive, subtractive, and pigmentary), as well as algorithms for computation of color resulting from mixture of arbitrary amounts of two colors under either of the three methods. Guidelines for extension of the algorithms to deal with simultaneous mixture of more than two colors are provided. Particular emphasis is placed on pigmentary mixture, with a discussion of a new geometric model, in which the hexagon is presented as a shape more consistent for modeling the pigmentary color gamut than the canonical circle.

Introduction

The human visual system analyzes color according to the levels of three primary components (red, green, and blue). Color television monitors thus span human colorspace by varying the amounts of red, green, and blue (*rgb*) phosphor excitement. Since computer graphics programs normally interface with these monitors, a color is often defined as an *rgb triple* of numbers representing the excitement levels [17, 20].

Computer graphics have been defined as "the creation and manipulation of pictures with the aid of a computer" [17]. This definition connects the artistic topics of color and color theory to computer science.

This paper is concerned with computer graphics applied to one aspect of color theory, that of color mixture. Three different models of color mixture are commonly discussed: additive, subtractive, and pigmentary.

Additive Mixture

When colored lights are combined, the color of the resultant light is determined by the rules of *additive mixture*. The color of that light is the sum of the colors of the input lights [7,13,14,15,21].

Since the rgb values represent the amount of light to be physically displayed in each of the primaries, the additive system is easily and naturally applied:

If the colors (r1,g1,b1) and (r2,g2,b2) are mixed in amounts m1, m2, the output color (r3,g3,b3) will be equal to their vector addition:

$$r3 = m1*r1 + m2*r2$$
$$g3 = m1*g1 + m2*g2$$
$$b3 = m1*b1 + m2*b2$$

If any one of the terms of the output possesses a value greater than one, the output color has luminance greater than can be displayed on the television monitor. In this case, corrective action must be taken (see Cook [4] for details).

This algorithm is easily extended to an arbitrary number of colors. The output will be equal to the vector addition of all input colors, within the same provision for correction.

Subtractive Mixture

When white light is shone through a series of colored filters, the color of the resultant light is derived according to the laws of *subtractive mixture*. Each filter "subtracts" from the white light the portion of the spectrum which it does not reflect. The final light will consist of only those portions of the spectrum which all the filters reflect [1,5,7, 13,15,16]. This process corresponds to mathematical multiplication:

$$r3 = (r1^{m1}) * (r2^{m2})$$
$$g3 = (g1^{m1}) * (g2^{m2})$$
$$b3 = (b1^{m1}) * (b2^{m2})$$

This algorithm can be extended to the mixture of an arbitrary number of colored filters by simply extending the number of terms involved in the multiplication. The exponentiation on the components reflects the fact that as the thickness of the filter increases, reflectance decreases proportionally.

Pigmentary Mixture

When pigments or dyes are mixed, the color of the resultant surface is determined by pigmentary mixture. This is the model intuitively used by a computer user. The intuitive mixture of blue with yellow is neither white (additive mixture) nor black (subtractive mixture), but rather green, the pigmentary mixture.

A model of pigmentary mixture is proposed which deals in terms of a color's **hue,** its **saturation,** and its **lightness** (hsl). The hue of a color reflects its basic nature, the saturation its paleness, and lightness the amount of white present in it. Well-defined algorithms for translation between rgb and hsl exist [12,20].

The hue of a number can be defined according to a variety of differing color wheels [2,6,8,10,14,18,19,21]. For example, the rgb to hsl translations commonly provided [12, 20], use a circular color wheel with red, green, and blue primaries. Pigmentary mixture, based on a red, yellow, blue primary system, requires a wheel in which those three colors form primaries (i.e. are equally spaced around the wheel at 120 degree angles) [8,18,21]. Translations between these two wheels can be made by simple mathematical mappings.

Each color can be uniquely mapped to a point in a hexagonal cylinder. As hue is essentially a modular quantity, the hue of a color corresponds to an angle of location. Saturation represents the proportional length of a line drawn at that angle from the center of a hexagon plane. For example, colors with saturations of 0 and 1 would be located at the center and edge, respectively, of the hexagon. The lightness of the color determines its height in the third dimension of the cylinder. The unique point so constructed will be called that color's *color point.*

Varying the hue changes the angle of location of the color point within the hexagon. Varying the saturation changes the distance of the color point from the center. Varying lightness changes the height of the color point in the cylinder.

After two color points have been constructed, one for each color in the mixture, a line can be drawn between them. This line describes all the mixtures of these two colors as their concentrations vary. The color point of the mixture is the point on the line located such that the ratio of the lengths of the two line segments formed is equivalent to the ratio of the amounts of the colors being mixed. For example, if there are equal amounts of color being mixed, the color point of the result will lie at the midpoint of the line. Once the color point of the mixture has been determined, its rgb value can be determined by inverting the operations described above.

Extension to more than two pigments can be accomplished by regarding the location of the mixture as the center of gravity of the color points of the colors being mixed, where each colorant is given a weight corresponding to its proportional presence in the mixture.

The above model contains many of the same rules as those of Sargent [18] and Von Bezold [1], with two major changes: lightness, not value, is used for the third dimension, and the hexagon, not the circle, is used for the planar figure.

A fundamental property of pigment mixtures is that complementary pigments, in equal proportion, mix to grey [3,8,9,15,20]. In the hue, saturation, and value (hsv) system used by Sargent [17] and Von Bezold [1], all colors of maximum intensity (value) lie on the same plane. For example, red, blue, green, orange, and white all are of full value. If the complementary colors of red and green or blue and orange are mixed, the color point that lies at the center of the plane is that of white, as it possesses no saturation and equivalent value. Thus, mixture in the hsv system fails to account for mixture of complementary pigments.

In the hsl system, all colors of equivalent brightness (l) lie on the same plane. Specifically, grey lies in the center of the primary (red, blue, green, orange) plane, rather than white, as grey possesses the same brightness as the primaries. Mixture of complementaries is thus perfectly simulated, grey lying at the center of the primary plane.

Justification of Hexagonal Geometry

Some previous studies of color [1,5,6, 12,18] have used the circle as the planar geometric figure within which to locate colors. However, the circle is not a suitable figure for pigmentary mixture. The mixture of two adjacent fully saturated colors should produce a mixture of full saturation. The midpoint of a line drawn between the color points of those colors will be displaced towards the center of the circle. Therefore, the mixture predicted by a circular model will be abnormally desaturated, because the midpoint of a chord of a circle will never lie on the edge of the circle. Thus, abnormal desaturation will occur in *all* but complementary mixtures using a circular model.

That problem can be minimized by using a regular n-gon instead of a circle. The midpoint of a line drawn between two points on the edge of an n-gon will often lie on the edge as well.

Note that this will also predict abnormal desaturation on occasion, as when the color points lie on the center of adjacent faces. However, it does this far less often than the circular model. The precise mechanism of computing resultant saturation is still under investigation. Curved lines connecting the color points fare no better than straight ones, as they predict abnormally high saturations for near-complementary mixtures. Straight line mixtures are easily computable for arbitrary color points, and were maintained for this reason.

What value should n take? N must be a multiple of two, so that every color is located symmetrically with respect to its complement. It must be a multiple of three, due to the presence of the three primaries. It should be as small as possible, because as n approaches infinity, a regular n-gon approaches a circle, a figure whose shortcomings have been discussed. Thus, the geometry of the situation implies that a hexagon will best approximate pigmentary mixture.

This geometric conclusion is supported by the findings of Smith [20] that the rgb system lends itself naturally to hexagonal color space, and of Kuppers [14] that the hexagon represents pure color more logically than the circle.

While the model will not predict the precisely correct solution in every case, it is generally believed that no model can [1,5,7, 13,19,21]. In nearly every case, however, it provides an excellent approximation.

Specifically, it satisfies each of the three basic principles of pigmentary mixture [3,9, 10,16,21]: a color mixed with black will lower its lightness, mixed with white will lower its saturation, and mixed with its complement will produce grey.

Implementation

These algorithms have been implemented as part of an interactive color mixing/matching/making database program written in the C programming language. This program is presently running at the University of Wisconsin Image Processing and Graphics Laboratory on a PDP-11/45 computer with an STC-70 graphics terminal.

Further Research

Currently, research is being performed to test the applicability and usability of old (e.g. C.I.E. and Kuppers [14]) and new color solids, and the "integrated mixture" algorithm of Kuppers [14].

Acknowledgments

The author wishes to thank Pat Hanrahan (presently at NYIT) and Karl Anderson (presently at Atari) for their assistance in this project.

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BENJAMIN FRANKLIN AND THE THREE FACES OF WOMEN

ELIZABETH WILLIAMS
English 783: Proseminar in Intellectual Backgrounds to the American Revolution

Three categories of woman appear in Benjamin Franklin's works: the "painted Woman," the "good Wife," and the "Woman of Wit." The painted woman corresponds to the feminine *daimon* found in mythology, and to the harlots in the Bible. She emerges in the eighteenth century as a woman of low life, the strumpet, embodying ungoverned sensuality, disease, corruption, and *deceit,* as evidenced by her "mask of paint." The good wife corresponds to the Sarahs, Rebekahs, Rachaels, Marthas, and Marys of the Bible; she inherits, up through the nineteenth century, the guardianship of moral and social values. The woman of wit, rarely surfacing in ancient literature—Sappho and Queen Esther are possible candidates—emerges as a kind of welcomed aberration, who, in the eighteenth and succeeding centuries, offers intellectual diversion and a less rigid morality. She is more trustworthy than the painted woman, less reliable than the good wife. This typology of women parallels the feminine images in three distinct stages of Franklin's life: youth, early adulthood, and maturity.

Before the eighteenth century there had been but two categories of woman fixed in the collective consciousness, the painted and the untainted. While hints of a mysterious and more complicated blend of feminity cropped up here and there, as in Leonardo's "Mona Lisa" (intellectualized earthiness bathed in spirituality), theological conditioning largely plowed that image under. Examine St. Paul's instructions to women:

> . . . *to be* discreet, chaste, keepers at home, good, obedient to their husbands, that the word of God be not blasphemed.
>
> (Titus 2:5)
>
> Wives, submit yourselves unto your own husbands, as unto the Lord.
>
> (Ephesians 4:21-24)
>
> . . . that women should adorn themselves in modest apparel, with shamefacedness and sobriety;
>
> . . . Let the woman learn in silence with all subjection.
>
> (Timothy 2:9)[1]

Although those directives may have held some merit, such passivity imposed on women by the patriarchy from St. Paul to the Puritan fathers, denied more or less half of the world's talent. Suppression can be a form of mutilation, producing some kind of un-wholesomeness, e.g., muteness leading to ultimate rage as in the works of Margaret Cavendish, a seventeenth century intellectual who wrote ". . . poetry, plays, orations, biography, autobiography, letters, philosophical works, and scientific treatises," and ". . . struggled to get her works accepted by the universities."[2]

Despite her enraged voice, Margaret Cavendish was a good wife and is largely remembered for the biography she wrote of her husband.

However, not all women felt type-cast. Across the channel, one century later, Mme. de Pompadour exerted tremendous influence at Versailles with diplomacy and dimples for King Louis XV and witty conversation for Montesquieu and for Voltaire, who characterized the Age of Enlightenment as somewhat more schizoid than we like to believe: "We live in curious times," he said, "and amid astonishing contrasts: reason on the one hand, the most absurd fanaticism on the other . . . "[3] If the traditional dualistic view of women was now passing through a prism (the light of reason) and becoming triadic, those women who dared to surface with wit and intellect were no less subject to ridicule than the women of paint had been. Mary Manley, the first Englishwoman to be called a political journalist, successor to Jonathan Swift as editor of the *Examiner,* was arrested for publishing her satirical work *Secret Memoirs and Manners of Several Persons of Quality of Both Sexes From the New Atlantis, an Island in the Mediterranean.*[4]

The good Wife was still the most revered woman in the Neo-classic mind. Further, she gained more respect as the century progressed, as the pursuit of Virtue became mandated by the great thinkers of the Age. With lyrical flourish Diderot remarked: *"Rendre la vertu aimable, le vice odieux, le ridicule saillant voila le projet de tout honnete homme qui prend la plume, le pinceau, ou le ciseau."*[5] Lord Shaftesbury, whose writings had created religious doubts in young Franklin's mind and carried him far away from the clutches of Bostonian Calvinism, wrote: ". . . the knowledge and practice of the social virtues, the familiarity and fervour of the moral graces are essential to the character of a deserving artist and just favorite of the Muses."[6] The genre of *Conduct Literature* was ascending: Novels, diaries, memoirs, poems, plays, autobiographies, and personal letters tended to concentrate on moral issues, restraints and controls. "One recorded one's daily life in order to evaluate one's conduct, and also to find evidence of God's will in the pattern of events."[7]

Right conduct was emphasized in Benjamin Franklin's young life by his father, Josiah: "At his Table he [Josiah] lik'd to have as often as he could, some sensible Friend or Neighbour, to converse with, and always took care to start some ingenious or useful Topic for Discourse, which might tend to improve the Minds of his Children. By this means he turn'd our Attention to what was good, just, and prudent in the Conduct of Life:"[8] Though little can be gleaned from Franklin's writings concerning his mother Abiah, evidence suggests that she fostered Franklin's belief in the power of virtue and the value of leading a discreet life.

Always an independent thinker, Franklin preferred to choose his own religious beliefs. Although he read "Books of polemic Divinity," from his father's library, he later regretted the time spent on them. Works of practical morality such as Plutarch's *Lives,* Defoe's *Essay on Projects* and Mather's *Bonifacius, An Essay upon the Good . . .* gave him such ". . . a Turn of Thinking that [they] had an Influence on some of the principal future Events" of his life.[9] Of the three, Mather seemed to wield the most influence.

As Franklin began to feel the temptations of sex, he gradually succumbed to the Painted Woman. His only confession of this occurs when he recalls his London sojourn in the *Autobiography:*

> . . . that hard-to-be govern'd Passion of Youth, had hurried me frequently into Intrigues with low Women that fell in my Way, which were attended with some Expence and great Inconvenience, besides a continual Risque to my Health by a Distemper which of all Things I dreaded, tho' by great good Luck I escap'd it.[10]

If Franklin had lived in the early twentieth century would he have been more explicit about his sexual adventures? Would we discover, for instance, that he *really* had had "an intrigue with a girl of bad character" before he left Boston for good? Or that he had been somewhat more involved with the "two women travelling together" on his way to New York, and ultimately London, than his memoirs reveal?

Franklin's neglect of Deborah Read during his eighteen-month stay in London, was the "erratum" he claims to have felt most guilty about; he sent only one letter to her during his stay abroad.[11] The need to correct his errant ways may have been predicated upon his growing understanding of what constituted a good relationship with a woman and the ultimate costs of being involved with a bad woman. London, for Franklin, was a laboratory for sexual experimentation; during his first English residency, far way from familial restraints and no longer influenced by "Religious restraints," he fell into a certain licentious style of life. Hogarth attempted to show how the very atmosphere of London was conducive to corruption. One cannot easily imagine Franklin, back in Boston, or even Philadelphia, making the kind of seductive proposal he did to "Mrs. T." She was the millener who had previously lived "together some time" with his friend James Ralph. Ralph had gone away to "a small Village in Berkshire" to teach, "recommending Mrs. T." to Franklin's "care";[12]

It was through his exposure in London to all sorts and conditions of women that Franklin began to formulate, at some point between his return voyage to America and his marriage to Miss Read, what I call his "theory of the open countenance" regarding women. The painted woman is a creature of false allurement whose bodily adornment and cosmetic coverings represent a mask. Her superficial beauty may disguise a deeply-flawed nature. When he later composed verses for the Poor Richard Almanacs, he extolled the supremacy of virtue over beauty:

> 'Tis not the Face with a delightful Air,
> A rosy Cheek and lovely flowing Hair;
> Nor sparkling Eyes to best Advantage set,
> Nor all the Members rang'd in Alphabet,
> Sweet in Proportion as the lovely Dies,
> Which bring th' etherial Bow before our Eyes,
> That can with Wisdom Approbation find,
> Like pious Morals and an honest Mind;
> By Virtue's living Laws from every Vice
> refin'd.[18]

In 1744 Franklin reprinted Samuel Richardson's *Pamela, or Virtue Rewarded;* it was the first novel published in America. Richardson expressed views similar to Franklin's on what constitutes virtue: "Beauty, without goodnes, is but skin-deep perfection" and "Virtue only is the true Beauty."[14]

Unlike the painted Woman, "the good Wife" possesses an inner beauty that does not fade. The implication in Franklin's concept of male/female relationship is that while men are responsible for the various vices of women, men need the rope of woman's virtue to pull them into shape. Poor Richard Saunders indicates as much:

> The plain Truth of the Matter is, I am excessive poor, and my Wife, good Woman, is, I tell her, excessive proud; she cannot bear, she says, to sit spinning in her Shift of Tow, while I do nothing but gaze at the Stars; and has threatened more than once to burn all my Books and Rattling-Traps (as she calls my Instruments) if I do not make some profitable Use of them for the good of my Family. The Printer has offer'd me some considerable share of the Profits, and I have thus begun to comply with my Dame's desire.[15]

The Richard/Bridget Saunders union is a comic parody of the Benjamin/Deborah Franklin marriage. Franklin offers a similar tribute to his wife in the *Autobiography:* ". . . it was lucky for me that I had one [wife] as much dispos'd to Industry and Frugality as my self. She assisted me chearfully in my Business, folding and stitching Pamphlets, tending Shop, purchasing old Linen Rags for the Papermakers, &c. &c."[16] There are constant warnings, however, in Franklin's writings, against marrying a termagent. Perhaps this was Franklin's subtle way of keeping Deborah "chearful." Both Lopez and Van Doren, the principal Franklin biographers, allude to Deborah Franklin's quick temper. Nevertheless, she earned the longest poem ever written by Franklin to a woman. It begins this way:

> Song
> Of their Chloes and Phillisses Poets may prate
> I sing my plain Country Joan
> Now twelve Years my Wife, still the Joy of my Life
> Blest Day that I made her my own,
> My dear Friends
> Blest Day that I made her my own.

2

Not a Word of her Face, her Shape, or her Eyes,
Of Flames or of Darts shall you hear;
Tho' I Beauty admire 'tis Virtue I prize,
That fades not in seventy Years,
My dear Friends[17]

Virtue, it would seem, is not natural but acquired. One needs a boost of some sort, either a strong tie with a virtuous person, or the practice of virtue through systematic moral exercise. Franklin invented a system as simple and as complicated as St. Ignatius Loyola's *Spiritual Exercises* to arrive at "moral Perfection." Understanding that "contrary Habits must be broken and good ones acquired and established, before we can have any Dependence on a steady uniform Rectitude of Conduct,"[18] he drew up a list of Thirteen Names of Virtue: TEMPERANCE, SILENCE, ORDER, RESOLUTION, FRUGALITY, INDUSTRY, SINCERITY, JUSTICE, MODERATION, CLEANLINESS, TRANQUILITY, CHASTITY, HUMILITY.[19]

Each of these virtues was tranformed into any number of epigrammatic lines in the *Poor Richard Almanacs*. Through the ingenuity and industry of Benjamin Franklin, the "wisdom" literature of the ancients was transformed into homely practical knowledge for the right conduct of Americans. We should look to the *Almanacs* to determine and understand subconscious attitudes toward women in America: "She that paints her face, thinks of her tail"; "Three things are men most liable to be cheated in, a Horse, a Wig, and a Wife."[20]

Once he had passed the dangerous shoals of youth, a very large dimension of Benjamin Franklin's character was govern'd by sobriety, high moral purpose, self-discipline and self-denial. After conceiving a plan to (a) practice each virtue for one week, (b) record his progress in a booklet, and (c) start over again when the thirteen-week cycle ended, he carried out the regimen diligently for a time.

Franklin's "Project in Virtue" establishes the tone for our introduction to the Woman of Wit and Franklin's mature years. Some observers would have us believe that he was a rake and a bounder who romped up and down the New England coast and the Continent, leaving a trail of bastards in his wake. To suggest such a hedonistic enterprise is absurd. Whether Franklin was guilty of infidelity cannot be verified. What is known is that in his mature years, Franklin was attracted to several women of wit and intelligence, that he formed close relationships with them, epistolary and otherwise, and that his life and theirs were enriched through these associations. One such relationship was established with Catharine Ray Greene.

Before considering the Frankin-Greene liaison, we must understand the pedagogical role Franklin often assumed with women. It probably stemmed from a relationship formed in childhood with his sister Jane, ever his "peculiar favorite." In one of his youthful disputations with his friend John Collins, Franklin argued for the education of women:

> He was of Opinion that it was improper; and that they were naturally unequal to it. I took the contrary Side, perhaps a little for Dispute sake.[21]

Despite the motive he claims, Franklin appears elsewhere in his writings to believe that a more enlightened education should be provided for the eighteenth-century woman of intelligence. Silence Dogood relates how her "Master," a "Country Minister," endeavored to raise her consciousness:

> . . . observing that I took a more than ordinary Delight in reading ingenious Books, he gave me the free Use of his Library, which tho' it was small, yet it was well chose, to inform the Understanding rightly, and enable the Mind to frame great and noble Ideas.[22]

Franklin was most likely influenced but not likely convinced by Daniel Defoe's *An Essay on Projects*. Defoe's proposal for "An

Academy for Women'' sounds two centuries ahead of the time:

> The capacities of women are supposed to be greater and their senses quicker than those of the men; and what they might be capable of being bred to is plain from some instances of female wit, which this age is not without; which upbraids us with injustice, and looks as if we denied women the advantages of education for fear they should vie with the men in their improvements.
>
> To remove this objection, and that women might have at least a needful opportunity of education in all sorts of useful learning, I propose the draught of an Academy for that purpose.[23]

Although no such women's academy was proposed for the meritous female population of Philadelphia, Franklin in principle, was not against educating women beyond the homely arts. Nevertheless, the woman must never be educated to the point where she would desire to be anyone other than the ''good Wife,'' for hers is the highest achievement of womanhood. In educating his own daughter Sally ''[H]e did not intend to open up to her the full Pandora's box of knowledge, but mainly the useful, the functional skills: reading and writing . . . arithmetic and some bookkeeping.[24] He believed a woman should receive enough education to be able to take care of herself in the event of possible widowhood. That goal was far short of what Defoe proposed for the pedagogy of woman, but Franklin was at least more open-minded than Hawthorne, who had little use for an intellectual woman, particularly a literary one.

Franklin conducted a kind of ''academy-by-mail'' in the numerous letters he wrote to innumerable people to educate them in scientific and political matters. Polly Stevenson, the daughter of Mrs. Margaret Stevenson with whom Franklin boarded in London, was one such fortunate pupil. Their correspondence continues from 1758 to 1786, undergoing many transformations. Polly was one ''woman of Wit'' to whom he could write highly technical letters. Theirs was an intelligent epistolary dialogue. James Stifler says of the friendship:

> It would have been an exceedingly dull man, which Franklin never was, not to have responded to the keen sparkle of this young woman's letters. All his life Franklin liked good company and clever conversation. He warmed up and uncovered the most delightful aspects of his amazing versatility under just such stimulus. Polly Stevenson gave it to him.[25]

Another such lady of genius in Franklin's life was Georgiana Shipley, the fourth daughter of Bishop Jonathan Shipley of Twyford, the small but famous site where the *Autobiography,* Part I, was written. Franklin met her in 1771 when he first visited Twyford; she was a scant fifteen years old when their correspondence began, but

> [i]n the course of time Georgiana wrote and read Latin and Greek as readily as English. She was equally at home in all Continental languages so that her friendship and correspondence was sought after by eminent persons throughout Europe.
>
> Her affections were strong and generous and to no one outside her family was she so devoted as to Dr. Franklin.[26]

But the most unguarded, playful, yet at the same time, highly educative correspondence was the one Franklin shared with Catharine Ray Greene. It carried undertones of

> . . . a romance in the Franklinian manner, somewhat risqué, somewhat avuncular, taking a bold step forward and an ironic step backward, implying that he is tempted as a man but respectful as a friend. Of all shades of feeling, this one, the one the French call *amitie amoureuse*—a little beyond the platonic but short of the grand passion—is perhaps the most exquisite.[27]

Catharine met Franklin in Boston about 1754. They corresponded until just short of his death in 1790. Her husband was William Greene, a surveyor and minor statesman, later Governor of Rhode Island (1778-1786).

Better known as "Caty," she was a woman of finely-wrought intelligence and ". . . a keen sense of humor and always had a house full of guests." Mother of six children she ran both house and farm and was "a model eighteenth-century housewife.[28] Although she had no formal education, she was known for her wit. One of the most famous letters of the Greene-Franklin portfolio, sent to Caty on October 16, 1755, embodies Franklin's expectations of an exemplary wife:

> Let me give you some fatherly Advice. Kill no more Pigeons than you can eat.—Be a good Girl, and don't forget your Catechise.—Go constantly to Meeting—or Church—till you get a good Husband; then stay at home, & nurse the Children, and live like a Christian.—Spend your spare Hours, in sober Whisk, Prayers, or learning to cypher.—You must practise *Addition* to your Husband's Estate, by Industry & Frugality; *Subtraction of all unnecessary Expences; Multiplication* (I would gladly have taught you that myself, but you thought it was time enough & woud'n't learn) he will soon make you a Mistress of it. As to *Division,* I say with Brother Paul, *Let there be no Division among ye.*[29]

We have, in the end, come full circle—back to Pauline Christianity. Although Franklin, in his youth, was attracted to the "painted Woman," he most likely, in his later years, came to admire most the woman who combined the faces of the "good Wife" and the "Woman of Wit." Most significantly, that composite—Franklin's ideal woman—remains, a paradigm whose wit serves only the causes of virtue.

Notes

[1] *The Holy Bible,* Authorized King James Version (London: Collins' Clear-Type Press, 1943).

[2] Joan Goulianoa, ed. "Margaret Cavendish, Duchess of Newcastle," *by a Woman writt: Literature from Six Centuries By and About Women* (Baltimore: Penguin, 1974), p. 55.

[3] Alfred Cobban, ed. *The Eighteenth Century: Europe in the Age of Enlightenment* (New York: McGraw-Hill, 1969), p. 260.

[4] Goulianoa, "Mary Manley," *by a Woman writt,* p. 103.

[5] Cobban, p. 245. (To show virtue as pleasing, vice as odious, to expose what is ridiculous, that is the aim of every honest man who takes up the pen, the brush or the chisel.)

[6] Ibid.

[7] David Levin, "*The Autobiography* of Benjamin Frankin: The Puritan Experimenter in Life and Art," *In Defense of Historical Literature: Essays on American History, Autobiography, Drama, and Fiction* (New York: Hill and Wang, 1967), p. 62.

[8] Benjamin Franklin, *The Autobiography of Benjamin Franklin,* Leonard W. Labaree, et al., eds. (New Haven: Yale Univ. Press, 1964), p. 55. Hereafter cited as *Autobiography.*

[9] *Autobiography,* p. 58.

[10] *Autobiography,* p. 128.

[11] Ibid., 96.

[12] Ibid., 99.

[13] *The Papers of Benjamin Franklin,* Leonard W. Labaree and Whitfield J. Bell, Jr., eds. (New Haven: Yale Univ. Press, 1959-), II, 10. Hereafter cited as *The Papers.*

[14] Samuel Richardson, *A Collection of the Moral and Instructive Sentiments* (Delmar, N.Y.: Scholars' Facsimiles & Reprints, 1980), p. 7.

[15] *The Papers,* I, 311.

[16] *Autobiography,* 145.

[17] *The Papers,* II, 353-54.

[18] *Autobiography,* p. 148.

[19] Ibid., 149-50.

[20] *The Papers,* II, 142 (from Poor Richard's Almanac, 1736).

[21] *Autobiography,* 60.

[22] Silence Dogood Letter No. 1 (Printed in *The New England Courant,* April 2, 1722), The Papers, I, 10.

[23] Daniel Defoe, *The Earlier Life and The Chief Earlier Works of Daniel Defoe,* Henry Morley, ed. (New York: Burt Franklin, 1970, pp. 144-45.

[24] Claude-Anne Lopaz and Eugenia W. Herbert, *The Private Franklin: The Man and His Family* (New York: W. W. Norton, 1975), p. 71.

[25] James Madison Stifler, *"My Dear Girl": The Correspondence of Benjamin Franklin with Polly Stevenson, Georgiana and Catharine Shipley.* (New York: George H. Doran, 1927), p. 38.

[26] Ibid., 231.

[27] Lopes and Herbert, p. 56.

[28] William Greene Roelker, ed. *Benjamin Franklin and Catharine Ray Greene: Their Correspondence 1755-1790.* (Phil.: American Philosophical Society, 1949), pp. 2-3.

[29] Ibid., p. 5.

POTENTIAL VERSUS ACTUAL DEVELOPMENT OF IRRIGATED AGRICULTURE IN CENTRAL WISCONSIN

Donald Last
UWEX Department of Environmental Resources
Stevens Point, Wisconsin

Abstract

Only 5 percent of the ten-county central sands area of Wisconsin having conditions suitable for irrigated agriculture is now actually being used for that purpose. Nearly 3 million acres in the region have an underground water supply great enough to sustain high capacity irrigation wells. Yet only 133,000 acres of cropland are presently being irrigated. A doubling or tripling of the irrigated cropland in the area is possible by 1990. Development of irrigated agriculture has had an impact on the economy and the natural resources of the area. Careful planning and decision-making is needed now so that the irrigation potential of central Wisconsin is realized by anticipation and not by accident.

In the past 20 years, there has been a seven-fold increase in the total amount of cropland being irrigated in Adams, Jackson, Juneau, Marathon, Marquette, Monroe, Portage, Waupaca, Waushara, and Wood Counties (Census of Agriculture, 1978). The reason for this rapid growth is self-evident. Yields on the sandy soils in the area are increased considerably with the addition of an artificial water supply. For example, Russet Burbank potatoes grown without irrigation may yield from 100-200 cwt/acre. Irrigation can increase this yield to 500 cwt/acre. The quality of the product is enhanced as well. For example, the percentage of higher value U.S. No. 1 potatoes is 19% greater on irrigated versus non-irrigated farmland (Vegetable and Fruit: Potential for Production and Processing in Central Wisconsin, 1964).

Actual Development Less Than Potential

Plentiful irrigation water is readily available in the vast aquifer underlying Wisconsin's central sands. As shown on Table 1, nearly three million acres in central Wisconsin have a subsurface water supply suitable for intensive irrigated agriculture. Five hundred gallons per minute is generally considered to be the minimum amount necessary for wells supplying smaller irrigation systems. One thousand gallons per minute is more desirable for the center-pivot irrigation units, which cover 160 acres in one revolution (Berge, 1964). As shown on Figure 1, there are about 2 million acres in central Wisconsin where wells could be expected to yield from 500-1,000 gallons of water per minute. An additional 1 million acres of the ten-county area could produce 1,000 or more gallons per minute (Lippelt, 1981).

Yet the latest agricultural census figures indicate that only 132,985 acres are being irrigated. This is just 4.6% of the *total land area* where ground water conditions would permit pumpage rates high enough to justify the use of irrigation equipment. Thirty-five percent of the ten-county area is cropland. Only about 7% of the existing *cropland* is being irrigated (Irrigable Lands Inventory Plan of Work, 1980).

Within the region, Portage County leads all others in the number of acres being irrigated (49,494). It is also the county which has realized the greatest amount of development. Nearly fourteen percent of the land area having irrigation potential is now being used for that purpose. Waushara County has

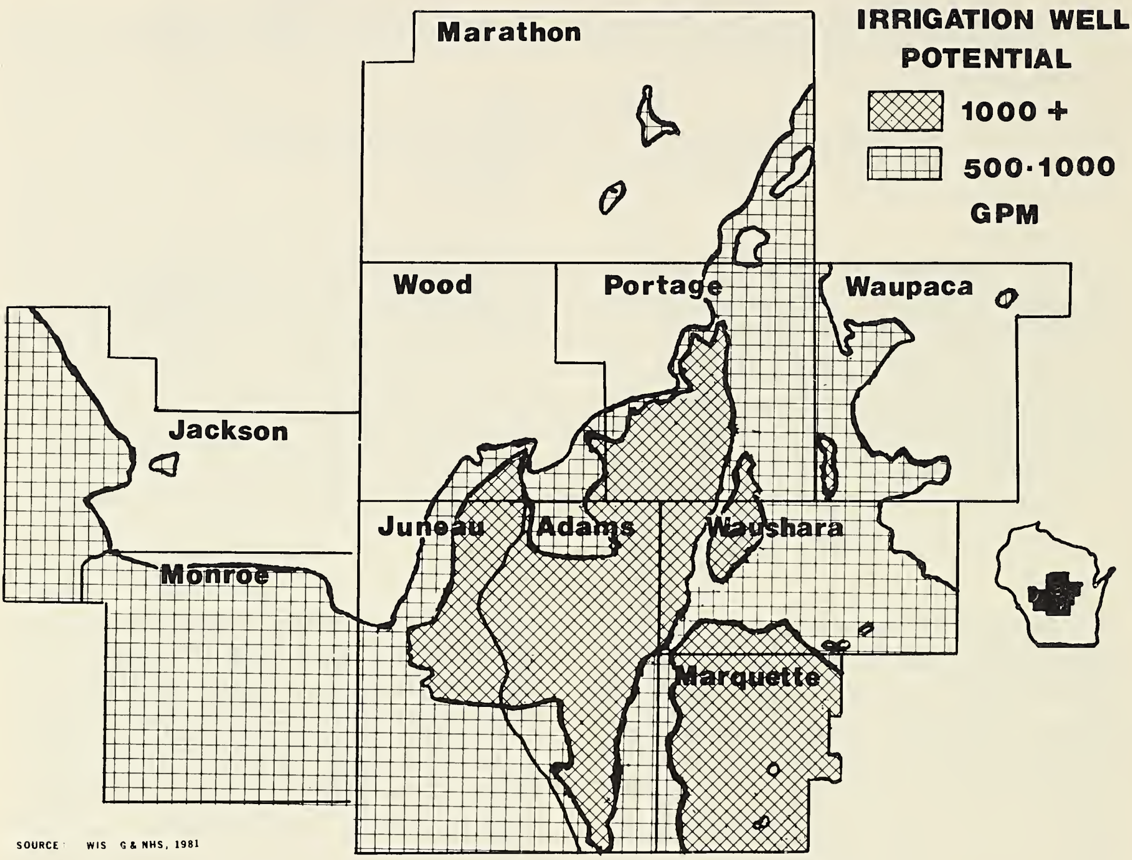

Fig. 1.

10.7% of its irrigation potential developed. None of the other eight counties in the region have realized even a 5% development level. Of these, Jackson and Monroe Counties have had less than 1% of the land area with potential actually developed (Table 1).

Future Development: How Much and Where?

There is the potential for an even faster rate of growth. A doubling or tripling of the amount of agricultural land being irrigated in central Wisconsin seems probable by the end of the decade. There is somewhat less certainty about where this additional irrigated acreage will be developed. Portage and Waushara Counties will, no doubt, see a continuation of the existing growth pattern. It is possible that counties such as Adams, Juneau, and Marquette will experience the sharpest absolute as well as percentage increases in irrigated cropland in the next few years. For it is in these three counties that the largest share of underdeveloped 1,000+ gallon per minute well potential exists. It is also that area which has geographic conditions most similar to Portage and Waushara Counties.

Geographic conditions other than ground water supply and well yield potential also help to determine whether or not an area is suitable for irrigation development. Soil properties, length of growing season, depth to ground water, and the steepness of the slope are factors which need to be considered. Rough terrain in Monroe County, for

TABLE 1. Central Wisconsin Agricultural Irrigation: Actual Versus Potential

COUNTY	IRRIGATION FOR AGRICULTURAL USE								Actual acres as percentage of potential acres Yields >500 gallons per minute)	
	Water use in millions of gallons per year[1] (1979)		*Actual acres under irrigation*[2] (1978)		*Potential acres under irrigation*[3] *Maximum yields of wells* in gallons per minute (500–1000)	(1000+)	(Total)			
	Amount	Rank	Amount	Rank	A M O U N T			Rank	Percent	Rank
Adams	4,180	3	20,646	3	122,125	297,952	420,007	3	4.9	3
Jackson	19	10	1,570	10	247,521	—	247,521	7	0.6	9
Juneau	731	4	5,388	4	328,619	111,766	440,385	2	1.2	8
Marathon	123	8	3,792	6	77,418	—	77,418	10	4.9	3
Marquette	240	6	3,774	7	33,530	263,195	296,725	6	1,3	7
Monroe	41	9	2,006	9	534,705	—	534,705	1	0.4	10
Portage	10,000	1	49,494	1	209,357	147,749	357,106	5	13.9	1
Waupaca	516	5	4,009	5	113,947	7,224	121,171	8	3.3	6
Waushara	5,340	2	39,143	2	265,104	100,044	365,148	4	10.7	2
Wood	166	7	3,163	8	48,932	20,309	69,241	9	4.6	5
Area Total	21,356		132,985		1,981,258	948,239	2,929,497	—	4.6	—
State Total	30,600		234,557		?	?	?			
Area as % of State	69.8		56.7		?	?	?			

[1] Interim Report Statewide Water Conservation, Part II, Agricultural and Industrial, Wisconsin DNR, December 1981, p. 6.

[2] United States Census of Agriculture, 1978.

[3] Irrigable Lands Inventory—Phase I, Groundwater and Related Information, Wisconsin Geological and Natural History Survey, September, 1981 (aquifer potential maps).

example, limits the development potential. Summer frosts are a threat to crops grown in the lowlands of Wood and Portage Counties. Wetlands occupy large areas of Waushara County. Poorly-drained soils are found in eastern Marquette County. In addition, the existing vegetation (native jack pine or scrub oak) may pose somewhat of a barrier to expanded agricultural land uses (Collins, 1968).

No estimate has been made of the amount of land in the 5,394,560-acre region which has its irrigation potential reduced because of the presence of unsuitable geographic conditions of the kind discussed above. However, estimates are available of the amount of land in the ten-county area where the existing land use precludes the development of irrigated agriculture. Homes, commercial or industrial enterprises, and public facilities have been built on land which was equally well-suited for agriculture. A network of roads, highways, and railway lines connects the many cities and villages, which further reduces the amount of land on which irrigated agriculture crops might have been produced. According to figures compiled by the Golden Sands RC&D office, these urban or built-up areas occupy 4% (215,782 acres) of the region. The federal government controls the ownership of large tracts of land with agricultural potential (e.g., Fort

McCoy). State parks, waysides, and wildlife areas may, in part, be located on lands of agricultural opportunity. Public lands, considered collectively with the area covered over with streams or lakes, account for 10% (539,456 acres) of the ten counties. Woodlands cover 42% of the landscape (2,265,715 acres). Large, wooded holdings are corporation-owned (paper companies) while smaller parcels are held by individuals or public bodies (school system, county). Agricultural use of the land for pasture and cropland (2,373,606 acres) constitutes 9% and 35% of the area, respectively.

From the foregoing, it can be concluded that aquifer potential is but one of many factors to be weighed when determining the development potential for irrigated agriculture in central Wisconsin. One must subtract from the 3 million acres where ground water conditions are suitable for intensive agriculture the land area where other physical characteristics make it difficult, if not impossible, to develop the potential. Also to be deducted are those areas reserved for other human activity (residences, businesses, industry, recreation, transportation).

Economic and Environmental Impacts

The development of irrigated agriculture has had tremendous impacts on central Wisconsin. These impacts have been both positive and negative in character. On the positive side are the significant economic advances the region has experienced. Money received by producers of potatoes, sweet corn, and snap beans is reinvested through the purchase of local labor and goods. Part of the income farmers earn is passed along to state and federal government in the form of taxes. The increasingly valuable agricultural property is taxed by local government. Income and property taxes benefit all area residents, because they help maintain roads and highways, support schools and universities, and contribute to the nation's defense system.

The following facts brought out during a March, 1982 Conference on Irrigated Agriculture at Stevens Point reflect the importance of such activity to the area economy (Kenyon, 1982):

1. "Barren" land, once valued at a few dollars per acre, is now worth as much as $2000 per acre.
2. Area farmers annually earn $25 million from the sale of their products to two Portage County canning and potato processing companies.
3. One Portage County potato products firm has just invested $30 million in order to double its capacity (annual employee payroll, $12 million).
4. One Portage County canning plant processes twenty-six semi-trailer truck loads of snap beans per day during the peak production period.
5. More food is produced than can be consumed locally; consequently, one Portage County potato broker shipped out 5500 semi-trailer truck loads last year.

The negative features of irrigated agriculture are largely associated with the natural environment. The rapid growth of this method of farming has had adverse impacts on soil, water, and wildlife resources. These adverse impacts are exemplified by the following facts, also presented at the 3-82 conference.

1. Chemical substances manufactured for farmers to control plant pests or to stimulate crop growth have been carried downward through the soil into drinking water supplies by excessive amounts of rain or irrigation water.
2. The removal of wind breaks or natural vegetation cover on large fields cleared to accommodate self-propelled pivoting irrigation systems has resulted in loss or displacement of soil.

3. University reports have pointed out a loss of habitat for foxes, rabbits, grouse, songbirds, and other wildlife types where marshes have been drained or trees cleared to produce irrigated agricultural products.
   In addition, federal government research suggests that the development of lands for irrigation causes seasonal as well as long-term changes in ground water levels (Weeks, 1971).

There are still other impacts of irrigated agriculture which are neither economic nor environmental. For instance, there have been social-political consequences where such agricultural activity has been carried out in close proximity to rural subdivisions. Non-farm residences are not very compatible with intensive agricultural activity of the type associated with irrigation in central Wisconsin. The arguments about which human activity is the "highest or best use" or which activity was "located there first" are inevitable signs of this land use conflict.

Needed: A Regional Development Plan

Uncontrolled development of irrigated agriculture—just like uncontrolled urban development—is not in the best interests of society. If allowed to grow as projected without limits or bounds, irrigated agriculture could pose a threat to the long-term health and well-being of central Wisconsin residents (Butler, 1978). Short-range economic benefits should not take precedence over longer range environmental costs.

What is needed now are joint discussions between farmers, agri-business interests, and those knowledgable about natural resource management and protection. Such discussions will help pave the way for the eventual establishment of policies on the growth of irrigated agriculture in central Wisconsin. When policies like these are developed and in place, they will help guide the anticipated growth. Controlled growth will allow farmers and agri-businessmen to make a profit while at the same time reducing the possibility of adverse environmental side effects.

The purpose of such discussions would be 1) to examine the growth projections of irrigated agriculture from now until the year 2000; 2) to examine the complex set of factors which today influence the amount and location of irrigated agriculture in central Wisconsin; and 3) to discuss alternative policies, programs, and practices which government (local, state, federal) might employ to better guide the development of irrigated agriculture in the region over the next two decades.

The ideas distilled from such discussions could then be reviewed and evaluated. Those with the greatest promise of success would then be adopted by decision-makers, policy bodies, and law-makers in the interest of reasonable and rational development of irrigation between now and the year 2000 in the region.

Future growth of irrigation in central Wisconsin is inevitable. But there are two rather different possible scenarios for this growth. On the one hand, growth could occur haphazardly and explosively, to the detriment of both the economy and the environment of the area. On the other hand, the growth may occur in a systematic rational fashion as a result of thoughtful anticipation and the establishment of sound policy designed to accommodate it.

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GADWALL DUCK INTRODUCTION IN NORTHWESTERN WISCONSIN

James O. Evrard
Wisconsin Department of Natural Resources
Baldwin

Abstract

Gadwall (*Anas strepera*) ducklings were released into unoccupied habitat in northwestern Wisconsin in 1970 and 1972 in an effort to establish a breeding population. Despite heavy first-year hunting mortality, sufficient survivors returned in subsequent years to establish a modest but successful breeding population. Releasing a large number of ducklings can overcome the initial heavy hunting mortality.

Introduction

Releasing gadwalls into unoccupied habitat to establish breeding populations has been successful in several states in North America, including Massachusetts (Borden and Hochbaum 1966), New Jersey and New York (Henny and Holgerson 1974), and Minnesota (Moss 1975). In 1970 and 1972, young gadwall ducks were released in the Crex Meadows Wildlife Area (CMWA) in northwestern Wisconsin through a cooperative project between the U.S. Fish and Wildlife Service (USFWS) and the Wisconsin Department of Natural Resources (WDNR). The objective of stocking gadwalls was to fill an unoccupied niche created by intensive management of the CMWA.

I acknowledge the efforts in this project of J. Bergquist, W. Wheeler, R. Hunt, and P. Kooiker of the WDNR, F. Lee and H. Nelson of the USFWS, and N. Stone.

Study Area and Methods

The 10,820-ha CMWA, located in Burnett County, Wisconsin, is managed primarily for waterfowl, sharp-tailed grouse (*Pedioecetes phasianellus*) and prairie chicken (*Tympanuchus cupido*) by the WDNR. Intensive fire and water management has attempted to restore the prairie wetland complex to conditions similar to those existing at the time of white settlement in the 1850's. Detailed descriptions of the area and its management are given by Vogl (1964), Bergquist (1973), and Zicus (1974). Gadwalls were released in the 970-ha refuge located in the center of the CMWA. Gadwalls were not known to breed on the CMWA prior to the stocking experiment although there was a vague and doubtful historical breeding reference somewhere "in the extreme northern part of the state" reported by Kumlien and Hollister (1903). Breeding records do exist for southeastern Wisconsin (Jahn and Hunt 1964).

The refuge contains approximately 320 ha of open water; 240 ha are sedge (*Carex* spp.) and cattail (*Typha* spp.) marsh; 110 ha are cultivated (corn, rye, and buckwheat); 280 ha are brush prairie (big bluestem (*Andropogon gerardi*), little bluestem (*A. scoparius*), sweet fern (*Myrica asplenifolia*), hazel (*Corylus* spp.), and oak (*Quercus ellipsoidalis*) brush); and 16 ha are aspen (*Populus* spp.) forest. Soils are organic peats and deep sands of the Meenon-Newson Association overlying Cambrian sandstone. Climate is cool continental and precipitation averages 800 mm annually.

In 1970, gadwall eggs were collected by USFWS personnel on the J. Clark Sayler National Wildlife Refuge in North Dakota and were taken to the Northern Prairie Wildlife Research Center, Jamestown, North Dakota, for hatching. On 10 August 1970, WDNR personnel transported 400 4-week-old gadwalls (200 ♂, 200 ♀) at night by truck from Jamestown to the CMWA where they were released the following day into an open-topped, 2.4-ha pen. The ducklings were banded with standard USFWS aluminum leg bands and numbered, white plastic nasal saddles (Greenwood 1977) were placed on the females for field identification of individual birds in subsequent years. Mortality in the pen was low—only 4 females died before the birds became capable of flight and left the pen.

On 8 August 1972, 200 additional gadwall ducklings (95 ♂, 105 ♀) were sexed, leg-banded, and transported from Jamestown to the CMWA where they were released during the night in the refuge pen. A raccoon (*Procyon lotor*) killed 6 birds during the second week of confinement.

Waterfowl breeding transects have been conducted on the CMWA since 1957 to develop annual breeding pair and brood indices using criteria developed by Hammond (1969). The road transect covers 10.6 km^2 and is conducted every 7-10 days in May, June, and July. Roads are driven during the early morning and all waterfowl observed with 7×35 binoculars and 25×60 spotting scope are recorded.

Results and Discussion

In 1970, gadwalls left the CMWA by 8 November. There was apparent heavy hunting mortality with a direct recovery rate approaching 25%. Most direct recoveries were in the vicinity of the CMWA with nearly 70% from Wisconsin. Approximately 5% of the ducks checked (95) during the first 2 days of the 1970 hunting season on the CMWA were gadwalls. Prior to 1970, gadwalls averaged 1% of the opening-day duck harvest checked. Indirect recoveries continued through 1972.

Gadwalls were again observed on the CMWA in mid-April of 1971. The 7 May waterfowl survey indicated 7 pairs (3 of the females had nasal saddles) plus an extra drake on the 10.6 km^2 transect. Two nests, both subsequently destroyed by predators, were found in the release area. No broods were observed. In 1972, the only gadwalls observed were 5 drakes in a flock on 5 June.

Gadwalls released in 1972 also suffered heavy hunting mortality. Gadwall ducks made up 9% of the opening day harvest compared to none examined in 1971. From 1973 through 1979 when the evaluation of the stocking experiment ended, gadwalls averaged 1% of the opening day duck harvest on the CMWA.

Waterfowl breeding transects were not conducted in 1973. In 1974, 6 gadwall pairs were counted on the CMWA transect. The number of indicated pairs has varied from 3 to 7 from 1975 to 1979. Broods were observed in 1974 and 1978, establishing the gadwall as a breeding species on the CMWA. While densities of breeding pairs have not reached levels reported for prairie habitat by Borden and Hochbaum (1966), the gadwall ranks sixth numerically among the breeding duck species on the CMWA (Table 1).

Management Recommendations

Gadwalls have recently expanded their range in northeastern North America (Henny and Holgerson 1974), Cantin et al. 1976). This expansion can be aided by releas-

Table 1. Estimated density of waterfowl breeding pairs recorded on the Crex Meadows Wildlife Area transect, Wisconsin.

	Pairs/km^2				
Species	*1975*	*1976*	*1977*	*1978*	*1979*
Gadwall	0.6	0.6	0.6	0.3	0.5
Mallard *(Anas platyrhynchos)*	1.6	2.1	4.9	3.3	3.5
Blue-winged teal *(A. discors)*	3.6	4.5	5.0	5.1	4.3
Ring-necked duck *(Aythya collaris)*	1.8	1.8	1.3	1.5	3.1
Others[a]	0.7	1.9	2.7	1.4	2.5

[a] Black duck *(Anas rubripes),* Pintail *(A. acuta),* American wigeon *(A. americana),* Northern shoveler *(A. clypeata),* Green-winged teal *(A. carolinensis),* Canvasback *(Aythya valisineria),* and Hooded merganser *(Lophodytes cucullatus).*

ing ducklings into suitable, unoccupied habitat. The gentle-release method used on the CMWA was successful. Since the young birds are highly susceptible to hunting, the release should be made, where possible, in a large area closed to hunting. Special hunting restrictions for the gadwall are not practical due to the difficulty hunters have in identifying the bird (Evrard 1970) and the political resistance to restricting the harvest of a species relatively abundant over a large area. The best approach appears to be liberating a sufficiently large number of ducklings at any one location or time to overcome the heavy first-year hunting mortality.

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THESES ON CHRISTIAN VIOLENCE

KENT D. SHIFFERD
Department of History
Northland College

> "What causes wars and fightings among you?"
>
> James 4:1

Christianity is unique among the semitic religions in its disavowel of violence.[1] No stronger statements against violence can be found in religious literature than those by Jesus. Consider the following. "You have heard it said, 'An eye for an eye and a tooth for a tooth,' but I say to you, Do not resist one who is evil.", and, "You have heard it said, 'Love your neighbor and persecute your enemy,' but I say to you, Love your enemies and pray for those who persecute you." (Matt. 5:38, and 43); "Blessed are the peacemakers, for they shall be called the sons of God." (Matt. 5:39). Based on such teachings, countless observers across the centuries have agreed with the conclusion stated by George F. Thomas, that "In his life and teachings alike, Jesus showed himself to be truly the Prince of Peace."[2] The example of Jesus and his teachings inspire those who hope for a social order founded on love, cooperation, and the sanctity of human life. But there is a little discussed and oft-ignored tradition of brutality and violence exercised in the name of this teacher.[3] Why? Why have Christians found it easy to sanction and commit violence in Christ's name, especially when he appears to have eschewed violence?

We are led to raise the question of whether there is not some ethical contradiction in Christianity, either in the teachings of Jesus himself, or in the traditions about Jesus and in the dogma and precedents established by the Church throughout its history. I believe this to be the case, and until we face it, Christian violence will continue. If Christians cannot summon the courage to exorcise the demons in their own tradition, to pluck out the offending members, they will be powerless to control those surges of violence which have characterized their past. My own study is directed toward that end.

It is a somber fact of history that in the name of Christ, men have murdered and condoned murder, tortured women and children, slaughtered in war, and executed each other without remorse. There have been many types of Christian violence including early acts of violence during the reigns of the first Christian emperors, the infamous *gestae Francorum* reported by the Bishop of Tours, Charlemagne's brutal Christianizing of the pagans east of the Elbe, anti-semitic pogroms carried out on the way to the Crusades, the Crusades themselves, carried out against Moslems, the Albigensian Crusade in Europe, the Spanish Reconquista, the Inquistion, the trials and burnings for witchcraft and heresy, the violence of Protestant and Catholic during the Reformation, mistreatment of natives and of Africans by Christians in the history of the new world, the holy war of American Protestant ministers in World War One, and contemporary Christian advocates of violence such as the Lebanese Phalange, the Way, the Christian Patriots Defense League, and so on.

No one knows when the earliest act of Christian violence occurred. We have records of Christian mobs doing violence to non-Christians in the second century and any number of official acts of violence with the dawning of the age of Constantine.[4] It is not my purpose in this paper to describe the entire catalog of horrors perpetrated in Christ's name in the 2000 years since he himself was the victim of Roman violence.

My purpose is to offer for debate several theses about the genesis of Christian violence. The following list of examples of Christian violence is designed merely to sensitize the reader to the seriousness of the phenomena. Let us take, for example, the legendary Christian monarch, Charlemagne, who ". . . for eighteen campaigns waged war with untiring ferocity. Charles gave the conquered Saxons a choice between baptism and death and had 4,500 [unarmed] Saxon "rebels" beheaded in one day; after which he proceeded to Thionville to celebrate the nativity of Christ."[5]

In the sixteenth century Protestants and Catholics tore one another to pieces. Martin Luther, "stated again and again, especially during the time of the Peasant's War, that it is impossible 'to rule the world according to the Gospel.'"[6] Accordingly, he uttered his famous instruction to the princes to cut them down like dogs [etc.][7] But the Protestants had no monopoly on violence during this period. A Catholic attack on the town of La Garde yielded this report. "The four principle men of La Garde were hanged and the clergyman was thrown from the top of his church steeple."[8]

A single example will suffice from the seventeenth century. There is a painting above the alter at Notre Dames des Victoires in Quebec, showing an English warship sinking beneath the waves of the St. Lawrence, her sailers drowning, and flying over this scene an angel of the Lord, bearing a shield with the inscription, "Deus providebat." It commemorates the destruction of Walker's fleet in 1690. Of course, the casting of wars in the mold of religion is not an isolated event in Christian history. Our Civil War gave us the great marching Battle Hymn of the Republic. At the inception of that tragic struggle, New Yorker George T. Strong, wrote, "Exsurgat Deus!" Calling "for God to rise up, he viewed the conflict as a 'religious war—more important to mankind than any since the Saracen invasion . . . was beat back by Charles Martel.' In Georgia, Charles C. Jones saw it as 'a national judgment' that 'comes from God . . . to accomplish given ends.'"[9]

Our own century also bears witness to Christian violence. The first World War was interpreted in Christian terms on both sides.

Americans did not enter the war until 1917 and the religious community was almost universally pacifist on religious grounds. Then it turned 180° and preached holy war. Turning pages of Christian journals from the year 1917 we find such assertions as, "We must help in the bayonetting of a normally decent German soldier in order to free him from a tyranny which he presently accepts as his choosen form of government."[10] One might wonder what would have been Jesus' response to such an assertion. A clergyman did, asking and answering what is perhaps the most bizarre question in the history of Christian ethics. "Would He [Christ] fight and kill? There is not an opportunity to deal death to the enemy that He would shirk. . . . He would take bayonet and bomb and rifle and do the work of deadliness against that which is the most deadly enemy of his Father's kingdom in a thousand years."[11] The phenomenon of Christian holy war is not some historic fossil, left behind in the middle ages.

Today we read in the newspapers of evidence of Christian advocacy of violence. The Way is a contemporary sect founded by Paul Wierwolle. A disaffected ex-Way member recently told a reporter, "A leader took me aside and told me not to worry. If people outside the Way were killed [in the coming revolution] he said it was no worse than animals dying because the people aren't saved and have no souls."[12] The militaristic tendencies of the new Christian conservatism are accompanied by a kind of Christian xenophobia as well. I recently saw the following grafitti on a wall at a great Midwestern university. "Don't feel sorry for the starving of the third world. They are the people of Satan and it's God's purpose that they starve."

We are here face to face with the least attractive visage of Christianity, and would do well to ask if these pathetic and reprehensible people are indeed Christians at all.

The only workable definition of Christian I have encountered is that all who call themselves Christians, are. We cannot simply dismiss the violence of Christian history as being the non-Christian part of that history. Nor would those who committed the violence do so. Charlemagne sincerely believed he was the ideal Christian monarch. Making distinctions is unfaithful to the past and, as C. S. Lewis has pointed out, linguistically unworkable.

> Now if once we allow people to start spiritualizing and refining, or as they might say, 'deepening,' the sense of the word Christian, it too will speedily become a useless word. . . . It is not for us to say who, in the deepest sense, is or is not close to the spirit of Christ. We do not see into men's hearts. We cannot judge, and are indeed forbidden to judge. It would be wicked arrogance for us to say that any man is, or is not, a Christian in this refined sense. . . . We must therefore stick to the original and obvious meaning. The name *Christians* was first given at Antioch (Acts xi.26) to 'the disciples', to those who accepted the teachings of the Apostles. When a man who accepts the Christian doctrine lives unworthily of it, it is much clearer to say he is a bad Christian than to say he is not a Christian."[13]

In fact, I would not even go so far as to distinguish between "good" and "bad" if by those terms Lewis means faithfulness to the true tradition. There is, nevertheless, a clear distinction, even contradiction, between the various elements of the tradition. I believe Christian advocates of violence are responding to certain other, bona fide elements of their tradition, a tradition which years of study and teaching has convinced me is complex, paradoxical, even a multidox.

The hypotheses I advance to account for the paradox of Christian violence can be classified into three groups: historical, doctrinal and social. In the first I suggest that Christianity inherited from Judaism a violent set of mind. In the second I suggest that certain aspects of Christian doctrine, rooted in the New Testament and elaborated by the Fathers of the Church, contain the seeds of violence. Third, I suggest that the social conditions to which Christianity adapted itself, with which it made its peace, guaranteed that it would be at least in part a religion of violence.[14]

Christianity inherited a violent mind set from Judaism. *Jaweh is a Warrior*, is the title of a recent book.[15] From earliest times the God of Israel was associated with violence. After the crossing of the Red (or Reed) Sea the Israelites sang this song to their deity:

> I will sing to Yaweh for he has triumphed gloriously;
> the horse and the rider he has thrown into the sea.
> Yaweh is my strength and my song,
> And he is my salvation;
> this is my God and I will praise him,
> My father's God and I will exalt him.
> *Yahweh is a man of war.*
> (Exodus 15:1, my emphasis)

Millard Lind points out, "There is no question but that the exercise of military power is the theme of this poem."[16] Yahweh becomes King in this paradigmatic experience—the warrior-god-king of Israel,[17] providing a normative image rich in possibilities made actual in the later course of Christian history. Even before the Exodus, in Egypt, society is divided into God's people and God's enemies, the latter (including non-combatants who are the enemy after all, the "people of Satan" as the graffitti had it) are struck down by the willful violence of Jahweh exercising his powers over nature. "I know that the king of Egypt will not let you go unless compelled by a mighty hand. So I will stretch out my hand and smite Egypt. . . . (Exod. 3:19) Moses, Jahweh's designated, slays an Egyptian. "It may not be insignificant that according to the tradition Moses was of the house of Levi (Exod. 2:1), a house already associated with violence in the Book of Genesis."[18] One could elaborate this for many pages. The Conquest of Canaan was a series of divinely commanded and aided military campaigns, or at the least it was seen so by the Hebrews (the doubts of current scholars being irrelevant—what we are seeking here is the *imago dei*). It was a conquest "involving a great deal of violence, [a conclusion] based not only on the simplified account of the book of Joshua, but on the archeological evidence as well."[19] Joshua reads, "So Joshua defeated the whole land . . . he left none remaining but *utterly destoyed all that breathed, as Yahweh* God of Israel *commanded.* (Josh. 10:40, by emphasis) In the song of Deborah in Judges, Jael is called "most blessed of women" because she:

> put her hand to the tent peg
>   and her right hand to the workman's mallet,
> She struck Sisera a blow,
> She crushed his head,
> She shattered and pierced his temple.
> He sank, he fell,
> He lay still at her feet. . . .
> There he fell dead. (Judges 5:24-27)

"Thou shalt not kill" does not apply to the enemies of God. Whatever we can conclude about the image of God *in toto* in the Old Testament, it is in part that of a violent deity who destroys armies, commands his people to commit genocide, and praises single acts of brutality. From the time of the Exodus to the wars of the Maccabees the Jewish God was associated in the minds of his believers with violence.[20] The argument of Vernard Eller, that all this is God's war and the Hebrews are expected to stand by and let God do it, is not only morally hypocritical—especially from the victims' point of view—but unfaithful to the Biblical text and without scholarly foundation. His is the valiant effort of a Christian pacifist to recast a tradition he can't bear to abandon, a tradition that is not wholly pacifist.[21] Thus, the warrior god is the first part of the violent legacy and Old Testament bequeathed to the Christians.

The second part is the eschatology of late Palestinian Judaism. Roman domination and Persian influence brought about a greatly heightened anxiety and laid the psychological preconditions for violence. The Roman conquest in 63 B.C. ended any realistic prospect that Israel would work out her divine future in the political sphere. "The redemption she hoped for in the future was not [to be] a real historical event, but a fantastic affair in which all history had been brought to an end for good and all."[22] God was no longer transcendent over history. ". . . another idea of transcendence came instead. God, like his people, was cut adrift from history. . . . He now became universal Lord of Heaven and earth . . . judge of the world."[23] He would bring about the fearful Last Days, the end of history itself. This awful event was made necessary by the power of sin on earth, for if God no longer operated in history, Satan did. Part of this was the influence of Persian dualism, the notion that at the Last Days the forces of light will lock in global combat with the forces of darkness. "Sin appeared to be an ineluctible power, spreading its tentacles over the whole world, and affecting the heart of the individual. . . ."[24] The Last Days would be accompanied by the coming of a Messiah. Of course, there were many variations on these themes. Some still hoped for divinely-aided political victory for the "one annointed of God to fulfill his purposes, like the ancient kings of Israel—who would overthrow the enemies of God."[25]

It is difficult for us to perceive how real and concrete was this mass anxiety.

> Evil is not to be thought of here as a philosophical abstraction: for the first-century man, it was a personal matter . . . evil existed as personal forces with which the universe, the community, and the individual were all involved . . . evil was a personal being, called

> simply 'the serpent,' who introduced to Adam and Eve the idea of questioning the will of God, and then of rebelling against it. In late Judaism the tempter was identified as Satan—*i.e.,* the Adversary. In the Book of Daniel, intersteller space is peopled with demonic beings so powerful that they can delay the messengers of God (Dan. 10). This dualistic conception of evil . . . was probably adopted by the Hebrews during the period of their contact with the Persians, whose religion was characterized by a sharp division of cosmic forces into good and evil, engaged in constant warfare . . .[26]

John the Baptist was only one of the pre-Christian heralds of the Last Judgment. "He felt called upon to announce an immanent crisis in world history. The content of his message is preserved in the Q source (Matt. 3:7-10, Luke 3:7-9). Here such phrases as 'Wrath to come' and 'ax is laid to the root of the trees' indicate that John was proclaiming the event long awaited by the Jews: God's final judgment upon the evils of the world."[27] The final struggle against Satan is on, and it is against the humans who are his helpers. "Satan," write Kee and Young, "is assisted by men who submit themselves to his purpose and thereby gain extraordinary powers. Others are involuntarily possessed by demons. . . . [this doctrine became a petri dish for the culturing of witch-burners.] Jesus's words in Mark 3:27 clearly imply that before the constructive work of establishing the rule of God can be completed the Kingdom of Satan must be destroyed."[28]

The new eschatological doctrines with their concept of a final struggle against Satan and a day of wrathful judgment to come, a judgment in which not only are men sent to everlasting hell, but cosmic violence is employed to destroy earth, all raised the stakes in the conflict between good and evil, including our own participation in it. Anxiety was raised to a high level. Feelings of anxiety, fear and anger are preconditions for violence. When the last judgment failed to occur on schedule, when it was put off again and again, each delay increasing both the desire for it and the fear of it, the event, with all its symbolic mythology, became suspended in a limbo of the future where it would fuel the hopes and fears and provide a rationale for first century Christians and for others down through history. The Last Judgment is God's Final Battle. Which side are you on?, is the question put by this terrible dualism. *Thus in late Palestinian Judaic eschatology we have both a violent and angry God and his enemies. Coupled with the holy war motif of the Old Testament we have the rationale and the role models for violence, both bequeathed as a legacy to whichever Christians would, in the future, feel the need to avail themselves of them. This argument comprises my first thesis about Christian violence.* The next five theses fall under the heading of Christian doctrine.

Any scholar or teacher who has attempted to elucidate early Christian doctrine knows it is a mass of confusion. Nevertheless, *the root of my second thesis is that the moral and ethical pronouncements of Jesus himself are confusing.*

Jesus' teachings on love, forgiveness, and non-violence may seem clear and unambiguous. For example, he instructed to forgive "seventy times seven" (Matt. 18:22), yet I know of no medieval "witch" who was forgiven 490 times before being burnt after her 491st conviction. The problem with Jesus' non-violent ethic is two fold. First, it has been watered down by interpretation, or simply rejected outright by his followers who wiggle through all manner of rationalizations in the process, as Key and Young point out. Jesus'

> . . . demand is for unimpeachable integrity and singleness of purpose, purity of heart. Discerning listeners—in Jesus' own day and ever since—have been prompted to explain: 'what man is capable of this?' . . . They have claimed that such teaching is utterly unrealistic in our world. . . . Some have said that we are not to take his demands literally. What Jesus meant to do was simply to illustrate the

> ideal attitude. . . . Others have insisted that Jesus' words must be taken literally . . . but that they cannot be complied with in this world . . . man can only fulfill them when God finally brings about the consummation of the kingdom. . . . Still others have sought to cope . . . by asserting that they are not practical, applicable, or even relevant to life in this world. They are to be understood only in terms of the coming of God's final judgment. . . . Jesus' ethic has been called an interim ethic . . . in expectation of the immediate end of the world.[29]

These enervating rationalizations appear to be contradictions of Jesus' ethic. Key and Young think they are. But one can only adopt such a position if one remains blind to the second part of the problem and that is Jesus's own statements to the contrary. While he did not adopt the holy war themes of the Old Testament, he did embrace the violent eschatology of late Palestinian Judaism. Indeed, he can be understood in no other terms. Thus, while Jesus' own teachings on pacifism and non-violence may seem clear, they do not exhaust his statements regarding violence.

In Luke 13:49-54, Jesus is quoted in his most violent statement.

> I came to cast fire upon the earth; and would that it were already kindled! I have a baptism to be baptized with: and how I am constrained until it is accomplished! Do you think that I have come to give peace on earth? No, I tell you, but rather division; for henceforth in one house there will be five divided, three against two and two against three; they will be divided, father against son and son against father, mother against daughter and daughter against her mother, mother-in-law against her daughter-in-law and daughter-in-law against her mother-in-law.

Matthew's account of this episode leaves out the first two sentences and adds the following to the end,

> and a man's foes will be those of his own household. He who loves father or mother more than me is not worthy of me; and he who loves son or daughter more than me is not worthy of me; and he who does not take his cross and follow me is not worthy of me. He who finds his life will lose it, and he who loses his life for my sake will find it. (Matt. 10: 38-39)

This makes it appear that Jesus is only using the language of violence in a metaphorical sense. He is not, perhaps, counseling physical violence against the members of one's own family, but merely saying that some will 'believe' while others won't, and that Christians must be willing to alienate their closest family members for sake of their religion. The various scriptural accounts are not identical and are subject to comparative interpretation, and they have been subjected to varying interpretations according to the needs of the historical ages in which Christians have lived and sought guidance from the scriptures.

One of the most difficult passages for Christian pacifists to explain is the single violent act of Jesus; although it should be pointed out that in the rejected non-canonical infancy gospels and other New Testament apocrypha, the young Jesus performs several violent acts including murder. Mark, the earliest gospel, reports: "And he entered the temple and began to drive out those who sold and bought in the temple, and he overturned the tables of the money-changers and the seats of those who sold pigeons (Mark 11:15-17). Luke's account, written later, is spare: "And he entered the temple and began to drive out those who sold, saying to them. 'It is written, 'My house shall be a house of prayer'; but you have made it a den of robbers.'" (Luke 19:45-46) The account of John, which is the latest, is more descriptive, adding, "And making a whip of cords, he drove them all, with the sheep and oxen, out of the temple, and he poured out the coins of the money changers and overturned their tables." In the accounts of this action, Jesus is neither meek, nor merciful, nor forgiving. He is intolerant.

Indeed, Jesus is extremely intolerant of those who do not believe he is a special messenger of God. The famous verses which open the Gospel of John begin with God's love for man, but end with God's condemnation of Man. "For God so loved the world that he gave his only begotten son, that whoever believes in him should not perish but have eternal life. For God sent the Son into the world, not to condemn the world, but that the world might be saved through him. He who believes in him is not condemned; he who does not believe is condemned already, because he has not believed in the name of the only son of God. (John 3:4-19) (Although unclear in some versions, these words are attributed to Jesus in the World Publishing Company's "Rainbow Edition" in which Jesus' words are printed in red ink.) In this teaching, God, unforgiving of unbelievers leaves them a choice of believing or perishing. At the Last Supper, Jesus appears to couple the love ethic with a violent punishment for those who fail to heed it, in what seems to be an inconsistency.

> When the Son of man comes in his glory, and all the angels with him, then he will sit on his glorious throne. Before him will be gathered all the nations, and he will separate them one from another as a shepherd separates the sheep from the goats, and he will place the sheep at his right hand, but the goats at the left. Then the King will say to those at his right hand, 'Come, O blessed of my Father, inherit the kingdom prepared for you from the foundation of the world; for I was hungry and you gave me food, I was thirsty and you gave me drink, I was a stranger and you welcomed me, I was naked and you clothed me, I was sick and you visited me, I was in prison and you came to me.' . . . Then he will say to those at his left hand, 'Depart from me, you cursed, into the eternal fire prepared for the devil and his angels; for I was hungry and you gave me no food, I was thirsty and you gave me no drink, I was a stranger and you did not welcome me, naked and you did not clothe me, sick and in prison and you did not visit me.' . . . And they will go away into eternal punishment, but the righteous into eternal life. (Matt. 25:31-36, 41, 42, 43, 46)

This teaching is typical of many of Jesus' utterances. He believed that mankind would separate into two groups, one favored, and the other accused. "He who is not with me is against me." (Luke 10:23) Jesus believed in a *dies irae* when a wrathful God would do violence to that part of mankind who had rejected him. He said to the multitudes, "You brood of vipers! Who warned you to flee from the wrath to come?", and, "Even now the axe is laid to the root of the trees; every tree that does not therefore bear good fruit is cut down and thrown into the fire." (Luke 3:7, 9) Asking the question, "When the Son of man comes, will he find faith on earth?" (Luke 18:8), he in Matthew reports his answer, given in the parable of the weeds of the field.

> "He who sows the good seed is the Son of man; the field is the world, and the good seed means the sons of the kingdom; the weeds are the sons of the evil one, and the enemy who sowed them is the devil; the harvest is the close of the age, and the reapers are angels. Just as the weeds are gathered and burned with fire, so will it be at the close of the age. The Son of man will send his angels, and they will gather out of his kingdom all causes of sin and all evildoers, and throw them into the furnace of fire; there men will weep and gnash their teeth. (Matt. 13:36-43)

In Mark, Jesus says, "But woe to him by whom the Son of man is betrayed." (Mark 17:21) Similarly in Luke: "And I tell you, everyone who acknowledges me before men, the Son of man also will acknowledge before the angels of God; but he who denies me before men, will be denied before the angels of God." (Luke 12:8-9) And "He who hates me hates my father also." (John 15:23) Indeed, whoever falls from the teaching will suffer punishments worse than physical mutilation. For example:

> Whoever causes one of these little ones who believe in me to sin, it would be better for him if a great millstone were hung round his neck and he were thrown into the sea. And if your hand causes you to sin, cut it off; it is better

> for you to enter life maimed than with two hands to go to hell, to the unquenchable fire. (Mark 9:42-48)

Those who do not accept Christ are reminded of the divine violence against Sodom. (Luke 10:10-15 and 17:22-37) In the parable of the vineyard, the fate of those who reject God is thus: "He will come and destroy those tenants, and give the vineyard to others. . . . The very stone which the builders rejected [*i.e.* Christ] has become the head of the corner. Everyone who falls on that stone will be broken to pieces; but when it falls on anyone it will crush him." (Luke 20:16-18) In John's gospel Jesus is reported as saying: "I am the vine, you are the branches. He who abides in me and I in him he it is that bears much fruit, for apart from me you can do nothing. If a man does not abide in me, he is cast forth as a branch and withers; and the branches are gathered and thrown into the fire and burned." (John 15:5-6) The language of Jesus is rich in the imagery of violence, but he also spoke directly and plainly. "You brood of vipers! how can you speak good when you are evil? . . . I tell you on the day of Judgment men will render account for every careless word they utter for by your words you will be justified, and by your words you will be condemned." (Matt. 12:34-36)

Professor Meinhold points out, "In the apocalyptic speeches of Christ the multiplication of wars, the filling of the earth with cries of wars, is a sign of man's deep involvement with the antidivine powers and of his degeneration. War, as an eschatological event, is both cause and result of sin.[30]

The same confusion or lack of ethical clarity characterizes the rest of the New Testament which is not, as Key and Young point out, ". . . a single, unified work, but an anthology of writings serving a variety of objectives and originating in widely scattered parts of the empire over a range in time of about a century. So we must not expect elaborate or systematic treatments of either ethical or theological matters."[31] What frequently happens, then, is that Christians choose the saying of Jesus or Paul that informs the moment. Ethics is governed by the principle of expediency.

But there was more confusion in the testimony of the early Christian centuries than merely ethical confusion, there was an immense theological confusion that resulted from the efforts to understand a Jewish prophet in terms of both the mystery religions of the east and the rational philosophy of the Greeks. While this may have been an intellectually fertile time, it led to two consequences which have great significance for the history of Christian violence. These are the mutual rejection of Christians and Jews and the long, brutal history of anti-semitism that culminated in the Holocaust, on the one hand. And, on the other hand, it led to the phenomenon of orthodoxy and heresy. Since so much was at stake, *i.e.,* the fate of the ultimate being, God himself, and the fate of all mankind at the last judgment, since the stakes were on a cosmic scale, and the whole business cast in a radical dualism of good people versus the enemies of God, it is easy to understand why so much violence has been done to dissenters (the confusion being so great and so much being at stake). Theses three and four, then, are that the theological confusion led to the creation and subsequent hatred of "The Jews" and of the heretic. Both were nurtured in the virulent, emotional hothouse of early Christian eschatology.

Rosemary Reuther has demonstrated in *Faith and Fratricide* that anti-semitism has its roots in the very core of Christian theology, that Christian scripture created the stereotype of "The Jew," the assassin of God's prophets and finally of God himself.[32] Christianity is an exclusivist religion, deliberately shutting out all who disagree, pronouncing them anathema. The first people shut out were the Jews. Reuther shows that the anti-Jewish trends in Christianity go back to earliest times and are linked to their proclamation of Jesus as the Christ which brought with it a new way of reading the scriptures. These were interpreted as scriptures. These were interpreted as signs of the coming of Christ and of his rejection by his own people. Gregory Baum, who introduces the book, writes that, ". . . the Christian affirmation of Jesus as the Christ was accompanied by a refutation of the synogogal reading of the Scriptures [*i.e.,* refutation, which Rosemary Ruether calls 'the left hand of Christology,' is the source and origin of Christian anti-semitism.[33] Reuther herself writes, "On the one hand, the Church argues that the true meaning of the Scriptures is that of a prophecy of Jesus as the Christ. And, on the other hand, it developed a collection of texts 'against the Jews' to show why the authority of the official Jewish tradition should be discounted when it refutes this Christological midrash of its own Scriptures."[34]

What powered this hostility was the great and unexpected disappointment at the failure of Jesus' Jerusalem mission to usher in the Last Days. Instead it ended with his execution as a common criminal. How could this happen to someone they believed was the Messiah? Especially when the very fact that it did happen convinced most Jewish people that he wasn't?[35] The only possible explanation was that it was destined to happen and they had to find proof of it in the Scriptures. Believing as they did, then, "Those who refused to believe in his name would be rejected from Israel and have no part in the community of salvation. Now the Church knew that it and it alone understood the real meaning of the Scriptures."[36] "Why," asks Reuther, "was it necessary to emphasize that the Jewish religious tradition not only rejects the gospel, but tries to kill its messengers (including its 'forerunners,' the prophets)? We would suggest that this theme in the Christian tradition developed from the crucial need to make religious sense out of the crucifixion itself, *i.e.* to provide a dogmatic necessity for the fact that the Prophet-King-Son of Man is not only to be unheard by an unbelieving people, but that *it was predicted that he should be killed by them.* This was accomplished by reading back into Jewish history a pattern of an apostate Israel which has always rejected the prophets and killed them."[37] The attitude a believer must adopt toward the perpetrators of this most monstrous sacrilege was clear. ". . . Christianity vilified Judaism outside its converted community as an apostate, sinful, worse than Gentiles, and even of the devil. It regarded the others as fallen outside the true covenant and ranked with the enemies of God. Hypocrites, blind fools, blind guides, whitewashed tombs, serpents, offspring of vipers and children of hell are among the epithets heaped upon rival interpreters (*i.e.,* Jews (of the tradition in the Gospel of Matthew."[38]

The "Jew," then, was created by the Christian as the first and worst heretic. As long as the Christians remained an insignificant minority in the Roman empire their violent and arrogant attitudes toward the Jews were inconsequential. When they captured the empire they captured the tools for actualizing their violence against the Jews. It is not far from that position to the First Crusade and its attendent massacres of Jews along the way to the Holy Land. The reasoning went, "why should we concern ourselves with going to war against the Ishmaelites [*i.e.,* the Moslems] dwelling about Jerusalem when in our midst is a people who disrespect our God—indeed, their ancestors are those who crucified him. Why should we let them live and tolerate their dwelling among us? Let us commence by using our swords against them."[39] Thus the theological conversion of Jesus into the classic eastern type of the dying personal saviour god activated the desire for revenge against those held responsible for his death. That his death was held to be inevitable and pre-destined and that the whole doctrine of the atonement, so central to salvation, would have been rendered meaningless without it, appears never to have occured to anyone. What the Jews were accused of and were powerless to prevent was the facilitation of the central event of salvation.

The ethical Jesus was submerged by the eschatological Jesus, a trend he himself began, and which gained force with the elaboration of Christian theologies and the heretical controversies that inevitably followed from that elaboration.

The most common cultural pattern for religion to take is mythical, that is, particular deities and their acts are not significant in and of themselves but rather point to a greater reality behind their mere appearance. Thus several versions of an event can be told without any threat or challenge to the validity of the ultimate truth which each version represents. Thus Egyptian creation stories signify several particular geographic locations which were the first place land appeared as the primeval watery chaos subsided.[40] Rationally speaking this is a contradiction in terms, since only one could be the first. However, the validity rests not with the historic event, but rather with the great message behind it, *i.e.,* that the universe is indeed a cosmos, a divinely ordered system. And in the mythic religions, the greatest message is the fundamental unity of the cosmos, including the ultimate union of man and God.[41] "Myth," according to Alan Watts, "is to be defined as a complex of stories—some no doubt fact, and some fantasy—which, for various reasons, human beings regard as demonstrations of the inner meaning of the universe and human life. Myth is quite different from philosophy in the sense of abstract concepts, . . ."[42] In a mythic approach to religion the concept of heresy makes no sense, and many different paths are recognized as leading to God or the Ultimate Unity.

Christianity partakes of the mythic approach, especially as it was expressed by the great mystics of the Middle Ages. But, says Watts, it unfortunately tries to treat myth as fact, resulting in deep ideological confusion.

> The confusion has its roots in the fact that Christian dogma is a blend of Hebrew mythology and history with Greek metaphysic and science. . . . As a result, then, Christian dogma combines a mythological story, which is for the most part Hebrew, and a group of metaphysical 'concepts' which are Greek, and then proceeds to treat both as statements of fact . . . in other words, it talks about mythology and metaphysic in the language of science. The resulting confusion has been so vast, and has so muddled Western thought, that all our current terms, our very language, so partake of the confusion that they can hardly straighten it out.[43]

This muddle had more than intellectual significance, for it was one cause of several that, a thousand years later, led to the roasting alive of young women for the "crimes" of heresy and witchcraft.

"Almost from the beginning," writes Watts, "Christian orthodoxy began to insist on the scientific rather than the metaphysical or mythical interpretation of the divine revelation.[44] Christianity became a peculiarly legalistic or creedal religion that put its adherents to the test of words. The influence of Hellenistic rationalism on the minds of the Fathers led them to put the great question of religion in the form, "what must the true Christian believe?", and to heatedly argue and debate ever more subtle points of doctrine until a welter of theological ideas rushed hither and thither throughout the Mediterranean civilizations. Cross-currents, tides, up-wellings, ebbed and flowed as a great intellectual plasma for several centuries. Complicating the picture was the welter of texts being read as scripture, more than four times what eventually found its way into the canon. For the first four centuries there were many Christian pathways to God, but this multiplasmic situation was vigorously opposed by many who early sought to reduce it all to deceptively simple creeds. Even after the canon was fixed at twenty seven books, they contained too much material of a polyglot nature to serve as a "scientific" rule of faith and, writes Oscar Cullmann (*The Earliest Christian Confessions*) "the essential content had to be extracted."[45] These creeds were mainly theological and not ethical statements. They concentrate on Jesus as a divine being rather than on Jesus as a teacher. Thus evolved a number of bitterly contested positions about who Jesus was and what it all meant in cosmic terms. Ideas barely mentioned in the scripture or not at all were elaborated into complex theological edifaces, such notions as the pre-existence of Jesus, the incarnation, the divine sacrifice as atonement for the sins of all mankind, the sacrament of the Eucharist as the physical body and blood of Christ and the whole complex and fundamentally illogical doctrine of the trinity, the idea of powers of evil and Christ's relationship with them, the last judgment, and so forth, evolved over centuries and attempts were made to codify them in brief, trenchant symbols fully understandable only by professional intellectuals. To the illiterate masses, among whom we must number most Christians for most of Christian history, it was impossible to make sense of it. Yet it was crucial! One's eternal fate rested on it, a fate either blissful or, depending on knowing the right answers to the theological puzzle, incredibly violent.

Indeed, the doctrine of an afterlife led in some cases to a devaluation of human life in the here and now. What counted was one's eternal fate, and this life, this body and its physical pains were only a means to the end of eternal life. Thus people could literally be killed in the belief it was for their own good, for they would be sent on to divine judgment. The most notorius of such cases is the statement attributed by Caesar von Heisterbach to Arnald-Almaric, a leader of the 13th century Crusades against the Albigensian heretics in southern France. On ordering the massacre of the people of Beziers, Arnald-Almaric is reputed to have said, "Kill them all, God will look after his own."[46]

How was it that the sword came to be wielded for Christ, against men, women, and even children? I believe the long road of violence led out of the doctrines of late Palestinean Judaism and of early, Hellenized Christianity, with their peculiar emphasis on exclusivity.

Those who pursued the creation of an orthodoxy, and it was done from many sides of the sea, including the losers who ended up being declared heretics, generally agreed that Christianity was an exclusionist religion.

> Christianity is a monopolistic faith in that, like later Judaism and Islam, it claims to be the one true faith, a faith destined to prevail for all on earth. The Christian wants to spread Christianity and he has often spread it with the sword; moreover, he wants the right kind of Christianity, his own. . . .[47]

Christianity evolved from an ideologically fluid religion to one in which creedal orthodoxy was favored, yet, at the same time, it represented a gigantic fertile synchretism of Greek, Persian, Hebraic and Gnostic ideas which have for two thousand years resisted efforts to reduce their living complexity to dead formula. What is perhaps the most multi- faceted collection of powerful religious ideas in the world was nevertheless, subjected to the creedalizing process. The effort to state the ineffable in scientific terms led to the mutually generating phenomena of orthodoxy and heresy. Not only was this development an intellectual necessity, *sui generis,* but the social and political matrix of the believers also fostered it. So important was the formulation of this true creed for social stability, that men were fighting over it in the late third century. "At least as early as the Arian controversy at the end of the third century Christians were resorting to bodily violence to further the work of God."[48] It threatened to disrupt the empire, and Constantine was forced to intervene.

The social context and causes of Christian violence became readily apparent with the identification of Church and State in the early fourth century. I have already alluded to the mutual rejection of the infant Church and the Jews, a rejection made necessary by orthodox Christology, or what eventually became orthodox Christology after the bishops had triumphed over the Gnostic churches. But there was a social dimension as well. The two churches became two separate communities, competing for converts in the same towns and cities of the empire. The peculiar Christology of the orthodox, and the social competition for converts, laid the foundation for twenty centuries of both latent and manifest anti-semitic violence which, by the twentieth had become so interwoven into the social fabric of Europe as to generate the Holocaust. This was possible beause Christianity captured the state and by means of it, the majority of the population. From Constantine to our own day the cross and sword of state have frequently been conjoined and the state has been the form in which it presented itself to the people. However, the first struggle over the social forms in which Christianity was to express itself in late antiquity was the struggle between the Gnostics' open-ended theologies and proto-democratic churches and their opponents, the creedalizing bishops who eventually won and established their own political authority as the proponents of the "true" faith within Christendom.

Elaine Pagels has demonstrated in *The Gnostic Gospels* that the struggle to reduce Christian faith to an authoritarian Creed, thus excluding the theologically rich alternatives, was as much a social struggle for political domination of the Christian masses, as it was an ideological struggle. She writes,

> Traditionally, historians have told us that the orthodox objected to gnostic views for religious and philosophical reasons. Certainly they did; yet investigation of newly discovered gnostic sources suggests another dimension of the controversy. It suggests that these religious debates—questions of the nature of God, or of Christ—simultaneously bear social and political implications that are crucial to the development of Christianity as an organized religion.[49]

One of the areas of disagreement was over the nature of Christ's resurrection. The Gnostics held it to have been a resurrection in spirit only. The orthodox bishops held it to be a bodily resurrection made manifest to the apostles from whom authority among Christians was passed in apostolic succession to themselves. Pagels observes, ". . . we can see, paradoxically, that the doctrine of bodily resurrection also serves an essential *political* function; it legitimizes the authority of certain men who claim to exercise exclusive leadership over the churches as the successors of the apostle Peter."[50]

Another institutional question was that of the role of women within the Church. The Gnostics admitted women to full membership as priests. This greatly offended the orthodox, male, bishops such as Tertullian, who suspects they not only preach and cure but even perform the office of baptism. "These heretical women," wrote the bishop, "how audacious they are! They have no modesty; they are bold enough to teach, to engage in argument, to enact exorcisms, to undertake cures, and, it may be, even to baptize!"[51] Tertullian charged the churches otherwise. "It is not permitted for a woman to speak in the Church, nor is it permitted for her to teach, nor to baptize, nor to offer [the eucharist], nor to claim for herself any share in the *masculine* function, not to mention any priestly office."[52] A thousand years later the Church would make as one of its justifications for the slaughter of the Albigensians the argument that they allowed women to perform priestly functions.

Pagels also points out that the two kinds of Christians split on the issue of martyrdom, with the bishops encouraging it and gnostic apologists opposing it as a ghastly blasphemy. The gnostic author of *The Testimony of the Truth,* ". . . ridicules orthodox teachers who, like Ignatius and Tertullian, see martyrdom as an offering to God and who have the idea that God desires 'human sacrifice:' such a belief makes God into a cannibal."[53] Pagels argues that the orthodox bishops believed the attack from the state could only be met by an institutional consolidation under (their) strong leadership, and could thus brook no opposition, especially from the Gnostics who were attacking the Church's most effective testimonial act, the act of martyrdom. Increasingly the bishops coerced their followers by threat of hell, and by withholding the eucharist, into conformity to an ever more rigid doctrine, hierarchy, ritual and canon. "The bishops drew the line against all who challenged any of the three elements of this system: doctrine, ritual, and clerical hierarchy—and the Gnostics challenged them all."[54] Thus did the church of Jesus, who had said, "Come unto me *all* ye who are heavy laden," (Matt. 11:28) become an excluding church, shutting out those Christians who had a different understanding of the sacred mystery, or who preferred congregational autonomy, or who admitted women to full participation.

The way in which these "orthodox" Christians dealt with this first "heresy" set the pattern for the ages to follow. They equated a particular form of Christian organization—theirs—with the right statement of the faith, and whoso rejected one was held to have rejected the other. The bishop Ignatius put it unequivocally:

> It is not legitimate either to baptize or to hold an *agape* [cult meal] without the bishop . . . To join with the bishop is to join the Church; to separate oneself from the bishop is to separate oneself not only from the church, but from God himself.[55]

Thus did the Church early on equate itself with God. When one recalls that the personality and will of God imaged in the Judaic and Christian scriptures included enemies and a violent punishment of these enemies, it becomes more understandable how it was that the bishops, acting for their God, in his place, could transform their own violent emotions and language into overt violence against those who disagreed with them. Once they captured the state of Constantine, and all of its successors, they would translate their hostility into acts of violence against those whom they would call "heretics."

The problematic relation between Christ and culture was sketched many years ago by H. Richard Niebuhr. He pointed to the polarity between the claims of Christ and the claims of society, between the One and the many, the eternal and the temporal, the absolute and the relative, the universal and the specific, the single-mindedness of Christ (mind God, all else will be taken care of) and the many concerns necessary to a functioning society. Polytheistic and mythic religions are not confronted by this problem. Christianity is. And it is complicated by the fact that the universal, absolute, divine message of Christ was delivered in the relativistic and culture-bound person of Jesus of Nazareth, thus confusing the issue of how particular Christians located in particular cultures at specific moments in history should act. Niebuhr suggests that,

> an infinite dialogue must develop in the Christian conscience and the Christian community . . . The dialogue proceeds with denials and affirmations, reconstructions, compromises, and new denials. Neither individual nor church can come to a stopping place in endless search for an answer which will not provoke a new rejoinder.[56]

The various positions actually taken by the Church, *i.e.,* whether it rejected a particular cultural context in which it found itself, or whether it affirmed the culture and its claims, depended in part on how much power it could wield in the social world. It also depended on which social classes and ethnic groups were in control of the Church hierarchy at the time. What did not change was the Church's implacable hostility toward those who did not agree with it, whether they, or the church itself, were in, or out, of power.

Before the church came to power and when it was a lower class phenomenon (slaves, fishermen, etc.), it violently repudiated Roman culture and, in the language metaphor employed in the book of Revelations, looked to the day when Babylon, the whore-monger, (*i.e.* Rome), would be destroyed by the cosmic assault of Christ himself. (Rev. 2:19-29,6,8,9,etc.) Again, note the violence of early Christians' eschatology. "So the four angels were released . . . to kill a third of mankind." (9:15). When the church stood outside the gates of power it cursed the social order and called down doom upon it. Then came the Edict of Milan (313), when those gates opened and the powerful embraced the church, the social order was sanctified and, as was the case earlier with the hierarchy itself, the social order and God were equated. Meinhold reports,

> Soon after the edict of tolerance of 313 . . . the Synod of Arles decreed that soldiers who deserted must be excommunicated from the Church . . . The monogram of Christ was affixed to the helmet of the soldiers and to the standards of the emperor's armies. With these changes the church indicated she was now ready to honor the profession of soldier and to encourage military service by Christians. From now on the wars which the Christian emperors were waging were considered wars for the propagation of the Gospel. . . ."[57]

Clearly, "the relationship between church and state changed radically under Constantine the Great (306-360) . . . The church, on her part, gave up her negative attitude toward the state. The state had become her friend and now provided her with an opportunity for missionary work . . ."[58] Church and state began to merge as Christianity, the universal, eternal and absolutist religion made compromise with the particular, temporal and relative society of Byzantium. Christ became lost in, or at least identified with a particular culture, and what is more, the needs and prerogatives of Church and state were so woven together as to be incapable of disentanglement. ". . . the imperial church, which was closely identified with the court of the Eastern Roman Empire, patterned her organization closely after that of the state. Her laws were the laws of the state."[59] In 346 A.D. the pagan temples were closed and the death penalty decreed for anyone found performing the old sacrifices.[60]

The merger between Christianity and the state during the age of Constantine became ever more firmly established. When the emperor Theodosius installed Nestor as Bishop of Constantinople, the latter preached a sermon in which he told the emperor, "Give me, my prince, the earth purged of heretics, and I will give you heaven as a recompense. Assist me in destroying heretics, and I will assist you in vanquishing the Persians."[61] Nestor clearly believed himself to be the Vicar of a god who was engaged in deadly warfare against enemies at home and abroad, and he makes alliance with the state to use its weapons of death against all who could not (would not) assent to a particular creedal formulation of faith.

Still, the problem of which creed was valid plagued the church and was the occasion for much internal violence.

Being a Christian, the emperor Constantius found out, was not a clear cut thing. At first he supported the Arians. When he replaced an orthodox bishop with an Arian prelate, riots broke out and three thousand persons lost their lives. Durant speculates that "probably more Christians were slaughtered by Christians in these two years (342-343) than by all the persecutions of Christians by pagans in the history of Rome."[62]

Certain of the Donatist heretics, in particular, evolved a cult of religious violence. These were priests who decried the efficacy of sacraments administered by priests who were in a state of sin. The state church turned immediately to the weapons now at its disposal and, using imperial troops, forcibly removed them from their churches. Reacting to the Church, which was now identified not only with the state but with the wealthy as well, some of them became Christian revolutionaries.

> Bands of revolutionaries, at once Christian and communist, took form under the name of Arcumcelliones, or prowlers; they condemned poverty and slavery, cancelled debts and liberated slaves and proposed to restore the

> mythical equality of primitive man. . . . Usually they contented themselves with robbery; but sometimes, irritated by resistance, they would blind the orthodox or the rich by rubbing lime into their eyes, or would beat them to death with clubs; or so their enemies relate. If they in turn met death they rejoiced, certain of paradise. Fanaticism finally captured them completely; they gave themselves up as heretics, and solicited martyrdom; they stopped wayfarers and asked to be killed; and when even their enemies tired of complying, they leaped into fire, or jumped from precipices, or walked into the sea.[63]

In a curious inversion of violence, these angry men at last turned upon themselves.

For a brief moment, the emperor Julian (361-363) tried to undo the alliance between Christianity and the state. He was killed on the Persian front. The historian Libanius believed he was assassinated by one of his own, Christian troops. Sozomen, another Christian observer, praised the assassin, "who, for the sake of God and religion, had performed so bold a deed."[64] Julian was the last apostate. Ever after the Church would make free use of the sword of state. The violence that was latent in Christian doctrine, rooted in its Judaic foundations, potential in its exclusion of all but one pathway to God, explicit in its eschatology, made necessary by its legalistic creedalism, was activated by its alliance with the state.

Another aspect of the Christ and culture problem was that the Christian leadership was variously captured by different ethnic groups and social classes whose position in society made them prone to violence, or whose particular historic traditions cherished warrior values. I have already noted that the early church was sometimes represented by the spokesmen of the exploited and alienated lower classes, hostile to the then-pagan ruling classes. And it is common knowledge that, once Christianized, the ruling classes came to dominate the church, especially in the Middle Ages in Europe, where the Christian social sanction of the feudal order gave Marx occasion to characterize Christianity as the "opiate of the masses."[65] The powerful and rich had much to defend against the lower classes and were not above using religion to do so. One need think only of Martin Luther, siding with the Princes during the great peasant rebellions of 1525. He specifically instructed the Princes, "For a prince or a lord must remember in this case that he is God's minister and the servant of his wrath (Romans, xiii), to whom the sword is committed for use upon such fellows. . . ."[66]

The Princes with whom Luther sided had had a long heritage of Christian violence. They were, or claimed to be, descendants of teutonic warriors and Vikings whose entire male-dominant social order was organized around military virtues.

The transformation of Christianity into a full blown warrior religion by the Normans is nowhere more penetratingly analyzed than in Henry Adams' *Mont-Saint-Michele and Chartres.* High on a summit overlooking the Atlantic the Normans raised a great abby church in the early twelfth century. Atop it they placed a statue of the archangel Michael.

> Standing on the summit of the tower that crowned his church, wings upspread, sword uplifted, the devil crawling beneath, and the cock, symbol of eternal vigilance, perched on his mailed foot, Saint Michael held a place of his own in heaven and on earth which seems . . . hardly to leave room for the Virgin of the Crypt at Chartres, still less for the Beau Christ of the thirteenth century at Amiens. The Archangel stands for Church and State, and both militant. He is the conqueror of Satan . . . His place was where the danger was the greatest; therefore you find him here. For the same reason he was, while the pagan danger lasted, the patron saint of France. So the Normans, when they were converted to Christianity, put themselves under this powerful protection.[67]

Here we do not have "the peace which passeth understanding."

Here in the great hall of the abbey Church the Duke (William the Conquerer) and his men listened to their favorite secular work, the Chanson du Roland. In the climactic death scene of the poem we are not very far from the old Viking faith.

> God the Father was the feudal seigneur, who raised Lazarus—his baron or vassel—from the grave . . . God the Father, as feudal seigneur, absorbs the Trinity and, what is more significant, absorbs or excludes also the Virgin, who is not mentioned in [Roland's] prayer. To this seigneur, Roland, in dying, proffered his right hand gauntlet. Death was an act of homage. God sent down his archangel Gabriel as his representative to receive the homage and accept the glory.[68]

Thus dies the archetypical hero of medieval literature—a Christian warrior, slain while slaying Jahweh's enemies, the merciful Mary and Christ not mentioned by the poet. Such was the Christian religion of the Normans whose case is one more evidence for the insights offered by H. Richard Neihbuhr in *Christ and Culture.* Culture captured Christ. These warriors were indeed men of God.

That the church was a thoroughly masculine institution has been alluded to elsewhere. If women were allowed in they were cloistered. The Churchman's relations with women (scandel- mongers of the Reformation notwithstanding) were either relations of fantasy, as was perhaps the source of psychological energy that powered the cult of the Virgin in the high middle ages; or, they were the relations of violence which resulted in the extermination of millions of women Churchmen thought to be out of step with true Christianity.[69] These unfortunate females were the so-called witches. In a classic case of psychological projection, the celibate clergy transferred their own repressed desires, guilt and anger onto females.

> According to the church, all of the witches power was ultimately derived from her sexuality. Her career began with sexual intercourse with the devil and wild orgies at the Sabat . . . The Malleus Maleficareum, or Hamer of Witches, stated that all witchcraft comes from carnal lust which in women is insatiable.[70]

The authors of the Maleus were subject to delusions such as the following:

> . . . what is to be thought of those witches who in this way sometimes collect male organs in great numbers, as many as twenty or thirty members together, and put them on a bird's nest or shut them up in a box, where they move themselves like living members, and eat oats and corn, as has been seen my many and is a matter of common report.[71]

It was this sort of evidence that caused historian G. Rattray Taylor to exclaim that the whole of Medieval Europe was "one vast insane asylum."[72] That is, of course, a gross exaggeration, but it should not blind us to the facts of neurotic male agression directed against women. But, whether the most pathetic example of Christian violence against the helpless is the Saxon prisoner bowing his head to the sword of the executioner, or the old women being tied to a stake by the spokesmen of Christ, in each case, a male dominated group is responsible. Masculinity is a common thread running through the history of Christian violence, whether it be an expression of dominant norms, as is the case of the warriors of Mont- Saint-Michele, or mental illness, as with the witch-hunters, or whether, as some recent research suggests, it be genetic.[73] Men are violent, and the history of the Christian religion has been in the main the history of Christian men.

My purpose in this paper has been to suggest that in spite of the fact that some of Jesus' exhortations are to love and non-violence, that historic Christianity is a religion afflicted with violence, and to offer several theses toward an explanation of this curious and usually shunned contradiction. These theses have included the following ideas: that the Judaic foundation of Christianity contains a strong tradition of divine violence; that late Roman Palestinian eschatology as developed by Christianity contains strong overtones of violence and eagerness for revenge on unbelievers; that the Christian assertion and Jewish rejection of Jesus as Messiah provided the framework for 2000 years of anti-semitic violence culminating in the Nazi genocide of the twentieth century; that the confusion of traditions (Judaic, Greco-Roman, Gnostic, *et alia*) in early Christian thought led to a felt need for creedal clarity, which rendered orthodox Christianity exclusionist, thereby defining and identifying those against whom it is permitted to exercise the anger of the wrathful God; and that the Christian movement was socialized in various ways that made the contradiction of its love ethic an historic necessity. Among the latter are included the contest with the Gnostics which began, among other things, the long and violent history of Christian sexism, culminating in the witch craze of 1500-1700; the confusion of Christianity with the needs of a particular social class, whether underdogs or rulers, and the infusion into Christianity of all the hatreds and passions of the class struggle; the capture of the hierarchy by the Germanic warrior tribes whose patron, the Archangel Michael, perfectly represented their militant Viking-style Christianity and whose ethos informed the Crusades; the capture of the church by males generally, and, finally, and most important, the alliance of Church and State. It may well be that this last is the sufficient cause for Christian violence and all the others are but necessary causes. That the socialization of the church into the norms of violence proved so easy and was almost unopposed suggests that the potential for violence, and the acceptance of violence, lies deeply buried in Christian doctrine. If so, this is a tragedy because much that is good is also rooted there.

Notes

[1] Vernad Eller. *War and Peace from Genesis to Revelation* (Scottdale, Pa.: Herald Press, 1981), p. 11

[2] George F. Thomas. *Christian Ethics and Moral Philosophy* (New York: Charles Scribner's Sons, 1955), p. 348.

[3] Harry Girvitz notes how little work has been done on the topic of violence and quotes Hannah Arendt who "also finds it surprising 'that violence has been singled out so seldom for consideration.'" I found almost nothing under this heading in card catalogues, literature indices or book indices, the more so in the area of religions, church history and ethics. "An Anatomy of Violence" in Sherman Stanage, *Reason and Violence* (Totowa, N.J.: Littlefield, Adams, 1974), p. 183.

[4] Thomas, *op. cit.*

[5] Will Durant. *The Age of Faith* (New York: Simon & Schuster, 1950), p. 462.

[6] Peter Meinhold. *Caesars or Gods?: Conflict of Church and State in Modern Society* (Minneapolis: Augsberg Pub. House, 1962), p. 106.

[7] Martin Luther, "Against the Robbing and Murdering Horde of Peasants," in Durant, *The Age of Faith* (New York: Simon & Schuster, 1957), p. 390. To wit "Therefore let everyone who can, smite, slay, and stab, secretly or openly . . . It is just when one must kill a mad dog. . . ."

[8] Amos Blanchard. *Book of Martyrs* (N.G. Ellis: Kingston, U.C., 1842), p. 121.

[9] Thomas B. Allen (ed.). *We Americans* (Washington, D.C.: National Geographic Society, 1976).

[10] "The Advocate of Peace" in Ray H. Abrams, *Preachers Present Arms* (New York: Round Table Press, 1933), p. 160.

[11] *Ibid.*, p. 68.

[12] Paul Maccabee. "The Way Invades Minneapolis," Twin Cities Reader, Vol. 6, No. 10, March 19-26, p. 8.

[13] C. S. Lewis. *Mere Christianity* (New York: Macmillan, 1952), p. 11. Historian Crane Brinton has arrived at a similar conclusion. "Since for centuries all Westerners were in a formal sense Christian, the actual conduct of men called 'Christians' has run the gamut of Western capacities, which are many and varied. It is at least clear that many different beliefs, many different human personalities, many kinds of conduct . . . have been given 'Christian' as an attribute. . . . I shall rarely mean by *Christian* all men known as Christians. I shall try to make clear when I am dealing with most, many, or even average ordinary Christians, and when I am trying to set up a Christian type, ideal, or pattern." *A History of Western Morals* (New York: Harcourt, Brace & Co., 1959), p. 149.

[14] Phillip Hallie. "Satan, Evil and Good in History" in Sherman Stanage (ed.) *Reason & Violence* (Totowa, N.J.: Littlefield, Adams & Co., 1974), p. 59, reminds us, "One does not do evil out of the blue. One does it under many pressures . . . It is a part of personal and public history, a resultant of many forces, as they say in physics."

[15] Millard C. Lind. *Jaweh Is A Warrior* (Scottdale, Pa.: Herald Press, 1980).

[16] *Ibid.*, pp. 48-49.
[17] *Ibid.*, p. 50, "Yahweh the warrior becomes Yahweh the king."
[18] *Ibid.*, p. 62.
[19] *Ibid.*, p. 65.
[20] *Ibid.*, p. 65.
[21] Eller, *op. cit.* cf. Chapter 3 "It's His war. Let Him fight it!," and elswhere. This is Eller's thesis.
[22] Rudolph Bultman. *Primitive Christianity In Its Contemporary Setting* (Philadelphia: Fortress Press, 1956), pp. 60-61.
[23] *Ibid., loc. cit.*
[24] *Ibid.*, p. 70.
[25] H. C. Key and F. W. Young. *Understanding the New Testament,* 2nd ed. (Englewood Cliffs, N.J.: Prentice Hall, 1965), p. 47.
[26] *Ibid.*, pp. 57-58.
[27] *Ibid.*, p. 80.
[28] *Ibid.*, p. 58.
[29] *Ibid.*, pp. 136-137.
[30] Meinhold, *op. cit.*, p. 124.
[31] *Ibid.*, pp. 66-67.
[32] Rosemary Ruether. *Faith and Fratricide: The Theological Roots of Anti-semitism* (New York: Seabury Press, 1979).
[33] Gregory Baum in Reuther, *op. cit.*, p. 12.
[34] Ruether, *op. cit.*, p. 65.
[35] *Ibid.*, p. 69.
[36] *Ibid.*, p. 72.
[37] *Ibid.*, p. 90.
[38] *Ibid.*, pp. 74 & 75.
[39] Slomo Eidelberg (ed.). *The Jews and the Crusaders: The Hebrew Chronicles of the First and Second Crusades* (Madison: Univ. of Wis. Press, 1977), p. 26.
[40] John Wilson in Henri Frankfort (Ed.) *Before Philosophy* (Baltimore: Penguin, 1949), p. 80.
[41] *Ibid.*, p. 36. This is also Alan Watts' point in *Myth and Ritual in Christianity* (Boston, Beacon Press, 1968), prologue.
[42] Alan Watts, *op. cit.*, p. 7.
[43] *Ibid.*, p. 62.
[44] *Ibid.*, p. 70.
[45] Oscar Cullman. *The Earliest Christian Confessions* (London: Latterworth Press, 1949), p. 11.
[46] Zoe Oldenbourg. *Massacre at Montsegur* (New York: Minerva Press, 1968), p. 116.
[47] Crane Brinton. *A History of Christian Morals* (New York: Harcourt Brace & Co., 1959), p. 150.
[48] *Ibid.*, p. 161.
[49] Elaine Pagels. *The Gnostic Gospels* (New York: Random House, 1979), p. xxxvi.
[50] *Ibid.*, p. 6.
[51] *Ibid.*, p. 60.
[52] *Ibid.*, p. 60.
[53] *Ibid.*, p. 92.
[54] *Ibid.*, p. 118.
[55] *Ibid.*, p. 105.
[56] H. Richard Niebuhr. *Christ and Culture* (New York: Harper, 1956), pp. 39-40.
[57] Meinhold, *op. cit.*, p. 131.
[58] *Ibid.*, p. 38.
[59] *Ibid.*, p. 38.
[60] Leo Pfeffer. *Church, State and Freedom* (Boston, Beacon Press, 1953), p. 13.
[61] *Ibid.*, p. 13.
[62] Durant, *op. cit.*, p. 47.
[63] Meinhold, *op. cit.*, p. 8.
[64] *Ibid.*, p. 20.
[65] Karl Marx, actually "Die Religion . . . ist das Opium des Voelkes," from his *Kritik der Hegelschen Rechtsphilosophie,* the introduction.
[66] Will Durant. *The Reformation* (New York: Simon and Schuster, 1957), p. 390.
[67] Henry Adams. *Mont-Saint-Michelle and Chartres* (New York: Mentor, 1961), p. 15.
[68] *Ibid.*, pp. 42-43.
[69] Mary Daly. *Gyn/Ecology* (Boston: Beacon Press, 1978). For these and other references on witchcraft, I am indebted to Deeana Copeland.
[70] Deeana Copeland, "The European Witch Craze of the 15th-17th Centuries," unpublished manuscript, p. 2.
[71] Daly, *op. cit.*
[72] As quoted in Url Lanharn's *Origins of Modern Biology* (New York: Columbia University Press, 1968), p. 77.
[73] Melvin Konner. "She and He," *Science '82,* Vol. 3, No. 7, Sept. 1982, p. 57.

THE LOSS OF AN ENTIRE WETLAND HABITAT AND ITS WILD BIRD POPULATIONS[1]

ROBERT A. MCCABE
Department of Wildlife Ecology
University of Wisconsin, Madison

The loss of avian habitats by natural means has been occurring from the time of the origin of birds in the early Jurassic 150,000,000 years ago to the present. Probably never in that long and occasionally violent period did greater losses take place than those caused during the last few centuries by technology in the hands of man.

In recent years we have become acutely aware of endangered bird species. Protective legislation in the form of restrictions on the capture, killing, or interference with critical species have been the main measures employed to reduce further losses. But when the food and cover needed for animal survival is seriously altered, the carrying capacity of the habitat is reduced, and when these habitat attributes are destroyed, the animal population is lost.

Exploitation of avian habitats in the name of progress by industry, agriculture, or recreation is at the root of the endangering process. Wherever man alters land, water, animals or plants to achieve individual or collective advantage, those birds that are obligate to that environment will be in jeopardy.

Loss of avian habitats has been justified on the grounds that the loss was necessary to benefit man. Today after many such habitats are already lost and the welfare of many birds is critical, we attempt to understand and, on occasion, to rectify the situation. One of the key aspects to the understanding is to know what and how much has been lost. Often there are few such data and even less information on the cause or the motivation for the habitat destruction.

The objective of this report is to record the loss of bird life brought about by the destruction of an aquatic habitat in an agricultural environment.

The location of this aquatic habitat, 3 miles (5 km) north of Sun Prairie, first appears on Ligousky's 1861 *Map of Dane County* (Wisconsin) as Lake Brasee (L. Brazee). It has been variously measured as 164 (65.6 ha), 122 (48.8 ha), and 170 (68 ha) acres, apparently depending on the season of the year when it was measured. It had about 2.3 miles (3.7 km) of shoreline in most years, and was 1,050 m long and 810 m wide at its greatest dimensions (Figure 1). In periods of drought and low watertable, part of the lake was dry and put into crops. I heard unsubstantiated reports that the lake "drained naturally" in some years and then subse-

Fig. 1. Aerial view of Brazee Lake prior to drainage. The long axis of the lake is oriented N-S.

[1] This paper was read before the International Ornithological Congress in Moscow, USSR, in August, 1982.

quently over several years gradually returned to its status as a lake. It was also alleged to have been spring fed, but I found no spring flowing into the lake. The main source of water was from ground water and surface drainage. There is no stream in or out of the wetland. Water was lost mainly during the summer, by evapotransportation. Its maximum depth in June 1950 was about 4½ feet (1.4 m).

The emergent vegetation along the shoreline was sedge (*Eleocharis, Scirpus, Carex,* and *Cyperus*), cattail (*Typha*), and bullrush (*Juncus*). In the water area, arrowhead (*Sagittaria*), pondweeds (*Potamogeton* sp.), particularly sago pond weed (*P. pectinatus*), Bur reed (*Sparganium* sp.), and Duck weed (*Lemna minor*) were common.

The main landowner petitioned the state ca. 1954 for permission to drain the lake so the land could be used for agriculture. The Wisconsin Department of Natural Resources brought legal action to prevent the drainage. I testified as a wildlife ecologist in support of the state's position that the lake had greater public value as a natural area than as cornfield that would profit only two or three landowners. The court, however, ruled in favor of the landowners, and the lake was drained the following year.

Bird disappearance was almost immediate. Although no species counts were made in the years following drainage, observation indicated that the most water-obligate birds (e.g., black tern, coot, ducks) disappeared first. Some red-winged blackbirds, and even yellowheaded blackbirds returned for at least three years before abandoning the marsh area completely.

One of the important ornithological aspects of Brazee Lake was the largest known colony of yellow-headed blackbirds in southern Wisconsin. These large handsome blackbirds were the primary species in a study of all the marsh birds which I began in 1947. A lake-edge study area of 1.32 ha (Figure 2) was set up on the west side of the lake. This was facilitated by a road that paralleled the shore of the marsh and by a line of telephone poles leading to a farm house on the far southwest edge of the lake. Numbers were painted high on each telephone pole large enough to be seen from the widest part of the study site. Nests found in the marsh were located by orienting to the numbered poles.

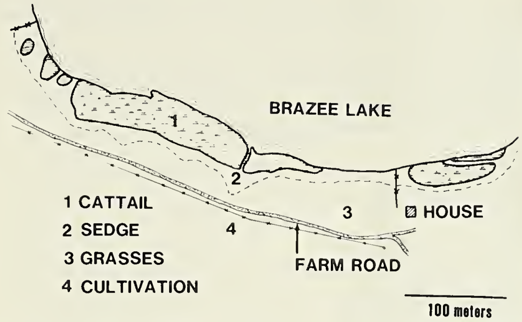

Fig. 2. The wetland study area where the yellow-headed blackbird colony was located.

Life-history data, ecology, and behavior data were recorded by a field staff of three persons. All nests were marked and examined twice a week and occasionally more often. Data on the breeding ecology of the marsh birds are not germane to this paper but the five-year nest total for yellow-headed blackbirds was 246.

All other bird nests found in the study area were also recorded during the field work. In all, 646 nests of 15 species were examined (Table 1). This amounts to 127 nests per ha in the year with the largest bird population and 76 per ha in the year of the lowest density, averaging 96 per ha over the 5-year period.

The data in this paper have not been published previously primarily because those of us interested in the lake and its marshy shores had hoped that the cropping scheme would fail, the lake would reclaim its own, and we could initiate periodic studies in this wetland. This has not occurred in spite of several crop failures, because outside financial support from the federal government and nonfarm income allowed the farmers to

TABLE 1. Active nests in the study area.[1]

Species	*1947*	*1948*	*1949*	*1950*	*1951*	*Total*
Yellow-headed Blackbird *Xanthocephalus xanthocephalus*	56	69	56	39	26	246
Black Tern *Chlidonias niger*	11	38	56	8	28	141
Coot *Fulica americana*	25	14	13	19	20	91
Common Gallinule *Gallinula chloropus*	11	14	7	13	12	57
Ruddy Duck *Oxyrua jamaicensis*	6	12	3	5	6	32
Pied-billed Grebe *Podilymbus podiceps*	0	11	2	1	12	26
Red-winged Blackbird *Agelaius phoeniceus*	5	5	2	1	5	18
Marsh Wren (long-billed) *Cistothorus palustris*	1	2	0	14	1	18
Least Bittern *Ixobrychus exilis*	0	3	1	0	2	6
Total	115	168	140	100	112	635

[1] Six other species had less than 6 nests each in the 5-year study.

continue the cropping program. Even in 1982 only part of the lakebed was suitable for corn production. Corn and silence dominate this once sound-filled, dynamic avian environment.

Technology has provided the means, and financial advantage the motive, for man to destroy the environment of wild creatures. Birds are only one, albeit major, example of dwindling habitat in this process we regard as progress.

Public lethargy and court rulings in favor of an individual's right to destroy what was legally his place the integrity of many bird habitats in jeopardy. Although some avian habitats are naturally transient through plant succession and ecological change, the responsibility of the wildlife manager and concerned laymen is to aid and abet factors holding a habitat in a given stage to promote the welfare of the avian species that rely on a static or slowly changing environment. Avian habitats are lost when gross physical change alters the ecological attributes or the plant succession of a bird's habitat.

The most insidious aspect of such loss of avian habitat, in particular wetlands, is that the loss usually represents a financial gain for *someone, somewhere.* The *someone* is often not in need of financial help and may be *somewhere* far from the site of the habitat destruction—out of sight and out of mind. Humanity is loath to accept responsibility for its own environment as well as that for wild creatures. This reluctance is difficult to understand because we in the USA and perhaps elsewhere in the world can recognize and identify the loss but are inept to do anything but record the damage.

In June 1982 the National Wildlife Federation (of USA sportsmen organizations) wrote in a major report:

> "It is estimated that we have lost at least 40 percent of the original wetlands in the lower 48 states. Of the approximately 148 million acres of wetlands we have now, we lose more than 300,000 [120,000 ha] each year. Some experts estimate that the loss is as high as 600,000 [240,000] acres each year. In the United States, coastal marshes have been disappearing at a

> rate of about one-half percent per year. One million acres of coastal marsh have been lost since 1954. By the year 2000, if the present rate of marsh loss continues, an additional one million acres will have been destroyed.
>
> A look at wetland losses across the country paints a stark and disturbing picture of the fate of wetlands—and equally, the fate of much of our wildlife."

In the Midwest where this Wisconsin study took place, the situation is even worse. Precise data are not available, and current state law has removed most restraints on drainage. The report continues:

> "Marshes along the Great Lakes have decreased 70 percent. These marshes not only provide habitat for fish and wildlife (for example, spawning habitat for northern pike), but they also help to prevent shoreline erosion and minimize the destructive effects of storms."

Apart from the loss of birds through the loss of their habitats, destruction of wild environments is often irreversible. Lack (*Jour. An. Ecology,* Vol. 34, 1965) makes a case for basic understanding of the biota itself. He states (p. 229):

> "There is therefore an urgent need for the conservation of natural habitats because, apart from their beauty, it is only here that some of the fundamental problems of biology can be studied. Partly, but only partly, I therefore think that the popular emphasis in conservation propaganda on rare or threatened species is misplaced. It evidently pleases many people that Pere David's deer *Elaphurus davidianus* survives in zoos, or that two pairs of ospreys *Pandion haliaetus* bred last year in Scotland, but I would cheerfully lose these and other scarce animals altogether if, in return, we could conserve examples of the most important natural habitats with their associated animals; and for the study of higher vertebrates, such as birds, extensive areas are required."

Fundamentally, Lack was correct in his assessment almost twenty years ago. Although I would not cheerfully accept the demise of any bird species, I too feel that as biologists we have paid too little attention to the role of lost or degraded habitats in appraising the plight of those birds (and other animals) that are becoming rare or that are truly endangered.

The loss of wetland habitats is easily rationalized because in their natural state they have little commercial value and often impede commercial schemes to achieve financial advantage. Wetlands are easily changed or destroyed by drainage, filling, sometimes by flooding, and more recently by pollution. Agriculture, urbanization, land fills (trash dumps), road systems, and hydro-electric schemes have taken a drastic toll of wetland habitats.

In the United States an Environmental Protection Agency report (1980) estimates that 120,000 ha of wetlands are lost annually. No data are available on the loss of birds by this loss of aquatic habitat. What I report here is a shameful microcosm that focuses on the need to protect all wetlands for the benefit of the wildlife resources and the public amenities associated with natural environments. We have yet to provide the legal and economic mechanisms to protect our wetlands, which recent studies have shown to have immense public value in protecting water quality and ground water recharge, and in reducing flood damage, as well as for wildlife habitat. Some form of compensation to the landowner might deter the drainage rig and plow and thus save many valuable wetlands.

Acknowledgments

The field work was ably assisted by Robert S. Ellarson, James B. Hale, Arnold S. Jackson, Jr., and Fredric H. Wagner. Editorial suggestions were made by Marie S. McCabe and J. J. Hickey. Research support was provided by the College of Agricultural and Life Sciences, University of Wisconsin, Madison, and the Charles W. Bunn Memorial Fund.

ASPEN UTILIZATION BY BEAVER *(CASTOR CANADENSIS)* IN NORTHERN WISCONSIN

Reed B. Johnson
Port Edwards, Wisconsin

Abstract

Johnson, Reed B. 1983. Aspen utilization by beaver *(Castor canadensis)* in northern Wisconsin. A quantitative survey of the feeding relationships of beaver at two ponds showed quaking aspen *(Populus tremuloides)* was the main food. Approximately 44 g/day (dry wt) of aspen inner bark were eaten by each adult beaver. Mixed coniferous-deciduous forest, with ample aspen, birch and willow, existed at both sites. The relationship between tree size cut and the amount of inner bark utilized was also examined. It was found that 1) proportionally more inner bark remained unutilized in larger trees which were cut, 2) generally, trees 3 to 5 in. in diameter were most likely to lodge in other trees when felled and thus remain unutilized, 3) approximately 9 to 12% of the available food from cut aspen was unutilized at each site.

Exploitation of beaver (*Castor canadensis*) was largely responsible for the early exploration of the northern United States and Canada by fur trappers. After near extirpation by overtrapping beaver have recovered well. Today populations have reached such levels that they are considered a nuisance in many areas.

The beaver has a great ecological impact upon the surrounding environment. Damming of streams floods valuable lowland forests, and occasionally, roads. Forest structure and composition near the ponds are altered by the cutting of large numbers of trees. Beaver meadows are formed when dams of abandoned ponds decay, lowering the water levels and allowing marsh vegetation to invade (Kendeigh 1974:84).

Whether one considers beaver a potentially valuable natural resource or a nuisance, it is important to have quantitative knowledge of the animals' food habits. A study was carried out from 14 May to 21 August, 1981, to observe feeding ecology of beaver in northern Wisconsin. Areas surrounding two beaver ponds were surveyed for forest composition, beaver food gathering strategies and food types. Various relationships between tree size and food utilization were examined in detail.

Study Areas

The study was conducted on two active ponds in T39N, R4E, Sects 21 and 22, Oneida Co., Wisconsin. Pond 1 was located on a small stream about 1 mi SSE of Squaw Lake. The feeding area at this pond was roughly 300 yds W of the lodge. Pond 2 was located on Stone Creek about 1.5 mi N of Stone Lake. There were two feeding areas located on the west side of the pond about 100 yds S and 250 yds N of the beaver lodge.

Methods

The quarter method (W.S. Brooks, pers. comm.) was used to determine the forest composition of feeding areas and surrounding forest at pond 1 and one feeding area at pond 2. The other feeding area at pond 2 was not surveyed for forest composition as it had recently been commercially harvested, so no mature trees existed in this area. Transect lines and sampling points along those lines were approximately 25 yds apart. Live trees and beaver cut stumps were counted only if at least 3 in. dbh (diameter breast height) or at the height of the cut, respectively.

To determine the total annual quantity of inner bark eaten, height and diameter at cut were measured for all trees that had been cut by beaver within the last two years. Approximate age of the cut was determined by peeling bark from the stump and observing wood appearance. Those stumps more than two years old were not recorded.

Populations of two adult beaver and several young were observed at each pond. Calculations were based upon populations of three adult beaver per pond, the third "adult" allowing for the young which consume approximately the same amount of food annually as a single adult.

To determine the quantity of potential food per tree, a quaking aspen (*Populus tremuloides*) of the average size used by beaver was cut about 12 in. above the ground. From base to branches, 15 in. sections were cut and measured for diameter at both ends. The outer cork was shaved from these sections with a knife and the inner bark (cambium and phloem) was peeled off and stored in labeled plastic bags for later dry weight measurements. Approximately 10 to 15% of the branches were peeled and the inner bark similarly stored. Bark was dried for 48 h at 90°C and weighed immediately.

To determine the quantity of unutilized food per cut tree at each pond, measurements of the length, and diameter at the base and top of the untouched logs were recorded. At each feeding area the number of aspen trees lodging in other trees when cut were counted and their base diameters taken.

Results and Discussion

Rue (1964: 42) stated that every beaver pond has an occupation time limit regulated by food availability. Beaver prefer to feed near water both for safety from predators and for ease in food transport. At both ponds, feeding activity was always within 100 ft of the water. Several strategies have been developed by beaver to increase ease in procurement of food sources. The water level may be raised by increasing the size of the dam or building alternate dams, thus bringing more food within reach. This process is efficient, but limited by danger of flooding the lodge if the water levels are raised too much. An alternate strategy is the digging of canals to a food source. Both techniques were employed at one of the ponds. The canals measured were about 24 in. wide and 6 in. deep. Water levels were probably higher at the time they were in use, thus increasing their effective depth. At one site, a main canal along the forest edge was approximately 180 yds in length.

Feeding areas at both ponds were in mixed deciduous-coniferous forest, with different species dominating at each. The importance value (IV = sum of relative frequency, relative density and relative dominance), used in comparing the relative importance and influence of the different tree species, indicates that paper birch (*Betula papyrifera*), balsam (*Abies balsamea*) and quaking aspen in that order were the dominant species at pond 1 (Table 1). Spruce (*Picea* sp.), aspen and birch dominated at pond 2 with maple (*Acer* sp.), alder (*Alnus rugosa*), tamarack (*Larix laricina*), and white pine (*Pinus strobus*) present in lesser amounts (Table 1). The difference in species composition at the two ponds is probably due to different environmental conditions or different histories.

Aspens (*Populus* spp.) are the preferred food of beaver (Rue 1964). The proximity of water to the large population of aspen explains beaver presence in these areas. Other foods noted were willow (*Salix* spp.), alder, birch, various ferns, sedges, grasses and aquatic plants. The woody plants mentioned were important not only as food, but were extensively utilized by beaver as construction materials.

The feeding patterns of beaver change seasonally, with preference for woody vegetation in the fall, winter and early spring, and

TABLE 1. Forest Composition of Feeding Areas at Ponds 1 and 2.*

	N		*Frequency (%)*		*AVG. DBH (in)*		*Importance Value (IV)*	
	Pond 1	*Pond 2*	*1*	*2*	*1*	*2*	*1*	*2*
Alder (*Alnus rugosa)*	0	2	0	20	0	3.3	0	14
Aspen (*Populus tremuloides)*	4	9	33	50	7.3	3.5	28	48
Cut Aspen	9	2	31	20	4.2	3.3	38	13
Balsam (*Abies balsamea)*	13	1	54	10	9.2	3.1	96	6
Birch (*Betula papyrifera)*	24	9	92	70	6.0	6.8	127	67
Maple (*Acer* sp.)	0	4	0	30	0	3.2	0	23
Spruce (*Picea* sp.)	2	10	15	80	3.7	5.0	12	83
Tamarack (*Larix laricina)*	0	2	0	10	0	12.3	0	25
White Pine (*Pinus strobus)*	0	1	0	10	0	18.5	0	25
Total	52	40					300	300

	Pond 1	Pond 2
* Mean Distance (MD)	8.92 ft	11.83 ft
Mean Area (MA)	81 ft^2	140 ft^2
Total Density (TD)	538 trees/A	311 trees/A

for herbaceous foods during spring and summer. In Ohio, Svendsen (1980) estimated that non-woody vegetation accounted for 90% of the feeding time during the summer and 40 to 50% in early spring and fall. In Pennsylvania, however, Brenner (in Svendsen 1980) found that only 33% of the vegetation consumed per day in spring and summer months was herbaceous material. I found no information regarding herbaceous feeding by beaver in Wisconsin.

By correlating data on the amount of inner bark per tree (Fig. 1) with diameters and numbers of the cut stumps, I determined that, for both ponds, a single adult beaver ate an average of approximately 44 g (dry wt) of aspen inner bark per day. Aldous (1938) estimated that beaver eat 640-670 g wet wt per day, which is equivalent to 160-220 g dry wt of inner bark per day. My consumption estimates are probably the more accurate of the two because Aldous's estimates were based on aspen eaten by captive beaver that had no herbaceous vegetation to supplement their diet. Further, Aldous's weights included the cork layer and the wood in twigs and branches under 0.5 in. diameter. The present study excluded the cork layer and the wood of twigs which are of little nutritional value even if consumed.

At both ponds, cut trees were present on which the inner bark was partially or totally unutilized. By measuring the unused portions of cut trees, the weight of unutilized inner bark was estimated. A correlation of stump diameter to unused log length indicated that, as stump diameter increases, so does the length of unutilized log, and thus also the quantity of unutilized inner bark (Fig. 2).

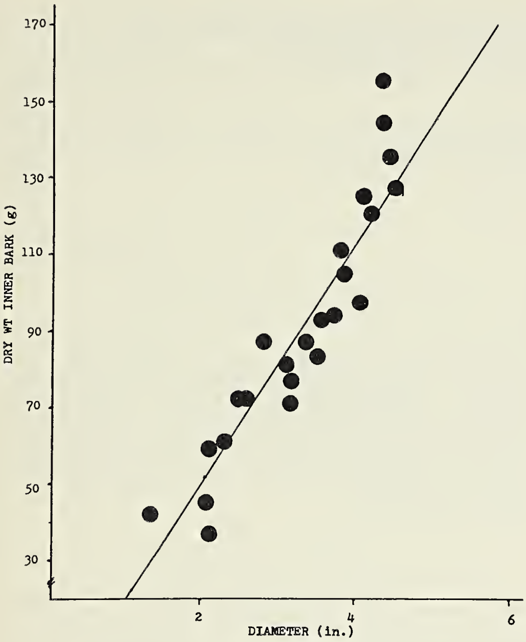

Fig. 1. The amount of phloem per 15 in. section versus the base diameter of the section.

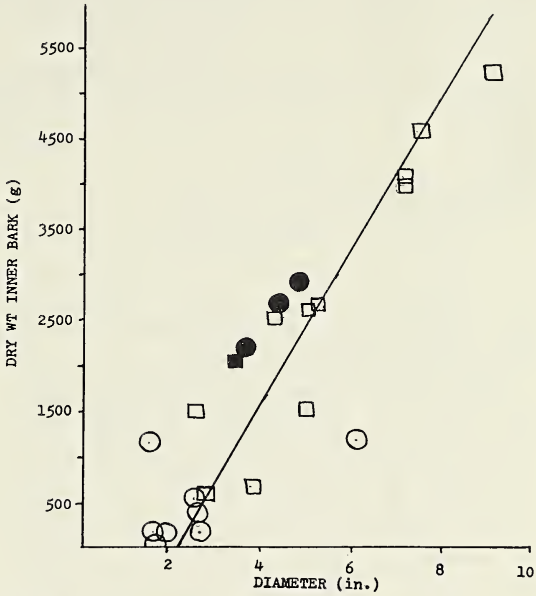

Fig. 2. The amount of unutilized inner bark of various sized log sections (open), and lodged trees (solid) at pond 1 (□) and pond 2 (○).

Nixon and Ely (1969) found that in trees under 2 in. dbh less than 1% was wasted. Aldous (1938) estimated that in aspen with a stump diameter (sd) of 1 in. there was 80% utilization and in trees of about 6 in. sd there was 35% utilization. Rue (1964: 109) estimated that the utilization of trees 4 to 6 in. in diameter was approximately 36%. There was a greater percentage of total utilization of the available food in the 1 to 3 in. sd trees, but the quantity of food per tree was small compared with that obtainable from larger trees. However, the latter were only partially utilized. Aldous (1938) found that a 7 in. tree, half utilized, would provide approximately the same amount of food as four 3 in. trees totally utilized. The present study confirms Aldous' estimate.

According to Aldous (1938), beaver prefer the relatively corkless bark of the small branches and limbs to that of the trunk. At both ponds the small branches of trees were generally totally utilized. Because the ratio of crown to trunk increases with trunk diameter, there is more preferred food available in larger trees even though there is more actual waste. However, larger trees are generally cut only after the small ones are used. Jenkins (1980) noted that beaver cut relatively more small trees as distance from water increased. That pattern was observed in the present study. Aldous (1938) observed that the degree of wastage in large trees is determined both by distance from water and by terrain. I also found relatively more trees were cut in the 1 to 3 in. sd class than in larger classes (Table 2).

Several reasons exist for the preference for, and more complete utilization of, smaller trees. Large trees take proportionately more time and energy to process, whereas small trees can be cut and carried to water after felling. Also, the large tree has a more extensive cork layer which is not utilized by the beaver for food. It would not be energy efficient to strip off the cork to get at the edible bark. Further, beaver prefer to feed in the water and a large tree, even if cut

Table 2. The Number and Diameter of Aspen Trees Cut at the Feeding Areas of Ponds 1 and 2 in the Last Two Years.

		Diameter Class (in)						
		0–1	*1–2*	*2–3*	*3–4*	*4–5*	*5–6*	*6–7*
Number of Trees	Pond 1	2	30	24	6	3	1	0
	Pond 2	1	23	26	5	3	1	2

* Mean diameter cut at Pond 1 = 2.4 in
Pond 2 = 2.5 in

into sections, is very cumbersome for a beaver to transport to the water.

Beaver do not plan the direction a tree falls when cut. Occasionally, a falling tree will become lodged in other trees and thus, suspended out of the beavers' reach, will remain unutilized. Compared to the number of trees cut, relatively few trees become permanently lodged. At both ponds, all lodged trees had a diameter of between 3 and 5 in. (Fig. 2). Apparently, trees under 3 in. sd were light enough in weight that the beaver could dislodge them, while trees over 5 in. sd were heavy enough to crash through most obstructions. Trees in the 3 to 5 in. class, however, became lodged and could not be pulled down. Generally the trees located near water lean toward the water or have more foliage in that direction because of reduced canopy and more sunlight so that when cut, the tree falls toward the water. This fact may influence the inverse relationship noted above of tree size to distance from water.

The total percentage of unutilized inner bark at both ponds, including lodged trees, was approximately 9-12% of the food available from cut aspen per year. This indicates that the beaver uses its food source efficiently. On the other hand, Aldous (1938) calculated that beaver waste 64% of the food available from cut aspen. It should be noted however, that his data involved a greater number of large trees than were found in the present study. Therefore, the relative efficiency of resource utilization probably varies from site to site, decreasing as forests mature and/or older trees become more prevalent.

Acknowledgments

I would like to thank William S. Brooks, Ripon College Dept. of Biology, for his guidance and technical advice, and Mary Lee Montoure, Shawano, WI, for her assistance on this project. I also greatly appreciate the help of Robert Petry, Manager Northern Woodlands and John Baer, Northern Wisconsin Forester of Nekoosa Papers, Inc., who gave me permission to use Nekoosa property and facilities in Oneida County.

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THE REVEGETATION OF A SMALL YAHARA VALLEY PRAIRIE FEN

James Hall Zimmerman
Department of Landscape Architecture
U. W.-Madison

Abstract

Following sewer construction in winter, 1971-72, the revegetation of exposed dredged peat was compared with an undisturbed portion of a 3-ha prairie fen near the Yahara River in Cherokee Marsh City Park, Madison, Wisconsin. In the absence of alien species and hydrologic alteration, and with prompt manual removal of the initial one-time massive invasion of willows and cottonwoods, full plant cover was restored in two seasons, and 49 of the 71 enduring vascular plant species had returned at reasonable to full frequency by 1979. Presumably germinating mostly in the disturbance year, the three behavioral groups were "true pioneers," "climax opportunists," and "climax dominants or associates." In the undisturbed portion, some climax species exhibited rotation in apparent dominance, varying in degree of vigor and flowering from year to year, possibly with influence from weather, animals and fire. The pioneering woody species are seen as local or temporary dominants in an otherwise sedge-grass-dominated system maintained primarily by consistent groundwater input.

Introduction

Defined as calcareous peatlands, fens vary floristically with climate. In eastern North America, fens in the cool humid forest regions have trees—especially white cedar (*Thuja occidentalis*) (Boelter & Verry 1977; Frederick 1974; Muenscher 1946). South of Curtis' (1959) "tension zone," virgin Wisconsin fens—even today—generally lack trees and dense shrub cover. Curtis ascribed this difference chiefly to prevalent presettlement prairie fires and early post-settlement hay-mowing, but he also mentions agricultural drainage as a factor favoring woody invasions. Vogl (1969), demonstrating woody and charcoal layers in sedge peat in S.E. Wisconsin, postulated that regional agricultural drainage after the 1930's prevented high water from returning, following drouth, peat fires, and livestock grazing impact, to account for the prevalent woody species' dominance in many of these peatlands reported in the 1950's by White (1965). A possible reason for the former lack of woody dominance in the moist undisturbed fens in the relatively dry prairie and oak grove regions is the ability of dense grasses and sedges (no doubt stimulated by frequent fires) to out-compete all invading seedlings, whereas in the humid north and east it is the wet (unoccupied and not inundated) mossy logs and stumps on which seedlings may quickly rebuild the forest after fire or windthrow. Preliminary studies by Kogler (1979) do not refute the hypothesis that red osier dogwood (*Cornus stolonifera*), typical of almost all woody species of southern Wisconsin, can be controlled in peatlands by high water tables which favor competitive sedge dominance and lower soil oxygen and nutrient availability. Sytsma and Pippen (1982) related patterns of fen succession to carr and forest to a complex of water availability and human impacts, with a persistent trend toward diversity rather than successional convergence, thus confirming the conclusion of Heinselman (1970). The importance of this habitat diversity to faunal as well as floral richness is seen in the drastic changes in the avifauna of Wingra Fen recorded between 1912 and 1968 as woody plant invasion progressed (Zimmerman, 1983).

Associated with porous sloping substrates —usually sandy or gravelly ice-contact deposits and glacial lake shores—the fens of southern Wisconsin and adjacent states are classified as groundwater slope wetlands by Novitzki (1982). They derive their steady flow of water, rich in calcium and magnesium bicarbonates and sulfates (Curtis 1959), from permeable glacial debris containing dolomites such as that spread southward in eastern Wisconsin by the Green Bay and Lake Michigan Lobes of the Wisconsin Ice Sheet (Martin 1936; Reed 1983). Some of the water may also come from underlying porous bedrock such as the Cambrian sandstones that supply many of the Yahara Valley springs and wetlands (figure 1). The

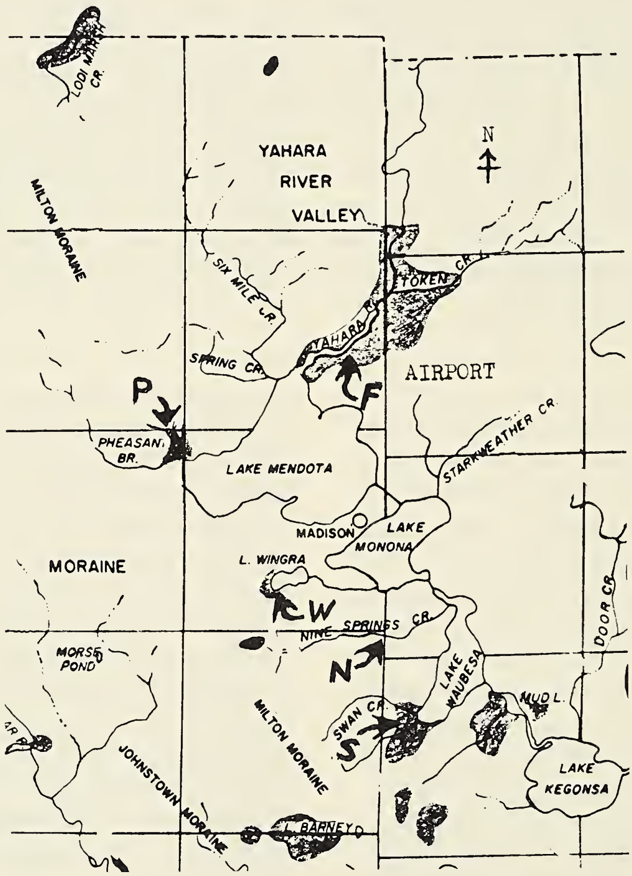

Fig. 1. Yahara Valley, Central Dane County, Wisconsin (after Bedford et al. 1974), showing locations of some of the prairie fens.

LEGEND: F = Wheeler-School Roads Fen (within shaded area indicating the extent of the Cherokee Marsh Fen Complex)
W = Wingra Fen in the UW-Madison Arboretum on Lake Wingra
S = Fen hump in the South Waubesa Wetlands Complex
N = Nine Springs Creek Fens
P = Fen in Pheasant Branch Wetland Complex

SCALE: 1:300,000 (1″ = 4.5 miles; 1 cm = 3 km)
Each square is one township (6 mi on a side)

uninterrupted artesian waterlogging assures minerotrophic peat buildup, despite some humification, sometimes 1-2 m above the surrounding terrain (Moran 1981; Kratz and Winkler 1982). The steady upward discharge of water under pressure also assures in summer that the peat remains cooler than the surrounding soil and air, and that the dissolved salts accumulate. In addition to evaporation and mineral incorporation into incompletely decayed plant matter, the upward gradient of increasing temperature and decreasing pressure may enhance the transport and deposition of calcium (Reed 1983).

The result is a substrate suitable only for an unusual assortment of plants adapted for the triple root stress of low oxygen availability, low temperatures, and skewed nutrition (Van der Valk 1977). Our fen flora includes certain disjunct wetland species of northern climates (*Scirpus cespitosus*), salt marshes (*Triglochin maritima*), wet limestone ledges (*Gentiana procera*), and even Sphagnum bogs (*Sarracenia purpurea*) (Moran 1981; Mandossian 1965). In Table I, the species are keyed to their affiliations. "Calcophilous" plants of fens, characterizing high-lime substrates, might better be called calcicoles, since they may be tolerant of a low availability of, say, phosphorus, rather than needful of a high level of Ca or Mg. Where surface peat isolation from groundwater, and prolonged leaching by pluvial climate precipitation, produce a

TABLE 1. Prairie Fen plants observed in the 5-ha Wheeler-School Roads Yahara Fen in the years 1972-79. (For starred species see text.)

Figures in the 5 columns are the % frequency in 1-m² quadrats; x = present in the zone but not in any quadrat; 0 = not observed in the zone.

Floristic affiliations: G = prairie grassland. W = general wetland. B = bog. C = (wet) calcicole.

DZ = Disturbed zone = 10m × 200m strip of peat spoils 1-20 cm thick, deposited in winter, 1971-72,

UZ = Undisturbed zone = similar-sized adjacent strip of virgin fen.

COLUMN	1	2	3	4	5
ZONE	DZ	DZ	DZ	UZ	UZ
YEAR	1972	1976	1979	1976	1979
# QUADRATS	8	5	16	10	16

Group A: Competition-tolerant perennial (cespitose and/or clonal) "climax herbs—dominants & associates" (symbol T in summary).

Species[1]	*English Name*	*1*	*2*	*3*	*4*	*5*
*Andropogon gerardi—G	Tall bluestem grass	12	20	24	80	84
*Carex sterilis—C	Small tussock sedge	36	20	60	80	90
Lysimachia quadriflora—G	Prairie loosestrife	12	60	72	90	90
Muhlenbergia glomerata, and M. mexicana—C	Fen muhlenbergia and "Anthill grass"	x	20	42	80	84
Viola cucullata—W	Marsh blue violet	48	60	48	70	54
Cladium mariscoides—C	Twig rush sedge	0	0	6	20	42
**Carex stricta—W	Tussock sedge	12	80	54	100	30
Solidago uliginosa—B	Bog goldenrod	0	40	0	80	30
**Carex lasiocarpa—B	Wiregrass sedge	0	0	36	10	24
**Carex aquatilis—C	Water sedge	x	0	12	40	12
Valeriana ciliata (edulis)—G	Valerian	0	0	0	x	12
Carex leptalea—C	Scaly sedge	0	0	0	0	12
Spiranthes cernua—G	Ladies' tress orchid	0	0	0	x	12
Carex prairea—C	Sedge	0	0	0	40	6
Hypoxis hirsuta—G	Yellow star grass	0	0	0	x	0

Group B: Competition-intolerant herbs.
O = "climax opportunists" persisting in climax fen.
P = "true pioneers" requiring major disturbance.
LIFE FORM: A = annual or biennial.
S = cespitose (short-lived?) perennial.
R = rhizomatous clonal perennial.

Species[1]				*English Name*	*1*	*2*	*3*	*4*	*5*
Asclepias incarnata*	W	O	S	Marsh milkweed	x	60	42	30	24
Aster junciformis	C	O	R	Rush-leaf aster	12	0	24	50	24
Aster lucidulus*	W	O	R	Lavender marsh aster	24	80	78	10	6
Aster novae-angliae*	W	O	S	New England aster	x	0	x	10	6
Aster simplex*	W	O	R	White marsh aster	x	0	18	10	0
Aster umbellatus	C	O	R	Flat-top white aster	0	x	0	x	x
Bidens cernua	W	P	A	Nodding bur marigold	x	x	0	0	0
Bidens coronata*	W	O	A	Slender bur marigold	x	20	6	x	x
Bromus kalmii*	C	O	S	Kalm's brome grass	x	20	12	50	12
Calamagrostis canadensis	W	P	S	Bluejoint grass	x	0	6	x	0
Campanula aparinoides	W	O	S	Bedstraw bellflower	x	0	48	30	24
Cardamine bulbosa	W	O	S	Marsh cardamine	0	0	0	x	0
Carex hystricina	C	P	S	Hedge-hog sedge	x	20	0	x	0
Carex sartwellii	W	O	R	Sartwell's sedge	12	0	6	0	x
Carex tenera, bebbii	W	O	S	Slender and Bebb's sedges	x	0	0	0	6
Carex tetanica	W	O	R	Sedge	0	0	12	30	x
Carex spp.				Unidentified Sedges	48	—	—	—	—
Cirsium muticum*	C	O	A	Marsh thistle	x	20	42	50	18
Cyperus erythrorhizos	W	P	A	Redroot galingale	x	x	x	0	0
Cyperus rivularis	W	P	A	Low galingale	x	0	6	0	0
Drosera rotundifolia	B	O	S	Roundleaf sundew	0	0	0	10	0
Dryopteris thelypteris	W	O	R	Marsh fern	12	0	24	60	24
Eleocharis acicularis	W	P	R	Tiny spike rush	0	40	0	0	0
Eleocharis elliptica	W	O	R	Peatland spikerush	12	0	24	0	24
Eleocharis obtusa	W	P	A	Annual spike rush	36	0	0	0	0
Epilobium coloratum	W	P	S	Willow-herb	12	x	0	0	0
Equisetum arvense	W	O	R	Horse-tail	12	40	72	0	0
Erigeron philadelphicus	W	O	A	Philadelphia fleabane	x	20	x	0	6
Eriophorum angustifolium	B	O	R	Cotton-grass	0	0	0	x	12
Eupatorium maculatum*	W	O	S	Joe-pye-weed	24	20	6	80	24
Eupatorium perfoliatum*	W	O	S	Bone-set	72	60	36	20	x
Galium labradoricum	C	O	S	Boreal bedstraw	0	0	0	60	0
Gentiana procera*	C	O	A	Lesser fringed gentian	x	x	x	x	x
Gerardia paupercula	C	O	A	Pink gerardia	x	60	6	x	0
Glyceria striata*	W	O	S	Manna grass	84	80	78	x	12
Hierochloe odorata	C	O	R	Sweet grass	12	x	x	0	0
Hypericum virginicum (Triadenum fraseri)	B	O	S	Bog St. John's Wort	12	20	6	10	0
Impatiens capensis (biflora)	W	P	A	Orange jewelweed	0	20	0	0	0
Iris virginica (shrevei)	W	P	R	Blue flag	0	0	6	10	0
Juncus dudleyi	W	O	S	Low-prairie rush	x	40	12	0	6
Juncus brevicaudatus	C	O	A	Fen rush	0	x	0	0	6
Juncus torreyi	C	P	A	Torrey's rush	x	60	18	0	0
Lathyrus palustris	W	O	R	Marsh pea	0	0	0	20	0
Leersia oryzoides	W	P	A	Rice cutgrass	0	60	0	0	0
Lobelia kalmii	C	O	A	Kalm's Lobelia	36	60	6	10	0
Lobelia siphilitica	C	P	S	Great blue Lobelia	0	x	0	0	0
Lycopus americanus	W	O	R	Water horehound	72	100	36	40	12
Lycopus uniflorus	W	O	R	Water horehound		60	60	70	30

Species[1]				*English Name*	*1*	*2*	*3*	*4*	*5*
Oxypolis rigidior	G	O	A	Cow-bane	0	0	0	0	6
Panicum flexile	C	P	A	Fen panic grass	0	0	12	0	0
Parnassia glauca*	C	O	S	Grass of Parnassus	0	0	18	90	36
Pedicularis lanceolata*	C	O	S	Lousewort	x	20	48	0	x
Potentilla palustris	B	O	R	Bog cinquefoil	0	0	0	x	0
Pycnanthemum virginicum	G	O	S	Mountain mint	12	0	0	0	0
Rhynchospora capillacea	C	P	A	Fen beak-rush	0	20	0	0	0
Rumex orbiculatus (brittanicus)	W	P	A	Marsh dock	12	0	0	x	0
Scirpus atrovirens	W	P	S	Black-green bulrush	x	20	0	0	0
Scirpus validus	W	P	R	Roundstem bulrush	48	40	60	20	12
Scutellaria galericulata	W	O	R	Skullcap	x	20	0	0	0
Solidago gigantea*	W	O	R	Smooth goldenrod	48	20	90	30	30
Solidago riddellii*	C	O	S	Riddell's goldenrod	12	40	90	40	30
Spartina pectinata	G	O	R	Cordgrass	0	0	0	x	0
Sphenopholis intermedia	C	O	S	Wedge grass	12	60	0	0	0
Thalictrum dasycarpum	W	O	S	Tall meadowrue	0	0	0	10	6
Triglochin maritima	C	O	R	Arrowgrass	0	0	0	x	x
Typha (mostly latifolia)	W	P	R	Cattail	24	60	84	0	6
Utricularia intermedia	C	O	R	Small bladderwort	0	0	0	x	0
Verbena hastata	W	O	S	Marsh Vervain	12	0	0	x	0
Moss (Amblystegium sp.?)	W	O	R	Marsh Moss	x	NA	6	NA	42

Group C: Woody species enduring wet peat (symbol Y in summary). (Most of the invading willows and cottonwoods were manually removed from the disturbed zone by the end of 1973.) The dogwood in the disturbed zone consisted of 6 mature bushes until 1979, when numerous 1-4-year-olds appeared.

Species[1]				*English Name*	*1*	*2*	*3*	*4*	*5*
Betula pumila	T	O	S	Bog birch	0	0	0	10	24
Cornus stolonifera	W	O	R	Red osier dogwood	0	40	90	50	48
Populus deltoides	W	P	S	Cottonwood	96	x	0	0	0
Ribes americanum	W	O	S	Black currant	0	0	6	0	0
Rubus spp.	W	O	R	Raspberries	x	0	0	0	0
Salix bebbiana	W	O	S	Bebb's willow	x	20	24	10	12
Salix candida	T	O	S	Sage willow	0	0	6	60	36
Salix discolor	W	O	S	Big pussy willow	x	0	24	0	6
Salix interior	W	P	R	Sandbar willow	x	20	30	0	0
Salix nigra	W	P	S	Black willow	x	x	0	0	0
Salix petiolaris	W	O	S	Red and green willow	x	20	42	20	42
Salix spp.				Unidentified willows	84	x	—	—	—
Viburnum trilobum (opulus?)	W	O	S	Highbush cranberry	0	0	6	0	0

SPECIES SUMMARY[2]	BEHAVIOR T	O	P	AFFILIATION G	W	C	B	LIFE FORM A	S	R	Y	TOTAL IN FEN	REASONABLY RESTORED
Group A Climax Herbs	16	—	—	5	2	7	2	—	11	5	—	16	10 of 16 T's
Group B Intol. Herbs	—	48	19	3	38	22	4	18	25	24	—	67	35 of 48 O's
Group C Woody Spp.	2	7	3					—	9	3	12	12	4 of 7 O's
TOTALS	18	55	22	8	40	29	6	18	45	32	12	95	49 of 71 T+O

[1] Scientific names after Fernald (1950).

[2] See text for discussion of additional upland alien invaders mostly considered temporary.

"poor fen," additional bog species may characterize the fen, as noted by Schwintzer (1978) for northern Michigan. Our most characteristic "poor fen" species is *Carex lasiocarpa,* whose floating mats may support either fen or bog plants, or mixtures, according to local water chemistry. Fen plants are not tolerant of prolonged, or even inter-

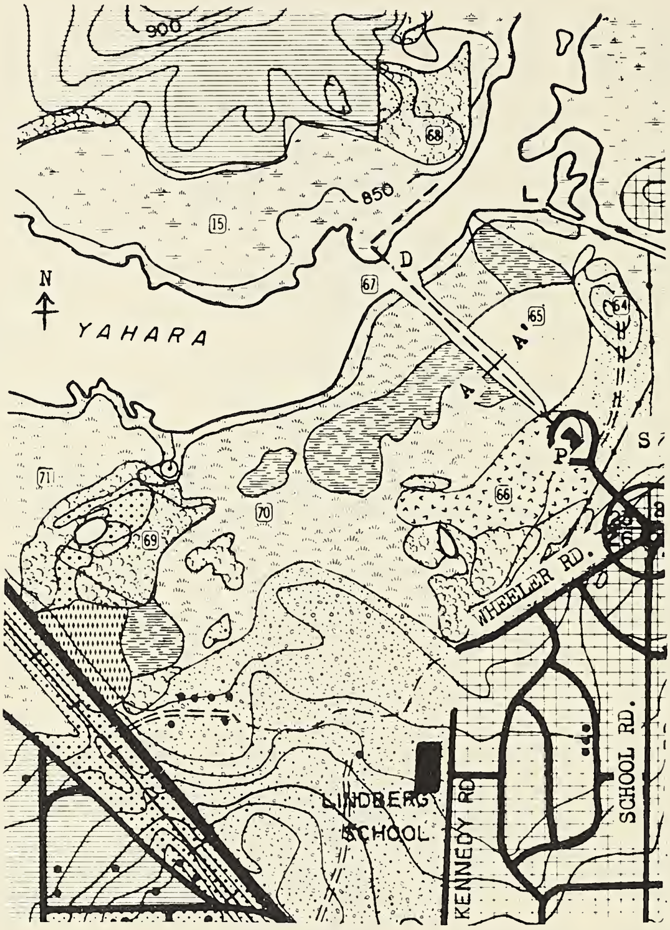

Fig. 2. Location of Wheeler-School Roads Fen (adapted from Bedford et al. 1974) in the SE 1/4 of Sec. 23, T 8 N, R 9 E, Dane County, Wisconsin, in the City of Madison and Town of Westport.

LEGEND: 64 Sand hill
65 Fen
66 Sand and gravel pit
67 Yahara River at site of sewer crossing (dashed line)
68–69 Oak knolls
70–1 and 15 Diverse natural sedge meadows, fens, low prairies and floating peat mats, with occasional islands of shrubs and aspens
73 wet carrs of willow, dogwood, and alder adjoining fens
L = outlet of large drainage ditch into Yahara River
D = outlet of level ditch over buried sewer pipe
P = sewer pump lift station
S = small drainage ditch

SCALE: 1:12,000 (1″ = 1000′; 1 cm = 120 m) mittent, inundation; Moran notes *Carex stricta* tussocks instead of fen species in an Illinois fen located on a river floodplain.

In the prairie and oak grove region, two extremes in a continuum of fen types may be recognized (Moran 1981; Reed 1983): the *calcareous fen* or marl flat, dominated by extreme calcicoles like *Eleocharis rostellata, Rhynochospora capillacea,* and *Potentilla fruticosa,* and the *prairie fen,* with typical wet prairie plants like *Andropogon* spp. along with some of the smaller fen calcicoles like *Carex sterilis* and *Lobelia kalmii.* The marl flats are associated with a rapid groundwater discharge and/or very high lime content; their marl deposit is probably the combined result of direct solute precipitation and the growth of diatoms, bluegreen algae, *Chara,* and molluscs. The prairie fens, in contrast, form deep peat layers (often over a layer of marl), to a depth of 1-3 m, largely as a result of root accumulation, although the organic matter is not incorporated into the upper mineral soil as is the case in true wet to dry prairies. Curtis (1959), Van der Valk (1975), and Kohring (1982) have demonstrated the "hybrid" or, rather, spectral or zonal nature of fens, in which floristic composition varies locally with the rate of groundwater flow, such as around a "discharge window," where varying degrees of waterlogging, lime accumulation, and peat formation depend on lateral distance from the window. The habitat permanance of steady flow combined with the high diversity of local conditions helps explain the puzzling richness of fen floras, which have evidently sustained relict and specialized species through climatic changes by excluding competition from widespread species which require more "average" conditions under a given climate. A further part of the explanation lies in the mechanisms of competition and renewal among populations of associated fen species. The temporary disturbance of the natural fen investigated here provided an opportunity to explore these dynamics, which have import for the management of rare and endangered species, as well as for wetland restoration.

The purpose of this study was to see if a disturbed fen could restore itself, and to determine useful management strategies applicable to this type of disturbance, which was devegetation due to displacement of surface peat. The undisturbed portion of the fen would serve as a "control" or benchmark area.

Site Description and Methods

A series of accidents paved the way for this opportunity. Glacial dams impounded Madison's five lakes in the spring-fed Yahara Valley (figure 1). In 1912, the Tenney park lock and dam in Madison raised the upstream water-level of the Yahara River north of Lake Mendota, preventing agricultural and urban drainage ditches (L and S) from lowering the watertable in a 3-ha hillside fen (#65) in Cherokee Marsh near Wheeler and School Roads (figure 2). From comparative observations of recently farmed fens in the area, this one appears to have had little or no human impact at least as far back as 1912; mowing and livestock grazing could have occurred before that if it was not too wet then. The vascular flora of this fen, described in Bedford et al (1974), and presented in Table I (Groups A, B, C), is similar to that of the six fens studied by Curtis (1959) near Madison, Wisconsin, and the ten prairie fens studied by Moran (1981) in northeastern Illinois. Of 37 "modal" species (those having their highest % presence in fens) and of 43 species with 33% or higher presence, in Curtis' fens, 24 and 38 species, respectively, occur in this fen. All of Moran's 36 most prevalent species (rated by presence and frequency in combination) occur in at least some Wisconsin fens, and 26 of them are found in this Cherokee fen.

Although Cherokee is one of the Madison Park System's "Conservation Parks", plans to avoid sensitive areas like the fen when routing the Waunakee-DeForest sanitary sewer interceptor were not implemented because a map was misdelivered. Following construction of the sewer, the segregated sand and peat were carefully replaced after being piled overwinter in 1971-72; but not quite all the peat could be scraped off the fen (figure 3). An irregular layer of raw fen peat 1-20 cm thick suffocated most of the vegetation on a strip 10 m wide and 200 m long, paralleling the sewer on its north side. That strip is herein referred to as the disturbed zone (DZ). When asked in April, 1972, by a seedsman for advice on what to plant to stabilize exposed peat, I asked to see the site. Field inspection indicated that the water table had not been altered, and that diverse native fen vegetation existed in the adjacent undisturbed zone of the fen (UZ). Since the usual recommended wetland cover, an Eurasian strain of reed canary grass (*Phalaris arundinacea*), can remain as a competitive monotype in both wet and drained fens, I obtained the cooperation of the Madison Metropolitan Sewerage District in allowing natural revegetation to occur.

Within one season, native fen plants plus a variety of temporary upland weeds attained 30% cover by visual estimate. No surface, wind or water erosion was observed. However, the peat replaced over the sewer pipe was so fluid that it flowed westward out into the river, leaving a level ditch (D in figure 2) containing shallow water connected to the river, allowing entry of fish which attracted angling adults and youth for eight years. By the time the high water of August, 1981, caused a peat mat to float downstream and lodge at the ditch mouth and close it off, a well-worn path had been made in the DZ parallel to the ditch. This path demonstrated the importance of devegetating disturbances to the perpetuation of truly pioneer herbaceous but not woody species. Although the fresh fen peat spoils had dried and become

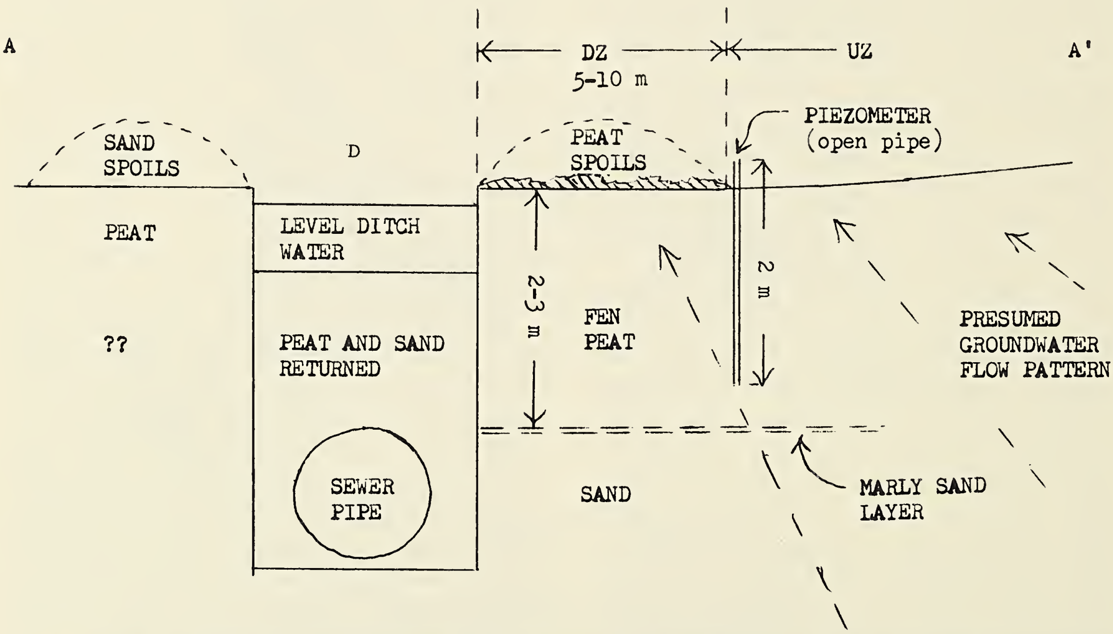

Fig. 3. Sewer Construction Impact: Transect A–A′of Figure 2 in Vertical Section Looking Toward River (vertical scale exaggerated),
DZ = Zone of Peat Spoils incompletely scraped off
UZ = Undisturbed Fen
D = Level Ditch

encrusted with salts during May, 1972, the upwelling artesian water had wetted the surface again by late summer, and pools of surface water remained in the spoils' irregularities through the following ten years. During even the dry summers of 1976-77, the water level in the piezometer (figure 3) remained near the peat surface, in contrast to the level in the impacted Wingra Fen in the University of Wisconsin Arboretum (figure 1) which dropped below the bottom of the pipe and whose peat developed large cracks (personal observation).

Observations were made at least once each summer in 1972 through 1982. The final accident was the fortuitous availability of summer ecology classes for doing vegetation sampling and manual labor. Although some data were lost and some were not reliable enough to use, one set of frequency data from eight 1-m^2 randomly placed quadrats was obtained in the DZ in August, 1972, and sets of five and ten quadrats in the DZ and UZ respectively were obtained in July, 1976. I personally sampled both the DZ and UZ again in September, 1979, using 16 quadrats each (Table I). Identification of immature and vegetative plants was accomplished by comparing mature species in the UZ. The frequency figures should be taken only as indicators of trends, for the uneven terrain and small sample could cause a large sampling error. The line intercept used by Reed (1983) is probably a more reliable as well as quicker procedure.

The shrub cover in the UZ was 50% in 1976, based on 100 m of line intercept; it was mostly red osier. Shrubs were lacking in the DZ, either because of trampling by machinery and burial, or possibly because they were scarce there to start with. The DZ alone suffered a one-time invasion in 1972 of numerous seedling woody species—the arboreal cottonwoods (*Populus deltoides*) and willows (mostly *Salix nigra*), the clonal *Salix interior,* and the cespitose *Salix discolor, S. petiolaris,* and *S. bebbiana.* It was assumed that this dense invasion (more than one stem per m^2) might have usurped the DZ for decades, since similar invasions have persisted around lagoons dug in 1936 and 1944 in the University of Wisconsin Arboretum (no doubt there aided by peat-drying due to spoils piling, water table lowering, and enhanced evapotranspiration by the woody species). Therefore, it was decided to remove them from the DZ. They were pulled up by hand, while it was still possible, in 1972 and 1973, when they were still small (20-200 cm tall). The widely scattered mature shrubby cespitose *Salix* and *Betula* species were allowed to remain in the UZ where they were not spreading. Several spring fires that swept the fen, including the latest (and only intentional) one in 1982, appeared to have little effect on any shrubs, since they always regained full size in one or two seasons. The seed source for the cottonwoods and tree willows was the ditch berm (L) 300 m to the north (figure 2). This fen was, uniquely, almost entirely free of seed sources of alien *Phalaris, Rhamnus,* and *Lonicera* species within a radius of 300 m beyond the fen.

Results and Discussion

Table I lists all the vascular plant species found in the UZ and DZ of the 3-ha Wheeler Road-School Road Sector of the Cherokee Marsh Fens, except for the mostly short-lived native and alien upland crop weeds, which were abundant in 1972 in the DZ. These included *Agrostis alba, Aster pilosus, Barbarea vulgaris, Chenopodium* sp., *Cirsium arvense, Erigeron strigosus, Fragaria virginiana, Juncus tenuis, Lactuca* sp., *Lepidium* sp., *Oenothera biennis, Panicum* sp., *Phalaris arundinacea, Poa pratensis, Polygonum* sp., *Solidago altissima,* and *Taraxacum officinale.* Except for occasional small clumps of *Agrostis* and *Phalaris,* these species ceased to dominate the DZ by 1973 and had nearly disappeared by 1979, as had occasional ephemeral seedlings of *Populus tremuloides, Carya ovata, Ulmus americana, Acer saccharinum,* and *A. negundo.* After 1973 the ground was fully covered by plants as the fen species rapidly spread and displaced the agricultural weeds without human intervention.

Group A of Table I comprises perennial herbaceous species believed to be tolerant of intense plant competition. They appear to be long-lived, persistent, and often slow-growing. The five starred species account for most of the cover, thus qualifying as "climax dominants." The others are "climax associates," likewise consistently well distributed and periodically very conspicuous in the UZ, and in similar undisturbed prairie fens in southern Wisconsin. Hence, they are all here considered to be species of the "climax" phase, defined as stable, given unchanging hydrologic conditions. In the recent dynamic allogenic "Gleasonian" model of wetlands (Van der Valk 1982), there is no "Clementsian" mesic climatic climax. The term climax as used here refers to the presumed most stable and enduring sedge-grass-dominated fen phase among the endless cycling between dry and wet phases characterizing all wetlands (Zimmerman 1982) and between open (disturbed or devegetated) and closed (fully vegetated) habitats (the "internal succession" of Curtis, 1959).

The double-starred species of Group A and the *Cladium* seldom flowered under undisturbed (crowded) conditions in the UZ; sometimes they flowered at the edge of water, or occasionally with fire or local animal or frost disturbances, in other fens. The "tussock sedge", *Carex stricta* (possibly including hybrids with *Carex aquatilis*), does not produce tussocks in the raised calcereous prairie fens of Wisconsin. *Carex sterilis,* however, always produces distinct small, dense, raised tussocks (with over 100 shoots/year) in the Yahara Valley Fens and some others, whereas it is reported by Moran not to do so in the northeastern Illinois prairie fens he studied. *Carex prairea*—locally dominant—forms raised tussocks as large as those of *Carex stricta.* Several species appeared to exhibit striking year-to-year variation in dominance as measured by vigor and heavy flowering; but unfortunately quantitative data were not obtained. In dry summers like 1976-77, *Andropogon gerardi* grew tall and tended to flower abundantly throughout the UZ. It also did so after fire, such as in 1982, despite waterlogging caused by abundant groundwater recharge and discharge. In the wettest year (1974), *Cladium* dominated several large areas with heavy flowering, whereas it was almost impossible to find in other years. *Carex sterilis* always flowered well and was easy to find through June; but it can be obscured in late summer in high *Andropogon* years. The flowering *Andropogons* were always all *A. gerardi,* whereas Moran found *A. (Schizachyrium) scoparius* to be nearly as important as a co-dominant. The latter was found to be the sole dominant in one small fen-like wet prairie in Jefferson County, Wisconsin (personal observation, 1982). Some of the vegetative shoots seen in the UZ were very flat but they did not form tussocks as is usual in *A. scoparius* in both wet and dry sites.

The colonization pattern of the species of Group A in the DZ is in general accord with expectations for climax vegetation: they require time. Even as late as 1979 (column 3), most of them failed to attain full frequency. The absence of the last five species, and of recognizable *Muhlenbergia glomerata,* in the DZ cannot be explained at present. *Muhlenbergia mexicana* commonly colonizes ant hills, which might qualify it as competition-intolerant (Group B); but it is widely prevalent in dense cover along with *M. glomerata,* although it sometimes is inconspicuous even in autumn. The other species may have needed a coincidence of dispersal and special weather conditions not experienced by 1982 in order to colonize the DZ. Possibly the *Spiranthes,* which has been known to invade open peat or moist sand, requires time for a specific fungal development. A solitary plant of *Valeriana* discovered in the DZ in 1982 might have been from a buried root rather than a windblown seed. The re-invading species evidently started mostly or wholly from seeds brought into or lying dormant in the peat, and grew soon after the disturbance ended (1972 and possibly 1973), since they were seen as numerous small plants in those summers, although the possibility of a few coming from buried roots cannot be ruled out. It is possible that the abundance of *Viola* in August, 1972, came from new (1972) ant-dispersed seeds finding the habitat still very open and thus highly favorable, in addition to some buried seeds and plants, whereas the slow increase in *Andropogon* suggests a gradual seeding-in (by wind) in combination with a slow maturation rate. The high values in 1979 for *Carex stricta* and *C. aquatilis* in the DZ, along with a conspicuous abundance of *Typha latifolia* and *Scirpus validus,* may indicate "pioneering" advantage. (Possibly, too, these four semi-aquatic species were augmented in the DZ with rhizomes brought in during peat dumping from flooded areas closer to the river.)

The species in Group B, in contrast to Group A, are rapid-growing and probably less competitive herbs, as deduced from the fact that they attained a much larger plant size and/or abundance in the DZ than in the UZ; moreover, many matured more quickly than the "climax dominants" did, and then some declined in abundance by 1979 (compare columns 1, 2 and 3). The starred species of Group B, in particular, exhibited unusual vigor in the DZ where plant cover was uneven and hence plant competition was perhaps reduced. For example, *Bidens coronata* occasionally reached 2 m in height in the DZ, in constrast to about 20 cm in the UZ, while *Gentiana procera* reached 50 cm in height, with 5-20 flowers per plant, in the DZ, in contrast to 10-20 cm, with but 1-3 flowers, in the UZ. This effect was as striking for some perennials, such as *Solidago riddellii, Pedicularis lanceolata,* and *Parnassia glauca,* as it was in the biennials and winter annuals.

A further distinction could be made, within the plants of Group B, between "climax opportunists" (0) which persisted in or reinvaded both zones, with a steady annual frequency but lower in the UZ, and the "true pioneers" (P) which appeared only temporarily after the dredging disturbance, and were not found in the UZ during the ten years of observation. The true pioneers tended to recur in the DZ only in the foot path along the ditch after the first few years. Both groups, probably differing only in the degree of their intolerance of plant competition, include calcicoles (C) and general wetland species (W), and they include both annuals-biennials (A) and perennials. The long-lived clonal perennials (R) like *Aster lucidulus* and *Solidago gigantea* persist as rarely-flowering widely-scattered short stalks in the UZ as do the (presumably short-lived) cespitose perennials (S) like *Eupatorium maculatum* and *E. perfoliatum.* With drainage, these (R & S) species soon explode and dominate the biomass, as noted in the Wingra Fen study (Salli 1965) as well as by Moran. Some perennials suspected of being short-lived in dense cover, such as *Carex hystricina* and *Scirpus atrovirens,* may persist indefinitely in springs, paths, ditches and pastures; but they had died out in the DZ by 1979. In one of the University of Wisconsin Arboretum's lagooned fens (Monroe Street Duckpond), both species persisted on eroding peat banks until 1948, 12 years after the original dredging, and then reappeared on spoils from redredging in 1974 (personal observation); possibly, then, their seeds lay dormant in the bottom peat for 26 years.

The dozen "climax opportunists" which had not appeared in the DZ by 1979 (and 1982) are placed in this category on the basis of personal observation elsewhere. No explanation can be offered for the behavior of *Thalictrum.* It is here, as usual, scarce in the virgin climax condition; but it was expected to invade the DZ in exceptional abundance. It is one of the commonest species in most of our somewhat pastured or drained fens today, whereas it was apparently a rare species in the early days (Cheney and True 1893).

The woody species (Group C in Table I) seem to fall into the same three classes as did the herbs. "Climax" species, marked T, appear to be stable in the UZ and in similar fens, neither increasing nor decreasing much over the years. Curtis (1943) reported a drastic decline in stem density of bog birch (*Betula pumila, glandulosa,* or *sandbergii;* part of a confusing complex needing further study) in Wingra Fen in the University of Wisconsin Arboretum, and a corresponding increase in flowering and stem density of *Cypripedium candidum,* after several years of annual mowing, simulating prairie fires; but whether the shrubs' roots actually disappeared is not clear. Moran reviews several observations suggesting that fires may help control shrubs; but again it is not certain whether these woody shrubs are actually eliminated by fire or merely kept in an inconspicuous subordinate state. As does the birch, red osier dogwood varies from 0 to over 50% cover in various undisturbed burned and unburned Wisconsin prairie fens, yet seemed not to be changing in the UZ in the ten years observed. The dogwood remained at 50% cover with neither seedlings nor rooted stolons observed in the UZ.

Reproduction of the "climax" woody species, however, may require special site conditions so they might really all be "opportunists" or even "pioneers." The birch, of low density in the UZ, was not observed to reproduce in either zone, whereas in the dry year 1976, birch seedlings appeared in spring at very high densities (up to $10/cm^2$) in the drying areas of peat exposed in Wingra Fen, only to die of drouth later in the season (personal observation). The dogwood was virtually absent in the DZ until 1979, when an abundance of seedlings (66% frequency, often occuring in groups of 2-6 individuals, estimated at 1-4 years of age, about 5-20 cm in height) was discovered there. Only six adult bushes were in that zone in 1979; presumably they predated the construction in 1972. The tardiness of this high rate of invasion by red osier dogwood suggests that a special means of seed dispersal was necessary, since berry production was high in all years (never all burned). Experimental germination was obtained readily in one season with stratification and/or scarification (Kogler, 1979); therefore seeds buried in peat should have grown by 1973. One possibility is that voles and shrews—probable important vectors and cachers of seeds (obtained either from berries or bird excrement)—would not invade the DZ until several years of revegetation had built up sufficient cover and litter to provide suitable habitat and food. Perhaps by 1979 the small mammal population was large enough to consume most of the seeds they brought in, as may be chronically the case in the UZ, where no dogwood seedlings were found. Habitat specificity, including temporarily reduced plant competition, as well as reduced water saturation, may be as important for the ecesis of dogwood as for bog birch. In Waterloo Fen (Jefferson County, Wisconsin) these shrubs are found mostly at the sides of the fen humps which may be subject to slumping and drying (personal observation). Shrub patterns are likewise conspicuous at Waubesa Fen (Kratz and Winkler 1982), and they form a ring around the Waubesa "gentian pocket" (Burr 1980) and the "prairie ring" in one part of Wingra Fen (Lovely 1983). These circles may surround "discharge windows." *Salix candida,* like bog birch, failed to colonize the DZ, perhaps likewise requiring a rare or narrow range of temperature or moisture conditions which did not coincide with the temporary absence of competition in the years 1972-73. A reasonable hypothesis for a scattering of dogwoods, willows and birches in the UZ and in other relatively undisturbed fens is that microtopography caused by anthills and trampling by deer might occasionally provide small dry colonization sites.

In contrast to the "conservative" woody species discussed above, *Salix bebbiana, S. petiolaris,* and *S. discolor* (which do occur at low frequencies in unaltered fens) invaded the DZ very abundantly, but did so only once, in 1972, while not changing in abundance in the UZ. Hence they can be called "true pioneers, like the tree willows and cottonwoods. Unlike the pioneer herbs, however, all these woody species may be able to dominate the vegetation for many years and even alter the environment (by shading ground herbs and drying the peat) to their temporary advantage and that of upland invaders. The sapling willows and cottonwoods reached a height of 0.5-2.0 m in the first or second years and were becoming difficult to pull out by autumn, 1973. It required about 20 people, working 2-3 hours, in both 1972 and 1973 to eradicate all these invaders save a few of the climax opportunist willow shrubs; although not counted, the number removed must have been on the order of 1,000-2,000 in the DZ, in many parts of which the density exceeded one per m^2. The unmanaged control areas of the DZ were perhaps not fully comparable since they were sandier and drier—at the east end of the ditch on both sides and all along the south side where sand had been piled. In these places an enduring dense thicket of cottonwood, sandbar willow and tree willows now reaches to ten m in height, with stem densities still approaching or exceeding $1/m^2$.

Conclusions

1. Given a chance, natural vegetation can restore itself in a prairie fen. In this case, without any planting, given a seed source of diverse native species nearby and possibly also in the peat, given an undisturbed hydrologic regime which soon wetted the additional (but thin) peat spoils cover, and given prompt removal of the one-time invading willows and cottonwoods, native plant species restored full cover by the second season's end. In 1979, after the eighth summer, 49 of the 71 enduring fen species had returned, including ten of the fifteen presumed "climax" fen herbs.

A major difference in aspect of the disturbed zone throughout this study was lack of red osier dogwoods. However, a late heavy invasion of seedlings of this shrub in the DZ (by 1979) portended abnormally dense dogwood cover in the future if these did not die and if they were not removed or thinned while still small. A second conspicuous difference in the restored disturbed zone as compared to the UZ was a greater abundance maintained through 1982 of semi-aquatic species, including *Typha latifolia, Scirpus validus, Carex stricta* and *C. aquatilis.* It was not clear whether this difference would be permanent or not and to what extent the invasion was due to temporary lack of competition in 1972, or to fortuitous seed availability, or to an artifact of spoils transport.

A distinction must be made between disturbances of the surface (soil or vegetation) and of the hydrologic regime (water levels, pressures, rates of flow, and sources). This fen was unusual in suffering only a surface disturbance; most fens today suffer hydrologic as well as surface impacts due to human activity, with characteristic resulting invasion of lowland and upland carr and forest, or of ragweed (*Ambrosia trifida*) and nettle (*Urtica procera*), or reed canary grass, or at least of general wetland opportunists such as *Impatiens biflora, Aster lucidulus* and *A. simplex,* and *Solidago gigantea* and even *S. altissima.*

2. When compared with the vegetation in the undisturbed zone, the response to disturbance revealed individual behavioral characteristics and relationships among the plant species. Several approaches for portraying the nature of plant succession are suggested by the results:

(a) A spectrum of survival strategies. At one end are the "climax dominants and associates" which endure competition, grow slowly, and exhibit a certain amount of year-to-year rotation in dominance. At the other end are the "true pioneers" which can invade only once, at a time of major devegetational disturbance, and then run their life course whether short or long. Among the woody pioneers, tree species while alive indicate by their age the date of the most recent major disturbance. In between the extremes are the "climax opportunists" which persist in or reinvade the climax phase at low vigor and frequency (in a steady-state pattern) and which indicate by becoming conspicuous the time and location of minor as well as major surface disturbances. Some of these plants may have special survival strategies such as the root parasitism of *Pedicularis* (Piehl 1965), fungal associations (orchids and perhaps others), and special dispersal and seed planting requirements such as being stamped into the soil by deer or livestock (suggested by various authors for *Gentiana* and *Cypripedium*). Reed (pers. comm. 1983) suggests subdividing the "climax opportunist" class into "general opportunists" found in many habitats (*Equisetum arvense, Impatiens biflora, Scirpus atrovirens, Thalictrum dasycarpum, Aster simplex, Solidago altissima*), "mid-succession" species (most of Group B in Table I), and "late succession" species (perhaps *Galium labradoricum, Spartina pectinata, Carex prairea,* etc.).

No doubt the individual strategems will prove to be so diverse and complex as to defy simple classification when fully known. For example, it has been suggested (Calvin DeWitt, U W. Envt. Studies Institute, pers. comm.) that *Cypripedium candidum* (absent in this fen but present in fens nearby), whose crowns are known to remain dormant during some growing seasons, might flower best when under environmental stress—the only time that expenditure of energy for reproduction is crucial—and if so would then indicate conditions of environmental change or habitat degradation rather than of stability and "health."

(b) The disturbance requirement for maintenance of even the "climax" vegetation. Some competition-tolerant species may occasionally have a chance to replace their senescent individuals in the local disturbed sites that favor the opportunists as well (the "gap-phase" of forestry and the "internal succession" of Curtis). Other climax members may require the prior establishment of mid-succession or even pioneer species to flourish (possibly the case for the last 5 species of Group A in Table I). However, it appears from this study that many of the permanent species of Group A reproduced chiefly in the year of major disturbance along with the pioneers. Succession, as measured by successive dominance of species, would then be an artifact of the different maturation rates of pioneer and climax types. Succession in other wetlands, too, has been found to be closer to this "fortuitous allogenic" model than to the traditional "environmental conditioning" model (Van der Valk, 1981, 1982).

(c) "Party-crashing" by species from alien ecosystems. In the Van der Valk model, plants play two games. Disturbances are like the periodic stopping of music in the game of "musical chairs." Once "in," either the climax dominant fen herbs or the pioneering woody species may then play "king of the hill," excluding most competitors and freezing for a long time the pattern of temporary disturbance and fortuitous seed availability. In these games, species from two alien communities—field and forest—may likewise get "in" and participate in the fen's successional cycle. In healthy fens, agricultural crop pests (American and Eurasian) are unlikely to remain except possibly the hydrophytic reed canary grass, which has persisted in a wet fen hump in Waubesa Wetlands for several decades (Burr 1980). A few small clones of reed canary have persisted in the DZ through 1982.

By shading and drying effects, woody invaders pose a serious threat to fen herbs now that so few gene banks of native species remain and now that additional Eurasian species are available. In the past, invading woody species such as alder (*Alnus rugosa*), tamarack (*Larix laricina*) and white cedar (in cool climates) and the cottonwoods and willows of river floodplains, accompanied or followed by other wet forest species, were probably a normal successional expression of dry phases of climatic cycles. Such an interpretation could explain the woody and charcoal layers in Vogl's sedge peat profiles. Tree-dried peat, in time of drouth, might be especially prone to burn. Today, Eurasian invaders of impacted fens exacerbate the extinction of native fen species by being pre-adapted for fens and relatively resistant to local consumers like deer, rabbits, and insects. Kogler (1979) documents the rapid invasion of Gardner Marsh (a ditched fen) by *Lonicera* x Bella (*morrowi* x *tatarica*), *Rhamnus cathartica,* floodplain trees (cottonwood, sandbar willow and ash), and especially the European fen buckthorn, *Rhamnus frangula.* The latter has abundantly invaded Wingra Fen (Lovely 1983) and is now appearing even in the minimally altered Cedarburg String Bog at Saukville (personal observation, 1983). It is not known if its recently widely propagated cultivar "tallhedge" will also invade natural communities.

3. Management of natural ecosystems to perpetuate native gene banks requires counteracting the human impacts. For fens, these impacts include alien species as well as hydrologic effects. A number of our rare or endangered plant (and possibly animal) species appear to be true pioneers or at least climax opportunists, dependent on a certain amount of recurrent local disturbance of the soil and the vegetation fabric by weather, animals, and probably by certain types of fire (for example, see Smith 1983). These same disturbances, however, may enable long-lived and often habitat-influencing alien species (from other habitats or continents) to usurp the site. Planting, earthmoving, and alteration of hydrologic regimes in the vicinity provide seed sources for these aliens almost everywhere today, so that the conditions (disturbance patterns) necessary for native species' maintenance in protected habitats risk allowing some aliens repeatedly to get a foothold. For example, lesser fringed gentians seem to benefit from light grazing or trampling by dairy cattle at the fen edge (Walworth County, Wisconsin, near Lake Comus, personal observation, 1981). In such places, these alien threats to lesser fringed gentians and other rare plant and animal fen species include: a) reed canary grass such as in South Waubesa and Wheeler Road fens, b) buckthorns and river nettles and giant ragweed in Wingra Fen and many others, c) purple loosestrife (*Lythrum salicaria*) in the Fox Valley Crane Refuge and at the Horicon Wildlife Refuge, and d) cottonwoods and several willows in all of these Wisconsin wetlands.

Management of natural areas, therefore, involves continual removal of the alien species within and without the protected area. Ironically, this constant cost-intensive spatial segregation of species is precisely what distinguishes the garden and the zoo from a natural area. The high cost of seizing opportunities to study impacted habitats and the high cost of maintaining virgin examples for comparison are justified by the high efficiency with which the interactions and dynamics are revealed, on which to base successful resource management strategies.

Acknowledgment

Special thanks are due to Mr. Jack Maxfield for his cooperation in enabling pursuit of this study as an alternative to planting on the disturbed peat of the right of way of the Madison Metro Sewerage District, and likewise to Mr. Si Widstrand, for permission to conduct the study and remove invading woody plants within a Madison Conservation Park. For critically reading this manuscript and for many helpful suggestions I am indebted to Mr. Donald M. Reed (biologist, S.E. Wis. Reg. Pl. Comm.).

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STORED-PRODUCT INSECT PESTS IN FEED MILLS IN SOUTHERN WISCONSIN

PHILLIP PELLITTERI AND G. MALLORY BOUSH
Department of Entomology
University of Wisconsin-Madison

Abstract

Twenty feed mills located in southern Wisconsin were sampled in an attempt to assess the stored-product insect fauna present during the summers of 1975 and 1976. Over 100 insect species were collected and identified, and 11 species recorded for the first time as occurring in Wisconsin. Various sampling methods, including insect traps and debris collections, were used to determine the degree of infestation within each mill, and to determine the insect fauna present.

INTRODUCTION

The worldwide movement of stored-product insects through commerce has often caused economic and political problems (Freemen, 1973). Early detection, and a knowledge of the life histories and habits of the insect species involved, are essential for correct control procedures and for the protection of the products involved (Aitken, 1975). Federal inspections and quarantine regulations do much to check the introduction or spread of stored-product pests, but the need to monitor the insect fauna remains. To illustrate this point, *Trogoderma granarium* the Khapra beetle, was first collected and identified in the United States in California in 1953 (Allen and Linsley, 1954), yet this destructive species had been introduced into the United States at least seven years earlier, and spread to four states before being eradicated in the early sixties (Cotton, 1963).

No comprehensive stored product insect survey has been previously conducted in Wisconsin. The plan of the present investigation was two-fold. First, 20 feed mills were sampled over a two-year period in Southern Wisconsin in an attempt to assess the stored product insect fauna present. Secondly, an analysis of interspecific distribution records for the collected species of stored product insects was made. This paper deals with the insect fauna collected and categorized during the two-year study.

MATERIALS AND METHODS

Sampling Sites

Twenty feed mills located in southern Wisconsin were selected as sampling sites during the Spring of 1975: Sampling was conducted in Dane, Rock, Iowa, and Jefferson counties during the eight-week periods of June 24 through August 12, 1975 and June 25 through August 11, in 1976. Permission to sample each mill was requested yearly, and an agreement was made to keep the affiliations and locations of each establishment unpublished. In 1976, two mills refused to allow further sampling for undisclosed reasons.

Each feed mill was visited biweekly and a) inspects traps were placed, b) previously placed traps were collected, c) a 250 ml. sample of spilled feed and grain was taken, d) and a hand collected sample of insects was made during each visit. Eight collections were obtained from each mill during the two year survey. Conditions of sanitation, infestation problems, and insecticide treatments were recorded, along with pertinent comments obtained in conversations with the mill managers.

Fourteen of the twenty mills were less than 28,000 sq. ft. in area and the remaining six sampling sites were more than 30,000 sq. ft. Small amounts of corn were stored in various bins and storerooms in each of the sampled mills. Fifty-pound bags of dairy cow, calf, hog and horse feed along with various dog foods were stored throughout the mills. Three of the sampling sites were also manufacturing plants and produced their own feeds for commercial sale.

Identification of Specimens

The following specimens were identified or confirmed by the following specialists at the University of Wisconsin, Madison: Phillip Kingsley (Anthocoridae), Dennis Engel (Diptera), Dr. R. D. Shenefelt (Braconidae), and Dr. Jim Mertins (Pteromalidae). Specimens of *Lariophagus distinguendus* were sent to the Insect Identification and Beneficial Insect Introduction Institute, Beltsville, Maryland, for verification. All Coleoptera and Lepidoptera specimens, and a majority of the Diptera and Hymenoptera were identified by the senior author. Identified specimens have been deposited in both the Department of Entomology, University of Wisconsin-Madison collection, and with the State Agriculture Department, Madison. Wisconsin State Department of Agriculture and University of Wisconsin Insectarium records, along with pertinent literature were used as the criteria for distinguishing state records for the occurrence of an insect species.

TABLE 1. Anthropods collected in southern Wisconsin feed mills during 1975 and 1976.

	1975 No. of mills present		*1976 (Total No. collected)*	
Insecta				
Thysanura				
Lepisma saccharina L.	1	(1)	2	(5)
Collembola	10	(—)	12	(—)
Hemiptera				
Reduviidae				
Reduvius personatus L.	1	(1)	2	(3)
Anthocoridae				
Lyctocoris campestris (Fab.)	3	(4)	—	
Xylocoris sp.	—		1	(1)
Orius insidiosus (Say)	2	(2)	—	
Nabidae	1	(1)	1	(1)
Pentatomatidae	—		1	(1)
Lygaeidae	1	(1)	—	
Homoptera				
Cicadellidae	1	(1)	1	(4)
Fugaloridae	—		1	(1)
Aphidae	—		2	(2)
Psocoptera	12	(1)	10	(—)
Coleoptera				
Anobiidae				
Stegobium paniceum (L.)	2	(5)	5	(15)
Trypopitys sericeus (Say)	1	(1)	—	
Anthicidae				
Anthicus floralis (L.)	2	(2)	1	(2)
Anthicus cervinus LeFerte	1	(1)	6	(10)
Bostrichidae				
Rhizopertha dominica (Fab.)	1	(1)	—	

TABLE 1. Anthropods collected in southern Wisconsin feed mills during 1975 and 1976.—Continued

	1975 *No. of mills present*		*1976* *(Total No. collected)*	
Carabidae				
Clivina impressifrons LeConte	2	(2)	—	
Agonum sp.	1	(1)	—	
Bembidion sp.	—		1	(1)
Agonoderus lecontei Chaudoir	—		1	(1)
Harpalus compar LeConte	1	(1)	—	
Chrysomelidae				
Undetermined spp.	1	(1)	1	(3)
Gastrophysa polygoni (L.)	1	(1)	—	
Disonycia sp.	—		1	(1)
Agalyma vitta F.	—		1	(1)
Coccinelidae				
Adalia bipunctata (L.)	3	(6)	2	(3)
Hippodamia convergens Guerin	—		1	(1)
Coleomegilla fuscilabris Mulsant.	4	(8)	2	(7)
Scymnus sp.	—		1	(1)
Cryptophagidae				
Cryptophilus integer Heer*	5	(22)	2	(5)
Cryptophagus pilosus Reitter	6	(9)	2	(3)
Cryptophagus obsoletus Reitter*	5	(8)	1	(1)
Cryptophagus croceus Zimm.	7	(18)	3	(3)
Cryptophagus sp.	2	(2)	—	
Atomaria spp.	2	(2)	—	
Cucujidae (Silvanidae in part)				
Cryptolestes turcicus Grov.*	11		9	
Cryptolestes ferrugineus Steph.*	12	(2,364)	9	(2,506)
Silvanus bidentatus (F.)	1	(1)	—	
Oryzaephilus surinamensis (L.)	19	(1,698)	17	(793)
Ahasverus advena (Walt.)	20	(755)	17	(185)
Curculionidae				
Sitophilus granarius (L.)	15	(779)	17	(1,455)
Dermestidae				
Attagenus megatoma (Fab.)	20	(455)	18	(342)
Attagenus elongatulus Casey	2	(3)	1	(1)
Attagenus spp. (larvae)	20	(1,014)	18	(579)
Anthrenus fuscus Olivier	2	(2)	—	
Anthrenus castanae Mels.	3	(4)	2	(2)
Anthrenus scrophularae L.	2	(2)	—	
Anthrenus sp. (larvae)	1	(1)	2	(4)
Trogoderma variable Ballion	1	(2)	1	(6)
Trogoderma glabrum (Hbst.)	5	(37)	5	(12)
Dermestes lardarius L.	11	(28)	15	(65)
Dytiscidae				
Ilybius sp.	1	(1)	—	
Endomycidae				
Mycetaea hirta (Marsh.)*	1	(1)	—	
Histeridae				
Dendrophilus xavieri Marsuel	4	(5)	2	(2)
Dendrophilus punctatus (Hbst.)	—		1	(1)
Carcinops pumilio (Erickson)	3	(3)	9	(118)
Acritus sp.	2	(4)	1	(128)
Sparinus sp.	—		1	(1)

TABLE 1. Anthropods collected in southern Wisconsin feed mills during 1975 and 1976.—Continued

	1975 No. of mills present		*1976* (Total No. collected)	
Hydrophilidae				
Cyphon sp.	1	(1)	—	
Lathridiidae				
Lathridius minutus (L.)	10	(35)	2	(5)
Cartodere sp.	1	(1)	1	(1)
Coninomus constricta (Gyll.)	5	(7)	1	(2)
Corticara sp. (near *elongata* (Curtis))	3	(4)	1	(1)
Undetermined sp.	1	(1)	—	
Lyctidae				
Lyctus planicollis LeConte	1	(1)	1	(1)
Mycetophagidae				
Typhaea stercorea	16	(163)	11	(66)
Mycetophagus quadriguttatus Mull.	5	(7)	3	(7)
Litargus balteatus LeConte	7	(7)	1	(1)
Nitidulidae				
Carpophilus hemipterus L.	11	(20)	2	(2)
Carpophilus sayi Parson	1	(1)	—	(2)
Carpophilus brachypterus Say	3	(3)	2	(2)
Glishrochilus fasciatus (Ollv.)	2	(2)	—	
Glishrochilus quadrisignatus	9	(25)	4	(6)
Omosita colon (L.)	1	(1)	3	(5)
Eupuraea sp.	1	(1)	—	
Ostomidae				
Tenebriodes mauritanicus (L.)	18	(269)	17	(151)
Orthoperidae				
Molamba sp.	—		1	(1)
Ptinidae				
Ptinus fur (L.)	7	(10)	4	(6)
Ptinus villiger (Reitter)	7	(11)	3	(13)
Ptinus clavipes (Panzer)	6	(14)	2	(3)
Gibbium psylloides (Czenpinski)	1	(4)	1	(2)
Pseudeurostus hilleri (Reitter)	1	(1)	1	(2)
Rhizophagidae				
Monotoma picipes Herbst	—		2	(3)
Scarabeidae				
Aphodius sp.	1	(1)	—	
Staphylinidae				
Philonthus spp.	2	(2)	4	(6)
Atheta spp.	4	(5)	5	(9)
Undetermined specimens	2	(3)	6	(11)
Tenebrionidae				
Alphitophagus bifasicatus (Say)	2	(18)	1	(1)
Alphitobius diaperinus (Panzer)*	3	(3)	1	(1)
Cynaeus angustus (LeConte)	4	(6)	5	(5)
Platydema ruficorne Sturm.	4	(4)	—	
Tenebrio molitor L.	19	(169)	17	(135)
Tenebrio obscurus Fab.	19	(29)	9	(12)
Tenebrio spp. (larvae)	20	(554)	18	(414)
Tribolium castaneum (Hbst.)	7	(258)	5	(234)
Tribolium confusum DuVal.	9	(207)	8	(179)
Palorus ratzeburgi (Wiss.)*	5	(129)	4	(122)

TABLE 1. Anthropods collected in southern Wisconsin feed mills during 1975 and 1976.—Continued

	1975 No. of mills present		1976 (Total No. collected)	
Diptera				
Chironomidae	—		1	(1)
Cecidomyiidae	4	(6)	4	(5)
Mycetophilidae	2	(—)	3	(—)
Psycodidae				
Psycoda spp.	2	(2)	2	(2)
Scenopinidae				
Scenopinus fenestralis L.	14	(101)	13	(42)
Muscidae				
Muscina stabulans (Fallen)	4	(11)	3	(4)
Musca domestica L.	2	(3)	1	(1)
Anthomyiidae				
Hylemya sp. (prob. *ciljcura* (Rondani))	7	(30)	9	(17)
Fannia canicularis (L.) (pupae)	2	(5)	1	(1)
Scatopsidae				
Scatopsis spp.	10	(42)	4	(28)
Tabanidae	—		1	(1)
Syrphidae	1	(1)	—	
Lonchaeidae				
Lonchaea sp.	5	(7)	—	
Caliphoridae	3	(3)	3	(3)
Dolichopodidae	—		1	(1)
Drosophilidae	2	(2)	1	(1)
Helicomyzidae	1	(1)		
Phoridae	1	(1)		
Undetermined Acalypterates	5	(12)	7	(10)
Lepidoptera				
Pyralidae				
Pyralis farinalis L.	14	(77)	8	(30)
Tineidae				
Tineola biselliella Humm.	4	(7)	4	(18)
Nemapogon granella (L.)*	3	(19)	5	(9)
Phycitidae				
Ephestia kuehniella Zell.	3	(11)	6	(12)
Plodia interpunctella Hubner	8	(89)	3	(17)
Hymenoptera				
Ichneumonidae				
Idechthis canescens (Gravenhorst)	4	(5)	2	(3)
Braconidae				
Metrious sp.	2	(2)	—	
Pteromalidae				
Lariophagus distinguendus Foerst*	9	(22)	5	(15)
Undetermined specimens	4	(6)	3	(3)
Bethylidae				
Cephalonomia sp.*	4	(6)	2	(4)
Plastanoxus sp.*	1	(1)	—	
Formicidae	1	(1)	1	(1)
Arachnida				
Chelontida				
Cheliferidae				
Chelifer cancroides (L.)	10	(42)	12	(102)

* State record for occurrence of species.

Sampling

A number of sampling techniques were used in an attempt to fully assess the insect fauna present in each mill. Samples of live and dead insects were hand-collected during each visit.

A 250 ml sample of whole grain corn, oats, grain dust, and spilled feed was collected from each mill. Each sample was passed through two sieves (U.S. standard sieve series #40 and #12), adult insects were separated, and the sample was incubated for 120 days at 21 ± 3°C and 60% RH, after which it was again passed through a sieve and all insects were removed and recorded.

A number of trap types were placed in each mill and were collected during the following visit. Pitfall traps using 100 × 15 mm plastic petri plates; 15 × 25 cm rolled sheets of single-backed corrugated cardboard; and cheesecloth-wrapped food traps baited with various combinations of poultry mash, whole grains, and Brewer's yeast were employed. Traps were brought back to the laboratory and stored at − 10°C until the insects could be separated and identified.

Results

Fauna

A total of 18,410 insects were collected and identified during the two year survey. The faunal list obtained is shown in Table 1. Eight orders, 60 families and over 100 insect species were associated with the 20 southern Wisconsin feed mills sampled. Eleven species have been recorded for the first time as occurring in Wisconsin.

Coleoptera

Coleopterans made up 90.6% of the insects collected (Table 2). Of the 83 species of beetles recorded, 62 are associated with stored products (Cotton and Good, 1937, and Aitken, 1975). The flat and rusty grain beetles, *Cryptolestes turcicus* and *C. ferrugineus* were the most abundant insects encountered. Both of these *Cryptolestes* spp. were identified for the first time as occurring in Wisconsin. Specimens identified as *C. pusillus,* which had been previously collected in the State were found in the University of Wisconsin Insectarium and in the collection of the Wisconsin State Department of Agri-

Table 2. Percentage of the total number of insects collected for select insects.

		1975	*1976*
Tenebriodes mauritanicus	adult	1.76%	1.39%
Tenebriodes mauritanicus	larvae	1.00	0.346
Dermestes lardarius	adult	0.29	0.749
Attagenus megatoma	adult	4.67	3.94
Attagenus spp.	larvae	10.41	6.67
Oryzaephilus surinamensis	adult	17.4	9.14
Sitophilus granarius	adult	7.99	16.77
Ahasverus advena	adult	7.75	2.13
Tenebrio spp.	larvae	5.69	4.78
Tenebrio molitor	adult	1.73	1.55
Tenebrio obscurus	adult	0.297	0.138
Tribolium castaneum	adult	2.64	2.69
Tribolium confusum	adult	2.07	2.13
Typhaea stercorea	adult	1.67	0.761
Cryptolestes spp.	adult	24.37	28.89
Palorus ratzeburgi	adult	0.379	0.253
Pyralis farinalis	adult	0.787	0.345
Ephestia kuehniella	adult	0.112	0.138
Plodia interpunctella	adult	0.913	0.196
Total		91.97%	83.16%

culture. Inspection of these specimens revealed that they had been misidentified by a taxonomist at the Smithsonian Institute, Washington, D.C. and were actually a mixture of *C. ferrugineus* and *C. turcicus.* Over 4,000 specimens were identified and 125 genitalia dissections were made, but no specimens of *C. pusillus* were found during this survey or in either collection. Bishop (1959) reported numerous misidentified specimens of *Cryptolestes* spp. as well as confused distribution records, and that *C. turcicus* and *C. ferrugineus* are the most abundant species found in the northern grain growing areas.

Attagenus megatoma was the most widely distributed insect, occuring in every mill sampled. Beal (1970) has recognized two subspecies of *Attagenus megatoma; A. megatoma megatoma* and the northern form *A. megatoma canadensis.* Movement of the two forms through commerce has somewhat obliterated the line of demarcation. The distinguishing characteristic between the forms is the number of golden brown hairs present on the elytra; no golden setae present in *A. megatoma megatoma,* and *A. megatoma canadensis* having golden brown hairs inserted in some numbers on the base of the elytra back to a distance equal to at least three lengths of the scutellum. Examination of the adult specimens collected during this survey revealed the presence of *A. megatoma megatoma.* No specimens of *A. megatoma canadensis* were collected, but numerous intergrade specimens (having golden hair inserted on the base of the elytra for a length of one half to two lengths of the scutellum) were found. The sample populations from a given mill had a characteristic and more or less constant appearance. *Attagenus megatoma megatoma* was prevalent in eastern Dane and Jefferson counties, while the intergrade specimens appeared in southern Dane and Rock counties. The gradation within mills was so constant that an individual specimen could be placed as to the county, and in some cases the mill, from which it was collected on the basis of appearance alone.

Sitophilus granarius, the granary weevil, was found to be abundant and widely distributed within the sampled feed mills. A number of mill managers reported farmer-delivered oats as the major source of the infestations, yet specimens were collected only in grain samples of whole corn, and weevils were not observed at any time on whole grain oats. The extreme winter temperatures and short storage periods (usually under one year) normally prevent weevil infestations from becoming economically important in Wisconsin, but weevil populations were sufficiently large in two feed mills during the spring of 1975 to require a fumigation. Although it has been recorded in stored grain in Wisconsin, the rice weevil, *Sitophilus oryzae,* was not collected in any of the feed mills sampled.

Other economically important stored product pests recorded include the cadelle beetle, *Tenebriodes mauritanicus,* the drugstore beetle, *Stegobium paniceum,* and the lesser grain borer, *Rhizopertha dominica.* Both *Tribolium castaneum* and *T. confusum* were widely distributed and in some cases abundant. Mixed populations of both species were collected during 1975 and 1976 in five and six of the sampled mills respectively. Laboratory experiments have shown that *Tribolium* spp. cannot coexist in a closed system (Yoshida, 1976), but no evidence of species dominance was observed. *Tribolium* populations were largest in the heated manufacturing mills. The tenebrionids, *Tenebrio molitor* and *T. obscurus,* were found to coexist in a number of sampled mills, but in all cases *T. molitor* was more numerous.

Various species of fungus beetles made up 32.4% of the total number of beetles encountered (Table 2). *Ahasverus advena,* the foreign grain beetle, was the most abundant fungus beetle collected. The hairy fungus beetle, *Typhaea stercorea,* was the most widely distributed mycetophilous beetle;

other members of the family Mycetophilidae, *Mycetophagus quadriguttatus* and *Litargus balteatus* were observed in a number of mills, but were not abundant. Seven species of Nitidulidae were captured, with *Carpophilus hemipterus* and *Glishrochilus quadrisignatus* being the most widely distributed and most numerous sap beetles encountered respectively. Although members of this family often infest corn in the field (Daugherty and Brett, 1966), *C. hemipterus* was the only economically important storage pest of this family collected. Members of the family Cryptophagidae appeared in better than 25% of the sampled mills. Species collected from this family in order of decreasing abundance include: *Cryptophilus integer, Cryptophagus croceus, C. pilosus, C. obsoletus* and *Atomaria* spp. *Lathridius minutus* was collected in ten of the mills sampled while four other species of Lathridiidae were encountered.

Members of two predaceous beetle families associated with stored product insects, the Staphylinidae and Histeridae, were observed and collected in a number of mills. The numbers of these carnivorous beetles collected in any given mill were normally low, but in two cases in 1976, large numbers of the hister beetles, *Carcinops pumilio,* and *Acritus* sp. were observed. In both instances the areas had remained undisturbed for long periods of time, and large populations of stored product pests had built up in the 8-30 cm of spilled feed and grain present on the floor.

Over 2,000 specimens of the sawtoothed grain beetle were collected, they were present in 95% of the sampled sites (Table 1). Observations on the number of beetles collected during each sampling revealed rather constant populations of *Oryzaephilus surinamensis* present throughout the summer.

Three minor stored product pests, the smalleyed flour beetle *Palorus ratzeburgi,* the lesser mealworm *Alphitobius diaperinus,* and the spider beetle, *Pseudeurostus hilleri,* along with the mycetophilous stored product beetles *Cryptophilus integer, Cryptophagus obsoletus,* and *Mycetaea hirta* were collected and identified in Wisconsin for the first time. Because of the cosmopolitan distribution of most of these species it is unlikely that any were recently introduced. The lesser grain borer, *Rhizopertha dominica,* was recorded for the second time in Wisconsin.

Diptera

A number of dipterans collected during this survey are not normally associated with stored products. Members of the families Chironomidae, Dolichopodidae, Syrphidae, Tabanidae, Caliphoridae and Helicomyzidae do not normally breed in stored product habitats, or feed on stored product insects. Their presence in the feed mills is therefore considered accidental.

Damp, mold-ridden stored products often support populations of mycetophilous Diptera. Species associated with these conditions collected during this survey include members of the families Cecidomyidae, Scatopsidae, Psycodidae, Mycetophilidae, Anthomyiidae and Muscidae. Pupae of *Fannia canicularus* were found in four of the sampled mills. Fifteen specimens of *Muscina stabulans,* which normally breeds in decaying organic matter (James and Harwood, 1969), and four specimens of *Musca domestica* were also collected.

Both the adults and larvae of the windowpane fly, *Scenopinus fenestralis,* were collected in over 60% of the feed mills. Adults were observed and collected at windows, and the larvae, which are predaceous on stored grain insects (Hinton and Corbet, 1955) were associated with samples of spilled grain and feed.

Lepidoptera

Five species of stored product Lepidoptera were recovered during the two years of sampling. The European grain moth, *Nemapogon granella,* was recorded for the first time in Wisconsin. The meal moth, *Pyralis farinalis* was the most abundant and widespread lepidopteran. Rarely economically important, this pyralid breeds in damp products (Anonymous, 1965). *Plodia interpunctella,* the Indian meal moth, and the Mediterranean flour moth, *Ephestia küehniella,* built up to economically important numbers separately in two Dane county feed mills in 1975. *Plodia interpunctella* was encountered in 40% of the sampled feed mills in 1975. *Tineola biselliella,* the webbing clothes moth, was prevalent in one feed mill during 1976. The important lepidopteran stored grain pest, *Sitotroga cerealella,* has not been collected in Wisconsin.

Miscellaneous Orders

Six specimens of the silver fish, *Lepisma saccharina,* were collected during the two-year survey. Because of a starch diet, Linsley (1944) considers these thysanurans to be of little importance and their presence largely incidental in stored products. Psocids (order Psocoptera), were observed in over 55% of the feed mills in 1975 and 1976. Their small size, speed, and cryptic habits prevented an accurate quantitative assessment. Members of the collembolan family Entomobryidae were collected in over half the mills sampled. The Homoptera and Hemiptera collected appear to be of accidental occurrence.

One species of Hymenoptera, *Lariophagus distinguendus* (family Pteromalidae), and two genera, *Cephalonomia* (prob. *C. tarsalis* (Ashm.)) and *Plastanoxus* (family Bethylidae) were collected in Wisconsin for the first time. *Lariophagus* has been recorded as a parasite of the rice and granary weevils (Cotton and Good, 1947). *Plastanoxus* spp. are parasitoids of various *Cryptolestes* spp., and *Cephalonomia* has numerous known stored-product hosts, (Evans, 1964). Distribution records within the twenty feed mills for these minute parasitoids are probably incomplete, as a majority of the specimens were hand-collected at windows, and the traps were not designed to capture hymenopterans. Other hymenopterans collected include the stored product lepidopteran parasitoid, *Idechthis canescens* (family Ichneumonidae), and the braconid, *Metrious* sp.

Discussion

Feed mills offered an excellent environment to sample the fauna of stored product insect in Wisconsin. Few regulations deal with insects in animal feed, and little concern is given to insect infestations. Sanitary conditions varied greatly throughout the feed mills sampled, and as business picked up in the spring and fall, mill managers reported that little time was invested in clean up procedures. Insect infestations levels found during this survey were directly proportional to the amount of debris found on the floor of a given mill.

The total number of insect species collected during this survey of twenty southern Wisconsin feed mills is higher than other previous surveys conducted in the United States and Canada. Few records of stored product insect infestations exist for Wisconsin, and because little previous sampling has been done outside of Dane County, over 140 county records for distribution were recorded during this survey. Too often when insect populations develop, chemicals are used to control the infestations, and no attention is given to identification of the species causing the problem. Knowledge of which species are present, and an understanding of their biology, would give clues useful in implementing future sanitary and cultural practices that could prevent infestations.

The most significant finding of the study was the repeated observation of the high percentage of fungus feeding insects associated with stored products. Unlike the southern United States, where stored grains are eaten and destroyed by primary pests such as the granary and rice weevils, Wisconsin's insect problems seem to be associated with moldy feed and grain. Although any insect contamination may lead to dockage when the grain is sold, Wisconsin's problem stems from moisture and mold problems, which can draw insects in from outdoors. Proper handling and storage could eliminate 90% of our stored grain insect problems in the state without any remedial control needed. This situation is unique to the upper Midwest.

Acknowledgements

Supported by the College of Agricultural and Life Sciences, University of Wisconsin-Madison.

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FIRST REPORT OF A SAMSON GRAY FOX

DAVID A. ROOT
College of Natural Resources
University of Wisconsin-Stevens Point

NEIL F. PAYNE
College of Natural Resources
University of Wisconsin-Stevens Point

There have been reports of samson red foxes (*Vulpes vulpes*) (Helminen 1961, Allen 1974) and other carnivores (Allen 1974), but none of gray foxes (*Urocyon cinereoargenteus*). The samson form is a genetic variant in which the normal long guard hairs of the coat are absent, showing only the woolly undercoat. Failor (1977) stated that this condition occurred more often among red than gray foxes, but could not document an observation of a samson gray fox. No Wisconsin records of samson gray foxes are known.

In late November 1979 a complete samson gray fox was shot in Richland County, Wisconsin. Gross examination revealed a lack of guard hairs over the entire body, in contrast to a lack of guard hairs restricted to the tail and hind quarters which is characteristic of partial samson foxes (Allen 1974). External measurements were: head, 148 mm; tail, 320 mm; hind foot, 132 mm; total body length, 641 mm. Jackson (1961) gave the following approximate measurements for the gray fox in Wisconsin: tail, 310-390 mm; hind foot, 130-145 mm; total length, 950-1,040 mm. Gross body weight was not recorded, but the animal appeared to be in good overall condition when shot. Tooth wear patterns (Wood 1958) indicated that this male was <1 year old when killed.

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"BURBANK WITH A BAEDEKER . . ."

MEREDITH E. ACKLEY
Milwaukee

Travel records can be broadly categorized as impersonal (objective and literal) or personal (subjective and interpretative). The former results when the purpose of the journey is the gathering of information and the intention of the account is the accurate reporting of that information. In the twelfth century, Rabbi Benjamin of Tudela visited Jewish communities from Sargassa to the boundaries of China and his account of conditions he observed is an early example of the impersonal record.[1] Lewis and Clark, instructed by Jefferson to gather information on practically everything from the Mississippi to the Pacific, recorded in their journals a mass of facts on animals, plants, people and geography.[2] However far execution may have fallen from intention, early records of exploration were generally of this type. They were intended as the basis from which further exploration, exploitation or colonization would proceed. Accuracy of reporting was the goal of the writer and assumed by the reader. It was of paramount importance not only to encourage the investment of capital and recruitment of colonists but also to protect both investment and colonists when they were finally committed to exploitation or settlement.

Nevertheless, credulity or inflexible religious, philosophical or geographical theories or errors in translation or transcription could lead to gross inaccuracies in the written record. Often over-zealous and imaginative projections of the desires and biases of the explorer resulted in records which were descriptions of what he wanted to see rather than what he saw. Often his description of what he hoped to find beyond the mountain range he did not cross cannot be distinguished from his account of areas he had actually traversed. Thus, Verrazano, determined to find Cathay whether it was there or not, saw the "vast Oriental sea" beyond the reefs of North Carolina and blithely compressed the North American continent into an isthmus.[3] (It is altogether appropriate that Verrazano, the first to sight the harbor of New York, has given his name to a bridge of that city. Many of its present inhabitants share his unusual view of continental geography.)

Some of the more speculative early records were based on interrogation of indigenous populations in whose answers the explorer heard only what confirmed his already entrenched beliefs in the Northwest Passage or El Dorado. Often these same *indigenes,* sensing from his questions the answers he wished to hear, happily cooperated by supplying them.[4] One of the consequences of this desire to please (or to get rid of the nosey and intrusive stranger) was that distances were shortened or lengthened depending on the circumstances of the questioning. In addition, the potential for error was increased by differences between the traveler and his informant in their sense of distance. The perception of "short" and "long" might bear little relationship to actual milage. Further errors might appear in the conversion from time to distance when the circumstances of the journey are not the same. A "three day's journey" may take considerably longer in the rain or when burdened with baggage. Furthermore, in gathering information on land he himself had not traveled through, even the most unbiased and objective explorer faced the problems of translation from one language to another, from one system of measurement to another or from a lack of system to understandable units. Who knows, for example, what is implied by "across many rivers"?

Errors might proliferate but the intent of this type of travel record was an accurate, factual and literal description of verifiable details of geography, agriculture, meteorology and inhabitants. Ideally, the account was a manual for use by succeeding travelers along the way as well as an advertising brochure and geographical record.

To guide him when he reached Cathay, Columbus took with him on his first voyage *The Travels of Sir John de Mandeville* which, unhappily, was discovered in modern times to have been written in the fourteenth century by a well-read Belgian who had probably never left his home in Liege.[5] For a variety of reasons, it is fortunate that Columbus was never forced to depend on the totally mythical *Travels.* However, the work, though spurious, is an example of another type of impersonal travel record—the guidebook.

Though among the first (and thoroughly fascinating in itself), the *Travels* hardly ranks among the best. It does, however, display many of the characteristics that distinguish the type. Most guidebooks are of less interest intrinsically than they are as historical or sociological indicators. For example, the very existence of a guidebook implies the existence of a "tourist"—someone with leisure and funds to pursue an activity not related to supplying his daily needs. The ostensible purpose of the *Travels* was to guide those on pilgrimage to religious sites in the Holy Land and beyond. Though many in the fourteenth century may have sinned mightily, few had the means or opportunity to atone so thoroughly. However, manuals for pilgrims were some of the earliest guidebooks. The *Travels* was extremely popular and underwent numerous translations,[6] but its fascination lies not in its worth as a guidebook but in its portrayal of the astonishing monsters and marvels to be met with in foreign lands—the men with heads beneath their shoulders who reappear in Raleigh's account of Guiana (see note 4), people with heads of dogs (complete with bark), the bountifull land of Prester John, the people with but one huge foot which they hold aloft to shade themselves while resting and more, much more. There are notations of distances between cities and outlines of alternate routes as in any guidebook but the delight of the *Travels* lies in the mythical not the real information that it contains.

There were no Baedekers because few traveled, as did Thomas Coryat in the sixteenth century, for enjoyment.[7] When they did, it was without benefit of marked routes and handy lists of monuments. Celia Fiennes, at the end of the seventeenth century visited extensively with friends and family throughout England and even beyond the pale to Scotland and Wales. Presumably, she relied on them for directions since it was not until 1697 that a law ordaining signposts on roads was passed.[8] The classically trained tutor sent with young noblemen on the Grand Tour probably learned through bitter experience the galleries and monuments to which his charges were to be exposed. But early travel was literally travail, a physically uncomfortable activity accompanied by fear of both the known and the unknown perils of the journey. The earliest travelers—minstrels, missionaries, mendicants or merchants—journeyed as a necessity of their calling and, though they and their tales were objects of interest and curiosity, relatively few of their hearers would willingly risk the vicissitudes of the road.

The guidebook emerged as a response to changes both in attitudes toward travel and in the physical conditions and economics of the journey. These factors were inter-related and development and change in any one influenced the others. Improvement in roads and accomodations and their policing and supervision made getting from one place to another a less uncomfortable and dangerous undertaking. The growth of a class with money and time to spend on travel encouraged improved conditions. Entrepreneurs, from gondoliers in Venice to merchants in Jerusalem with a large supply of left-over fragments of the True Cross, realized the value of this new source of income.

As early as the end of the sixteenth century, young English noblemen were sent to travel on the Continent at the end of their formal schooling. Destined in the nature of things to govern the country and to shape international policy, it behooved them to know something of the countries with which they would treat. Under the guidance of a mentor, they traveled through France and Italy on the Grand Tour, meeting their French and Italian counterparts, viewing public works, watching ceremonies, looking at shipyards and, regrettably, betraying hospitality by acting as spies for their government. They might, in addition, visit ruins, sketch vistas and copy inscriptions.[9] Perhaps nothing so completely separates the tourist from the native or the traveler by necessity than the veneration of historical sites. To those who for ages had frugally re-used the beautifully chiselled stones of Greek or Roman ruins to shore up their own houses, the interest of the tourist in the preservation of fallen buildings must have seemed more than slightly mad.

As the eighteenth century ended, spying was no longer an adjunct of the Grand Tour but travel had come to be considered an educational activity and, moreover, a serious one. One did not travel to get away from it all but to learn more about it. Many of the newly rich and newly leisured, lacking the traditional education of the upper classes, strove to amend their difficiencies by travel. The guidebook was a necessary tool and reflected the solemn diligence of their methodical approach to the wonders of foreign lands. It told them not only what they could but what they *should* see and experience for maximum benefit. Baedeker began publishing his series of guides in 1829 and soon his name was a synonym for "guidebook." He introduced a system of rating both attractions and accomodations and himself visited the areas covered by his guides and awarded the ratings. Until the innovation in mid-century of the tours of Thomas Cook the Baedeker was indispensable to the inexperienced but eager traveler.

Ultimately, changed conditions and attitudes contributed to making travel fashionable. Because travelers obviously could afford to spend time and money on pleasure and would return from the journey "broadened" by the experience, travel became a symbol of status. The early travelers by necessity—the government agent, the diplomat, the merchant—were joined by the wealthy for whom travel was a social exercise and by frowning note-takers plodding purposefully around tombs and tumuli. Of more significance, however, to the development of the literature of travel was the emergence of the figure of the permanent wanderer, the professional traveler.

Fashions and status symbols, however, lose their value as they become less exclusive. As more and more people clutching Baedekers thronged the world's cultural, historical and recreational centers, a curious reversal took place "Bright young things" began to separate themselves from the earnest bourgeoisie by *avoiding* those havens of culture found in the pages of Baedeker. In the late eighteenth and much of the nineteenth century, most who wrote of their travels scrupulously reported the number of steps at Lourdes or windows at Versailles. As time passed, however, an increasing number of travel books appeared with introductory disclaimers stating that the author would not dream of insulting the reader's intelligence by offering anything resembling a guidebook stuffed with mere dull facts. By implication, both writer and reader shared the assurance and independence of settled incomes or secure positions in society and were absolved from the grim necessity of being broadened.[10]

The useful guidebook is, of course, still with us. The classic Baedeker was followed by Murray, Michelin and countless others and by those publications which echo its humble and utilitarian origins by advising the traveler on what can be seen and done for a minimum daily expenditure. These are the most fleeting of an ephemeral form. When economics—changes in prices or rates of exchange—make it impossible to see Europe for a dollar a day, wholesale revisions raising the ante to five, ten or fifteen dollars render the existing publications useless.

Like the explorers' records, guidebooks intend objectivity and factual accuracy. There is, certainly, selection of detail and even an occasional negative judgement but the selections and judgements are more likely to reflect the temper of the time than the impressions of an individual traveler. Though contributing to an understanding of the social and economic aspects of the history of travel and, thus, to social history generally, the guidebook—with few exceptions such as E. M. Forster's *Alexandria*[11]—has never attempted to be and has never been accused of being literature. It is the antithesis of the personal travel record.

The disclaimer, sometimes teetering on the edge of the arch and coy, became a convention of the personal record. The introductory apologia, familiar as a conceit of other genres since the Renaissance, appeared somewhat earlier. If the journey served no obviously useful purpose and the record could not be justified as educational, the apologia served to excuse what might seem a frivolous exercise. Ill-health might be adduced as the reason for the journey and the insistence of friends the reason for publication. In the late nineteenth century, for example, Isabella Bird Bishop journeyed throughout the world. In Indochina, the Rockies, Afghanistan, she traveled with daunting stamina in or on every mode of conveyance known at the time including horses, camels, donkeys and her own feet. Her doctor had prescribed travel for her delicate health. Having, at age seventy, ridden a thousand miles through Morocco, she died, no doubt delicately, at seventy-three.

It is the diffidence of the apologia (not, incidentally, a characteristic of the numerous works of Bishop) that is significant in the development of the literature of travel. It defines a period of transition from the informational and utilitarian to the personal and subjective records. It signals the tentative entrance of the individual voice—though only at the urging of friends. It is a further step toward the travel record which, in Lawrence Durrell's phrase, evokes a "spirit of place."[12]

In 1844, in his introduction to *Eothan,* Arthur Kinglake defended his approach in a wry disclaimer which indicates the broad conventions of the personal travel record. He writes, ". . . the book is quite superficial in its character. I have endeavored to discard from it all valuable matter derived from the works of others. . . . I believe that I may truly acknowledge, that from all details of geographical discovery or antiquarian research—from all display of 'sound learning and religious knowledge'—from all historical and scientific illustrations—from all useful statistics—from all political disquisitions—and from all good moral reflections, the volume is thoroughly free. . . . but it is true in this larger sense,—it conveys, not those impressions which *ought to have been* produced upon any 'well-constituted mind,' but those which were really and truly received at the time of his rambles by a headstrong and not very amiable traveller, whose prejudices in favor of other people's notions were then exceedingly slight."[13]

The development of the personal record implies an audience receptive to a subjective and interpretative—in other words, literary rather than informational—record. It implies, further, a knowledgeable audience of readers who respond to the record as well as the event, taking pleasure in the author's communication of a spirit of place though the place is one they have no intention of visiting or, perhaps, one that no longer exists. The personal and subjective nature of these accounts is strikingly apparent, for example, in Arthur Symonds' re-creation of his experience of Arles. Other accounts stress the blinding sun, the intensity of color, the heat or the mistral which drives the unwary insane. Symonds was impressed by a road lined with Roman tombs and describes Arles as a mausoleum covered by the dust of centuries which deadens sound, obscures outlines and mutes color—a description in which there is no hint of the sun drenched riot of Van Gogh's Arlesian canvasses.[14]

It is true that the intense enthusiasms of some of the early explorers result in vivid images. Accounts of discovery in North and South America often communicate an almost poetic sense of a world new-made and awesome in its abundance. In their heightened imagery, these accounts become literary as well as informational but the conveying of facts remains their main objective.[15] The fully developed personal record, however, is the product of a traveler who is as much, if not more, a writer as he is a wanderer and who may journey with the express purpose of then writing of his travels. In establishing a sense of place, the author endeavors to communicate an emotional experience by ennumerating and describing those details that have contributed to the impact of the place upon the person. A journey of a hundred miles remains a hundred miles in Baedeker or Michelin. In the personal travel record it may seem to stretch forever or to be over much too soon. Readers are not concerned, in reading the personal account, with the actual mileage but respond, rather, to the writer's description of the boredom of a seemingly unending road, perhaps, or his perception and re-creation of the poignancy inherant in the fleeting nature of all journeys.

An increase in the personal statement marks the development of this type of travel literature. Where Baedeker may say, "From this spot can be seen . . . ," the author of the personal record says, "When I saw this, I reacted thus. . . ." The object of scrutiny—a person, an activity, a flower, a backstreet—may never appear in the pages of a guidebook. (There are, however, numerous titles which begin "Little Known . . ." or "Unnoticed . . ." or "Undiscovered . . ." which are guidebooks in the strictest sense.) The object becomes image—the single *memento mori* of Symonds' description of Arles or the more complex structure of Robert Louis Stevenson's *The Amateur Emigrant*. As Stevenson travels further from Scotland on his way to California, the objects and situations he describes reflect his increasing alienation and the journey becomes a metaphor of the emotional and spiritual trauma of movement into the unknown.[16]

The writer of the personal record may scoff at those attractions which earlier travelers felt compelled to visit and extol or he may find in them a significance quite different than that which is assumed to be their historical or cultural value or he may simply ignore the usual or expected sites. In *Iberia,* James Michener explains that there is no description of the city of Logroño because his energies were spent, so to speak, in gathering information for an impassioned description of the various wines of the region. He tastes one from central Rioja, then one from lower Rioja. Then, "A patriot from upper Rioja now proposed, 'Our wine is the one that travels well, and when you're in a foreign country and want a breath of Spain, order a bottle from our region.'" Michener concludes, "I have only the kindest memories of Logroño, and if I cannot remember a single monument in the city or any public works, in Rioja wine I found a friend whose dark red countenance and crisp syllables evoke for me the spirit of pilgrimage wherever I encounter him."[17]

In records such as those of Fiennes or Bishop, the object of their scrutiny remains firmly rooted in actuality. They may be highly individual in their judgements and in that sense personal, but they are commentaries rather than evocations. Wales, for example, sent George Borrow[18] (and others) into raptures but elicited the following from Fiennes. ". . . from thence my Relation carry'd me to Holly Well (Holywell) and pass'd thro' Flint town which is the shire town, 5 mile from Harding; its a very ragged place many villages in England are better, the houses all thatched and stone walls but so decay'd that in many places ready to tumble down; there was a Town Hall such a one as it was. . . ." And she continues, ". . . they speake Welsh, the inhabitants go barefoote and bare leg'd a nasty sort of people. . . ."[19]

Though there may also be a wealth of factual information in works such as Michener's, images like Rioja wine and a Romanesque church on a treeless plain communicate the traveler's experience of locale and evoke the spirit of place. If it can be said that in these accounts the object becomes image, in works such as Stevenson's *An Inland Voyage,* the experience becomes metaphor. Stevenson describes the exhilaration he felt canoeing on the Oise in flood and then says, "If this lovely and beautiful river were, indeed, a thing of death's contrivance, the old ashen rogue had famously outwitted himself with us. . . . If a man knows he will sooner or later be robbed upon a journey, he will have a bottle of the best in every inn, and look upon his extravagances as so much gained upon the thieves. And above all, where instead of simply spending, he makes a profitable investment for some of his money, when it will be out of risk of loss. So every bit of brisk living and above all when it is healthful, is just so much gained upon the wholesale filcher, death. We shall have the less in our pockets, the more in our stomach, when he cries stand and deliver. A swift stream is a favourite artifice of his, and one that brings him in a comfortable thing per annum; but when he and I come to settle our accounts, I shall whistle in his face for these hours upon the upper Oise."[20]

At the furthest remove from the commentaries of Fiennes is William Beckford's *Dreams, Waking Thoughts and Incidents* in which the actualities of the journey are almost completely subordinated to the singular mental experience of the writer. Unfortunately, Beckford's reflections are neither broad nor deep and are muddy enough to obscure almost all sense of place. These are not unusual faults of this type of extremely personal record. His descriptions, though profuse, lack specificity but his imaginative daydreams are lovingly detailed. Nothing, however, in his vague descriptions of town or terrain seems sufficiently unusual to warrant the speculations they engender. The experience does not grow into metaphor; it remains simply an excuse. The relationship of statement to object seems purely fortuitous. His account may be so completely divorced from the actuality of place that it ceases to be description and becomes vision. "It was a mild, genial evening; every mountain cast its broad shadow on the surface of the stream. . . . All were asleep except a female form in white with glow-worms shinning in her hair. She kept moving disconsolately about; sometimes I heard her sigh, and, if apparitions sigh, this must have been an apparition. Upon my return, I asked a thousand questions, but could never obtain any information of the figure and its luminaries."[21]

In their handling of details of place, these examples represent four broad types of the personal travel record. In Fiennes, the details remain fact. In Michener, they become image, in Stevenson, metaphor and in Beckford, excuse. An attempt to recognize and define categories such as these (with a constant awareness that they grade one into the other and have no firm boundaries) is a necessary first step in developing a critical system which will aid in further analysis and understanding.

Because travel literature, like the mystery novel, is defined by subject rather than form, criticism often concentrates on the journey or the locale, on the "what" rather than the "how" of the record. Rather than analyzing the intention of the record or the method by which the writer reconstructs the journey for the reader, this type of criticism at its worst can degenerate into cavail over where the traveler did or did not go or what the critic thinks should have been seen and was not. Superficial criticism of this nature also encourages the undertaking and subsequent recording of specialized and sometimes peculiar journeys. Paul Theroux's train rides and Anthony Smith's ballooning are examples, and good ones, by and large, of this type of specialized journey.[22] One would not be surprised, however, to find among titles of this type something like "I Journeyed from Boise to Butte on Hands and Knees Pushing a Peanut with My Nose" and to discover within its pages much about ant hills and nothing about the Rockies.

Figures of speech based on the traveler and the journey are ubiquitous in fiction and poetry. Life seen as a journey from birth to death or death seen as a journey from which there is no return are examples so ubiquitous, in fact, that they have lost much of their metaphorical character. Dip into allegory or fantasy, for example, from *The Fairie Queen* to *The Lord of the Rings* and there will be the hearty welcome of "mine host" at the inn, the threat of the highwayman, the solace of companions of the road, the loneliness of a stranger in a strange land and the fear of a mis-step that will plunge the pilgrim into the Slough of Despond. Figures of speech such as these, from the sparrow's flight through the warmth of the great hall that converted an English king to Christianity to the "carry me home" and "lonesome road" plaints of popular songs need no exigesis. They are immediate in their impact and economical in their execution. The development and application of a critical system or rhetoric that focuses attention on the travel record as a literary production will enhance not only the understanding and appreciation of travel literature but also those works of fiction for which it has supplied the raw material of metaphor and image. As the title of this article suggests, even the lowly guidebook may provide material for image-making.[23]

Notes

[1] *The Itinerary of Rabbi Benjamin of Tudela,* ed. Marcus Nathan Adler (New York: Philip Feldheim, 1966).

[2] *The Journals of Lewis and Clark,* ed. Reuben G. Thwaites (New York: Dodd, Mead and Co., 1904).

[3] Lawrence C. Wroth, *The Voyage of Giovanni de Verrazzano* (New Haven: Yale Univ. Press, 1970).

[4] In his first voyage to Guiana, Sir Walter Raleigh was convinced of the potential riches to be plundered from the city of Manoa (the El Dorado of the Spaniards) by the revelations of a native, Topiawari, and the captured Spanish governor of Trinidad, Berreo —neither of whom, for different reasons, was a disinterested informant. More astonishing, however, was his credulous acceptance of the existence of "a nation of people whose heads appear not above their shoulders; which though it may be thought a mere fable, yet for mine own part I am resolved it is true, because every child in the provinces of Arromaia and Canuri affirm the same. . . . Such a nation was written of by Mandeville, whose reports were held for fables for many years, and yet since the East Indies were discovered, we find his relations true of such things as heretofore were held incredible. . . ." Sir Walter Raleigh, "The Discovery of the large, rich and beautiful Empire of Guiana," in Richard Hakluyt, *Voyages and Discoveries,* ed. Jack Beeching (Harmondsworth: Penguin Books, Inc., 1972), p. 402.

[5] *Mandeville's Travels,* ed. M. C. Seymour (Oxford: Oxford Univ. Press, 1967).

[6] On the basis of an English translation, "de Mandeville" was known as "the father of English prose" until it was discovered that the original manuscript was written in French.

[7] *Coryat's Crudities* (Glasgow: J. MacLehose and Sons, 1905).

[8] *The Journeys of Celia Fiennes,* ed. Christopher Morris (London: The Cresset Press, 1949).

[9] Geoffrey Trease, *The Grand Tour* (New York: Holt, Rinehart, Winston, 1967).

[10] This attitude toward the tourist was so prevalent that it needed no explanation when it appeared in popular literature. For example, "She liked travel but dreaded sight-seeing and would retain memories as sharp as pencil drawings of unimportant details—a waiter, a group of sailors, a woman in a bookstall." describes a character in Ngaio Marsh's mystery novel, *A Wreath for Rivera* (*Photo Finish & Two Other Great Mysteries,* New York: Nelson Doubleday, Inc., n.d.).

[11] *Alexandria: A History and a Guide* (Garden City: Doubleday and Co., 1961).

[12] *Spirit of Place,* ed. Alan G. Thomas (London: Faber, 1969).

[13] *Eothan* (Lincoln: Univ. of Nebraska Press, 1970), intro. p. xvi.

[14] "Arles II," *Wanderings* (London: J. M. Dent and Sons, 1931), pp. 23–27.

[15] Pierre Esprit Radisson, one of the first to travel on Lake Michigan in the mid-seventeenth century, writes, "We embarked on the delightsomest lake of the world. . . . the country was so pleasant, so beautiful, and fruitfull that it grieved me to see that the world could not discover such enticing countries to live in. This I say because the Europeans fight for a rock in the sea against one another, or for a sterile land and horrid country. . . . Contrariwise, these kingdoms are so delicious and under so temperate a climate, plentiful of all things, the earth bringing forth its fruit twice a year, the people live long and lusty and wise in their way." *The Explorations of Pierre Esprit Radisson,* ed. Arthur T. Adams (Minneapolis: Ross and Haines, Inc., 1961), p. 91.

[16] *The Amateur Emigrant* in *From Scotland to Silverado,* ed. James B. Hart (Cambridge: Harvard University Press, 1966). See also Meredith E. Ackley, "The Creative Artist as Traveler: Robert Louis Stevenson in America," *Transactions of the Wisconsin Academy of Sciences, Arts and Letters,* vol. 69 (1981), 87-92.

[17] *Iberia: Spanish Travels and Reflections* (Greenwich, Conn.: Fawcett Publications, Inc., 1968), p. 861.

[18] *Wild Wales* (New York: W. W. Norton, 1955).

[19] Fiennes, *op. cit.,* pp. 179-181.

[20] *An Inland Voyage* (New York: Charles Scribner's Sons, 1902), pp. 108-109.

[21] *Dreams, Waking Thoughts and Incidents,* ed. Robert J. Gemmett (Cranberry, N.J.: Fairleigh Dickinson Univ. Press, 1971), p. 86.

[22] Paul Therroux, *The Great Railway Bazaar: By Train Through Asia* (New York: Ballantine Books, 1976).

______ *The Old Patagonian Express: By Train Through the Americas* (New York: Pocket Books, 1980).

Anthony Smith, *Jambo: African Balloon Safari* (New York: New American Library, 1963).

[23] T. S. Eliot, "Burbank with a Baedeker; Bleistein with a Cigar," in *Collected Poems 1909-1935* (New York: Harcourt Brace, 1936), pp. 47-48.

TWO WISCONSIN LIBRARIES: 1854-1954

LOUIS KAPLAN
*Emeritus Director of Libraries,
University of Wisconsin-Madison*

This is the story of two publicly supported libraries: the general library of the University of Wisconsin, and the library in the State Historical Society of Wisconsin. More specifically this is the story of how two libraries sought a *modus operandi* in the building of library collections. For them, an agreement on policy could not be avoided. Being publicly supported, those responsible for acquisitions simply could not ignore each other. Mindless duplication was infeasible, not only on economic grounds, but in order to avoid the charge of squandering public monies.

Where a state-supported society and university are in separate cities, the need for cooperation is lessened. Likewise of significance, even when the two are in the same city, is the scope of the society's acquisition program: the less ambitious the program, the less is the need for cooperation. Working out a coordinated policy is relatively simple when a society is content to make its own state its exclusive area of interest. In Wisconsin, even after extensive retrenchment, the acquisitions program of the society is exceptionally comprehensive. Unlike publicly supported societies that limit themselves to the region of which they are a part, the Wisconsin society took on a greater responsibility.

In explaining these differences among historical societies a leading author has written: "Whether support comes from private citizens or legislatures, State historical societies develop their own different approaches and characteristics. These depend in part upon location, the relative age of the State, the nature of the inhabitants, and the extent of their resources; they depend also to a considerable degree upon the personal interests and abilities of the individuals who have shaped them in critical periods of their careers."[1]

Wisconsin, especially among state-supported societies, is different. Lyman Draper, its first director, made a difference. Furthermore, among this kind of society, Wisconsin got an early start. A society founded in the 1850's was likely to be more ambitious than a society that got its start in the eighties or nineties. In the nineties, the imperatives of fiscal support and the growth in book production served as a warning to those inclined to be overly ambitious.

For the University in Madison the Society was both a problem and a blessing. Struggling to support its variety of activities, the youthful nineteenth century University was troubled by the failure of its library to keep pace with those in comparable universities. Nearby, was the Society—eager to serve the widest possible constituency, including university students and professors. What was the University to do? Should it, or could it, challenge the propriety of the Society's wide-ranging acquisitions policies? Or should it remain quiet, hoping that its energetic neighbor would successfully carry out its self-appointed responsibilities in a manner suitable to the needs of a university?

A Cavalcade of Books (1954-1956)

In the years 1954-1956 the Historical Society transferred a large number of books and periodicals to the new Memorial library of the University of Wisconsin. Most of the volumes dealt with British and European history; others with Central and South America. Included also were a considerable number of titles by and about Shakespeare, and a large and unusual collection on history, science and theology that had once been the property of a Dutch minister.

Two widely divergent estimates have been made of the number of volumes transferred. Benton Wilcox, then the Society's librarian, put the number at 50,000 *volumes*. Clifford Lord, sometimes Director (now deceased), set it at 100,000 *titles*.[2] Wilcox, employing an accounting procedure common among librarians, regarded a book of pamphlets as a single volume. Lord, wanting to account for the pamphlets separately, estimated that the total number of pamphlets transferred was equal to the combined total of books, periodicals and bound documents. Unfortunately, the proportion of pamphlets among the British publications was probably smaller than among those relating to the United States. Consequently, because the number of pamphlets cannot be estimated with sufficient accuracy, Wilcox's count of 50,000 volumes (inclusive of pamphlets) must be taken as more reliable.

Two other questions arise in connection with this transfer. How did it come about that an American historical society had acquired a large body of materials on foreign history and literature? And why, after many years of ownership did the Society in the mid-twentieth century relinquish its title to it? Some answers to these questions are to be found in the sections that follow.

Two Giants in the Pursuit of Research Materials: Lyman Draper and Reuben Gold Thwaites, 1854—1913

Two more eager and energetic accumulators of library research materials than Draper and Thwaites would be difficult to imagine. Both held the title of Secretary to the Historical Society, Draper in the years 1854-1886, and Thwaites from 1887 to 1913. Draper's biographer has written that he "wanted all American history—and any other kind of history."[3] To assist him in this task, Draper had Daniel Steele Durrie, who for about 37 years gave almost undivided attention to augmenting the Society's library. As has been written of the pair, they "worked together with one heart and hand in many an endeavor. . . ."[4] It was Durrie who supervised the printing of the library's catalog that appeared in 1873; one needs only casually to inspect this volume to see that Draper had more in mind than American history. With respect to foreign history he was drawn strongly to Great Britain and her colonies, so much so that he wrote a rationalization of his conduct:

"Whatever relates to English history, her colonies, her primitive manners and customs, and the genealogy of her families, has an intimate relation with American history and habits of thought. In all our American history there is so intimate a blending of our own with the annals of the fatherland, that our growth and progress cannot be properly delineated without constant reference to these blending relations."[5]

Reaching beyond American and British history, and indeed, beyond history itself, was the Society's acceptance of the Tank collection. Consisting of 4,812 volumes and 374 pamphlets, it was rich in works of science and theology as well as in history. Gathered by her father, a minister in Holland, and presented to the Society in 1868 by Mrs. Otto Tank of Howard, Wisconsin, this was the kind of acquisition in which Draper could exult.[6] Nor was he swayed negatively by the foreign languages in which the books appeared. Said Draper, with respect to these languages, the Society must be ready to serve "the wants of our citizens of all nationalities."[7]

In the same year, Draper was able to announce the purchase of 37 volumes of newspapers, published, in part, in Capetown (South Africa), Melbourne, Liberia, China, Smyrna and Constantinople.[8] Then in 1873, the Society acquired an esteemed Halliwell edition of Shakespeare's works in 16 folio volumes.[9]

Thwaites, too, deserves his reputation as a great but sometimes indiscriminate collector of research materials. In quantitative terms alone, his accomplishments were impressive; in 13 years he managed to double the size of the Society's library, and then trebled its size after 26 years in office.[10] Better organized than Draper, Thwaites proceeded to systematize the acquisition process; and then in his methodical way, by purchase, by exchange and by begging, he continuously enriched the Library's resources. One writer claims that in the era of Thwaites, about 75 percent of the accessions came as gifts.[11]

No more than Draper, did Thwaites turn down opportunities to grasp sources that were unrelated to American history. Regretfully, however, he was forced to report that apart from material on English history the Society's library possessed "few sources of information for *original* study." In the absence of the requisite funds, with respect to original sources "we cannot venture far beyond our old-time speciality of Americana."[12] Even so, he made the best of his opportunities. A "monumental" work on animal locomotion by Muybridge is but one example; of the works of Shakespeare, in 1900 the Society possessed 1,000 volumes; a vellum manuscript copy of the *Book of Hours* was the prized accession of 1888;[13] at a price of $265, paid by a donor in 1890, the Society became the owner of *Monumentos del Arte Mexicano Antiguo,* edited in three large folio volumes by the "famous" Mexican scholar, Antonio Penafiel.[14] In 1912, the year prior to Thwaites' death, the Society acquired funds for the purpose of establishing a Hollister Pharmaceutical Library—despite the existence of a well-established library in the University's School of Pharmacy.[15]

No matter how far afield, gifts were difficult to refuse; as for purchases, Thwaites recognized that in order to maintain its reputation as a library of history, the Society would need to arrange with the University for a division of interests. Logically, he argued that such an arrangement would be facilitated if the two libraries were to come together in a single building.[16] So long as the Historical Library continued in the State Capitol building, and the University Library in Assembly Hall (later Music Hall), the process of rationalization would be delayed. Even before the two libraries were united in 1900 in the first unit of a magnificent structure at the foot of Bascom Hill, Thwaites conceived of a division of responsibility in which the University would acquire materials in literature and the general sciences, while the Society would develop a "department of History."[17] But as will be seen, his definition of history was worthy of Draper.

In retrospect, several alternatives were available to those responsible for the development of the Society's library. One choice, the narrow one, was to limit the materials to the history of Wisconsin; most readers of this article will no doubt be amazed to learn that this narrow alternative seemed to be in the minds of those who wrote the Society's constitution of 1854.[18] An alternative was to embrace the history of the Middle West, or the whole of the United States. Yet, as already seen, to Draper and Thwaites these alternatives were too confining, and this no doubt explains the greater latitude permitted in the constitution of 1897. To fit his style, that constitution made legitimate what Thwaites desired, namely, to cover the whole of history, with special attention to Wisconsin and to the "Middle West."[19]

The University's Reaction to Draper and Thwaites

In 1900 when the two libraries jointly occupied the new building on the lower campus, the University library claimed 75,000 volumes and 25,000 pamphlets. The Society at this time estimated its holdings at 114,572 volumes and 112,374 pamphlets.[20] How is this difference in resources to be explained? To begin with, the Society was far ahead of the University in the persons of Draper and

Thwaites, whereas those responsible for the University library prior to 1890 were professors (with clerical assistants) who attended to library business on a part-time basis. Furthermore, the University had other problems to which it assigned a higher priority. Though there was no intention to ignore the library, the Regents and the administration could not fail to recognize that the Society's library in the State Capitol building was ably serving both students and professors. In 1891, the Society's Executive Committee was told that "students and professors now form a large proportion of our readers. . . ."[21]

This is not to imply that the University had no interest in its library. Certainly President Adams made no secret of his desire to improve the standing of the library in academic circles. As evidence, there are the remarks he made before the Regents in 1897 in which he spoke of the relative affluence of Michigan and Cornell in library holdings. "I fear," said Adams, "the members of the board are tired of hearing me on this subject . . . ."[22] Nor was the University's first full-time librarian (appointed in 1890) quiescent. Said he to the Regents: "While progress has been made, the library is still greatly inferior as a working library to those of many American universities with which the university of Wisconsin is proud to compare herself in equipment and work."[23] All to little avail. Despite the complaints of Adams, the protests of the faculty and students, and the pleas of the University Librarian, the library in Wisconsin continued to lag behind those found at comparable universities.[24]

The Delineation of Acquisitions Policies, 1895-1950

Even before the new building was jointly occupied in 1900, the two libraries undertook informal agreements. As Thwaites revealed in 1897, for the past "two or three years" the libraries had been guided by informal stipulations by which the University undertook responsibility for science, technology, philosophy, philology, education, the fine arts, and belles lettres (except for Shakespeare and old English drama). For its part, the Society continued purchases in its established specialties of history, genealogy, travel and description, economics, sociology, Shakespeare, old English drama, and newspapers. Admittedly, according to Thwaites, there were aspects of the agreement that left open "many complicated exceptions" which in the future would need to be addressed.[25]

Further clarification was achieved by 1907, in a document in which the Society declared its areas of interest to be North, Central and South America, the United Kingdom, and the British colonial possessions in the western hemisphere. In recognition that all aspects of history in these areas would be too ambitious a program, the Society agreed that on the subject of education it would concentrate on materials relating to the United Sates; on immigration, the Society would not go beyond the United States and Great Britain; American labor materials were to be restricted to specific labor unions, the general topic of labor to be left to the University. Priority of interest in agriculture was conceded to the University's school of agriculture. With respect to anthropology, the University was to be responsible for white Americans, while the Society would concentrate on works relating to American Negroes and Indians. All municipal public utilities, except those in American and Canadian cities, were declared to be within the University's purview. In church history, the Society limited itself to the United States and to the Church of England.

Despite these retreats, the Society's library was left with a considerable mandate. Except for subjects regarded as having only minor interest, it was still responsible for the history, broadly interpreted, of the United States and Great Britain. Of materials on Central and South America it still had much to acquire, as for example, in politics, biography, genealogy, travel accounts, and general descriptive geography.[26] In fact, looking ahead some thirty years, it was to become clear that the Society had staked out a claim too great for its financial resources.

With the arrival in 1941 of Edward Alexander, the new Director of the Society, a fresh look at the library's problems was guaranteed. Affable, yet energetic, among his many problems Alexander recognized that there was one that he might in a relatively short period of time move in the right direction. Quickly, he saw that his library's book budget was hopelessly incapable of meeting its wide-spreading acquisitions program. Surprisingly, that budget for 1941-1942 was less supportive than it had been ten years earlier.[27] Acting in concert with the University Librarian, two consultants—the historian, Dean Blegen of Minnesota, and the librarian, Metcalf of Harvard—were brought to Madison in 1943 to offer advice pertaining to acquisition policies and to the problems of space.

On acquisitions, the consultants recommended that the Society limit itself to American history, "broadly" defined. They found that in American history the Society's library was losing ground, and that the situation with respect to Great Britain and Latin America was even worse. As for the University Library, in order to take on new responsibilities, it would require a doubling of its book budget.[28]

Determined to accept the advice of the consultants, Alexander made a straightforward recommendation to the Executive Committee of the Society's Curators. Clearly, he pointed out, the Society's library was attempting much more than it could manage. The obvious solution was for the library to cut loose those of its responsibilities that could with propriety be turned over to the University. Given the inadequacy of funding, how could the Society justify the ambitious course set by Draper and Thwaites? The book fund, which stood at $10,700 in 1928-1929, had now shrunk to $6,000. Moreover, Alexander had more than the library on his mind; it worried him to have no funds for the museum.[29]

Responding to the suggestions of the two consultants, and to the importunities of Alexander, the Curators agreed to the change in acquisitions policy, and when the Regents of the University added their approval, the librarians of the two organizations began to hammer out the details of a written program.

The Memorial Library and the American Historical Research Center, 1950-1954

From the viewpoint of dividing the responsibility for collection building the year 1950 was marked by two related events. One was the passage by the State legislature of an appropriation for the University for an independent library building. The other was the announcement by the Society of the creation of an American Historical Research Center.

When the two consultants (Blegen and Metcalf) arrived in 1943, storage space had been a critical problem for both libraries for about twenty years. After the original building had been extended in 1913, each library had its own bookstack in a U-shaped structure. Without success the University had, in 1925, sought funds for an independent library building. In their report of 1944 the consultants made suggestions designed to enable the two libraries to remain in the same building: for newspapers, they advised that a separate structure should be constructed; and to provide supplementary shelving for books they recommended a T-shaped addition to the existing building.[30] These recommendations met with little favor. The Society feared that their library would soon be regarded as merely another agency of the University.[31] Within the University there was strong support for an independent structure.

From that moment the University moved with determination towards legislative approval of a new library building. Within a legislative appropriation for the University passed in 1945, the Regents set aside a portion for a library, but this money had to be diverted elsewhere within the University because the State Architect failed to move expeditiously with the preparation of the necessary drawings.[32] Finally, a special library appropriation was approved in 1950 to honor those Wisconsin citizens who had seen military service.

Professors in the American section of the History Department were troubled by the promise of a separate University library. To some of these professors it was unpalatable, for example, to divorce books on American history from those on American literature. Having these books in the same library building, as they had been since 1900, was a convenience that they preferred not to lose. Of interest, therefore, to these professors was the announcement in 1950 by the Historical Society of the formation of an American Historical Research Center.[33] If acceptable to the University—and this is what led to considerable debate—those books in the University library relating to American culture would not be transferred to the soon-to-be constructed Memorial Library, but would remain behind in the library of the Historical Society. More explicitly, this meant that the University's books in American literature, economics and political theory (among others) would be affected. Though requiring a considerable outlay in funds, both for books and additional study facilities, the Director of the Society was confident that he could win the support of the legislature in favor of the new Center.[34]

Opposition to the Society's proposal was immediately expressed by the Department of English,[35] and soon after when the University Library Committee made a canvass of other departments it became clear that except for the History department, disapproval was overwhelming. Therefore, in the autumn of 1950, the Director of the Society was informed that "with a new University Library in the offing it is impossible to persuade the faculty of the wisdom of transferring to the Society new fields for purchase."[36]

This is a story with a sequel. When the Joint Committee of the two library committees met on the 16th of January, 1953, it was told that a majority of the History department now wanted the books of the Society to be transferred to the Memorial Library in accordance with their previously expressed desire to keep all books on American culture together. As those in attendance knew, the Curators were unlikely to accept this suggestion, and the chairman of the History Department himself said that the main purpose was to have his department's wish made part of the record.[37]

In his *Clio's Servant,* Clifford Lord wrote that the University had missed an outstanding opportunity in not accepting the Society's plan for the American History Research Center. As he expressed it, "the great vision" thus offered the University community was not to be realized.[38] Whether the opportunity would in practice have proven successful must remain a matter for conjecture. Realistically, in-so-far as it concerned the University, the proposal was doomed from the start. Not realized by Lord and by certain members of the History department was that within the University a transformation in attitude towards its library had come about. One element in the change in outlook was the prospect of the new library building. Additionally, three hundred thousand dollars had been raised in 1945-46 to acquire the heralded Thordarson collection. Consisting of about 11,000 titles representative of various aspects of Anglo-Saxon civilization, the purchase of this private library containing editions prized by connoisseurs served to convince the faculty that better days were surely ahead for its library.

Thus, with its new confidence in the future of the University library, the faculty in 1950 was sending an unprecedented message to the Society: no longer would it willingly surrender acquisitions that were normally the province of a major research library. On the other hand, there was no disposition within the University to challenge the Society in those fields for which its library had become famous.

Once the University made known its opposition to surrendering its responsibility for the whole of American culture, there arose the need to end the delineation of fields of collecting that had been tinkered with since 1945. This task was completed in 1954, producing a document not significantly different from earlier versions.[39] Of the various stipulations made the most important was the Society's agreement to confine its area of interest to the region north of the Rio Grande, inclusive of Canada.[40] Cut loose were Great Britain and South and Central America. While including a number of details that do not require enumeration, some of the provisions found in the 1954 document are essential to an understanding of the degree to which the Society was reshaping its program to fit its pocket-book. Among the variety of concessions made by the Society some of the most important are as follows:

Literature—except fiction and essays by Wisconsin writers.

Economics—except materials on Wisconsin finance and production.

Banking, industry, railroads—as with Economics.

Anthropology—only as it relates to the area north of the Rio Grande.

Recreation—except in Wisconsin.

General periodicals.

Foreign newspapers.

Manuscripts—only those pertaining to American history.

A Retrospective View

For almost a century the University library danced to the tune played by the Wisconsin Historical Society. When Draper made the Society responsible for the whole of the United States, the University raised no protest. Likewise, with respect to Canada, Great Britain, and Latin America. In other universities the need to forego foreign history did not arise. In other historical libraries, such as those in Minnesota and Ohio, because these did not claim more than state and region as areas for acquisitions, their neighboring university libraries were not required to ignore the whole of the United States.

Understandable, and even fortunate from the viewpoint of his successes, was the University's decision not to challenge Draper's program as it related to the history of the United States. Actually, the University could hardly have mounted a competing campaign, considering that during the whole of Draper's tenure the University had not appointed a full-time librarian. Less excusable, as the University moved into the 20th century, was its acquiescence with respect to historical materials on Great Britain and Latin America. On these subjects, because the Society's holdings were not exceptional, the University could with justice have offered to take over. Had the University library in the twenties or thirties been in possession of an adequate budget, would the Society have been willing to accept the offer?

Not until 1950, in connection with the proposal by the Society to inaugurate a comprehensive library of American civilization, was the University able to call its own tune. Now it was the Society that was in the weaker position by virtue of asking the University to surrender that which it already held. Unlike 1941, when the Society was anxious to absolve itself of responsibilities, the University in 1950 was determined not to give way as it had in the past.

Though it is true that scholars profited from the policies set by Draper and Thwaites, in the end both the Society and the University were forced to face the consequences. The Society, for its part, inherited a program it could not support. As the consulting team of Blegen and Metcalf reported, the Society's ability to collect research materials on the United States was impaired by the requirements of its extended acquisitions policies. Years before Alexander called for a halt, the Society might have insisted that the University assume responsibility for areas outside the United States and Canada.

Nor did the University library escape unscathed. For this the Society could not be blamed; yet it is true that the strength of the Society's library made it possible for some University officials to argue that it was necessary to include the Society's collections when counting volumes on the University campus. That university libraries in other states could follow the same procedure seems not to have been taken into account. Actually, the situation was worse than they knew. For example, the library of the University of Minnesota, not the largest in the mid-West, had almost as many volumes in 1927 as did the two libraries in Madison combined, and by 1945 it had forged ahead.[41] Not until the fifties did the University of Wisconsin finally bestir itself in response to the need for more rapid growth.

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[26] The document referred to is found in the Society's Archives, Series 678, Box 26, File 5.

[27] *Proceedings,* 1941, p. 29.

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[29] *Ibid.,* p. 495-497.

[30] For the text of their report see the *Wisc. Mag. Hist.,* 27:498-502 (June, 1944). See also *Proceedings,* 1944, p. 493.

[31] Lord, *Clio's Servant,* p. 373-374.

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[34] See the minutes of the Library Committee of the Society, dated June 24, 1950 in Minutes of Proceedings, 6:32.

[35] Minutes of the Joint Library Subcommittee dated July 18, 1950 in Minutes of Proceedings, 6:33.

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[37] Minutes of Proceedings, 7:10-11.

[38] Lord, *Clio's Servant,* p. 435-436.

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[40] The relevant agreements are to be seen in the Society's Archives, Series 678, Box 26, File 5. See especially the material dated April 1 and September 15, 1945.

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THEME AND SPEAKERS IN SHUMWAY'S "SONG OF THE ARCHER"

Jim Missey
Department of English
University of Wisconsin-Stevens Point

With the publication of the fourth book of poetry, *Practicing Vivaldi* (La Crosse, Wisconsin: Juniper Press, 1981), by the Wisconsin poet, Mary Shumway,[1] a critical appreciation of some of her early work is in order. An examination of Shumway's early narrative poem, "Song of the Archer,"[2] can provide insights into her methods and themes.

The theme of the poem, suggested by frequent quotations from Yeats's "Sailing to Byzantium," is that life (or love) gives way to death, out of which something permanent (art) is reborn; this theme is articulated or evoked by the three principal speakers in the poem—the chorus, which acts as a kind of framing narrator; the archer-centaur Chiron, who narrates the main line of action; and the adult poet Chris, who, as a child, is the main character in Chiron's narration.

The first speaker is the chorus, represented in the text with roman type, the other two speakers being represented with italicized type. Though the chorus's is not the first voice we hear—Chiron's is that—it may be thought of as structurally the first voice since the chorus, providing a more general overview than the other two speakers, sometimes quotes Chiron and sometimes evokes rather generally the theme of the poem.

In the form of somewhat general commentary, the chorus refers to twin aspects of the theme, death and rebirth. Lines of the chorus towards the end of the poem, just after Chris has noticed that something has happened to her grandmother (she may have fallen under the weight of something she was carrying), bespeak the inevitability of death:

We have seen August reach
Into autumn without holding back thieving winds
Nor catching leaves from swift brooks plying
A chrisomed shore; we have seen sun come and go
Without the seven trumpets . . . ah, we worry the
Very daylight with how to become what we anyhow
Must become . . .

A few lines later, the chorus suggests another aspect of the theme, namely, that out of pain (or death) shall come a rebirth in the form of art, in this case "The Song of the Archer":

Once the wash of the wind lay open the quick
Heart shall the heavens tell and shall we hear
The song of the archer roaming the early hill[.]

The rather dense metaphorical language concentrates the meaning of the lines, which may be explained as follows: A wash in the West is similar to an arroyo, or dry gully, so one has the impression of the wind's channel or path lying open, suggesting exposure and perhaps dessication. The exposure implies vulnerability, perhaps the vulnerability one feels after being reduced, diminished, or hurt by death. But the "quick/Heart"—a heart cut to the quick or a vital heart or even a quickened heart—speaks (maybe cries out), calling forth "The song of the archer."

Though the first speaker, the chorus, refers generally to the theme of the poem, the second speaker, Chiron, evokes the theme in more specific terms. The opening lines of the poem, for example, which are spoken by Chiron, combine the suggestions of mortality inherent in a dying day with the vitality of sexuality: Chiron likens the setting sun to "*a slaughtered bull*" that "*Spewed blood . . . over a/brewing storm. . . .*" The scene includes "*two cats*" that "*Coupled deep by the shed*" and "*A young chit*" presumably sitting "*In the rust wood where centuries rutted and/spilled Novembers,*" the young chit being Chris. The sexual connotations of the lines are deepened by the pun on "rutted," which suggests that the centuries were not only in a rut in producing Novembers year after year but that they copulated like animals and had as their offspring a succession of Novembers; and there are sexual overtones in the word "chit," too, which may mean not only a pert girl but, obsolescently, the offspring of a beast, for example, a cub (see *Webster's New International Dictionary,* Second Edition).

Not only does Chiron evoke death and life in the opening description of the setting, but he does so in a description of the sunset that comes a bit later:

The earth
Turned slow from the dying sun and blood seeped from the veined dust into a million tiny
Serpents shimmering in the turning, the tiresome turning.

The lines obviously describe a form of death —the sunset—and the weariness evoked by them suggests that the earth itself is approaching death. But the vividness of the imagery, with streaks of sunlight being likened to "*a million tiny/Serpents shimmering,*" indicates also the presence of life, albeit a somewhat repulsive life.

In addition to Chiron's presenting the simultaneous presence of life and death in some of the early descriptions, the archer-centaur later conveys the theme of the poem, that human existence is made up of a cycle— from life to death to, in the form of art, rebirth. This theme is shown in Chiron's dramatization of the vitality of Chris's grandmother (Gran), moving evocation (through Chris's reaction) of Gran's death, and symbolization of the death with the suggestion of rebirth.

Concerning Gran's vitality, before the grandmother dies Chiron vividly and affectionately evokes her liveliness. He shows it in her colorful, if somewhat corny, way of speaking (ironically, everything she says has the feeling of death about it, though not the way she says it): "'*Don't like the looks of that sky,' her grandmother/said, 'Something rotten in Denmark, if you ask me./I wish it'd storm if it's goin' to.'*" Later, in warning Chris about being burned in the woods, she says, *"Fine grease spot/You'll make in the devil's kitchen."* And still later, after some nearby Indians have finished a ceremony for someone who has died, she says, *"Well, I guess that's that. It's sure none of us/gets outa this world alive. . . ."*

Not only does Chiron show us the vitality of the grandmother, but he movingly evokes her death through Chris's reaction to it. Chris offers to carry something that Gran is carrying, but Gran stubbornly refuses any help and then apparently stumbles under the load and dies. Gran's dying is frozen in slow motion, the effect being to deepen Chris's anguish. Twice Chris calls out to her grandmother, "What's the matter," and eight times she calls to her mother to come. One has the impression of Gran's slowly slumping to the floor—like the slaughtered bull, perhaps, mentioned in the second line of the poem—and of Chris's mother's responding in a painfully slow fashion. There is some reproach against the mother—Chris may blame her for her grandmother's death. After the eighth time that Chris calls her mother, the mother says, "'*I suppose we should at least* see . . . ,'" recalling an earlier incident in the poem. In that incident, after Chris had asked her mother whether she could hunt turtles in the slough and got her mother's response, Chris had said, "*All you ever say is 'we'll see' . . . well, when* will/*we?*"

In addition to showing in a moving way Gran's death through Chris's reaction to it, Chiron also symbolizes it in his description of the physical setting at the time of the grandmother's death; and he hints at a rebirth. The physical setting is a latent and then breaking storm during a dying day of a dying year (the time is November, "*the month of the hunter*)". Using heightened diction, Chiron describes the storm's breaking as Gran dies, with a possible pun on "dam":

The
Old earth shuddered beneath her knees, the dam
crumbled and dissolved in the boiling flood, and
Thunder rode dusk from the river to the hill where
the storm lay broken.

But if the storm symbolizes death, it also offers hope of renewed life. In the last lines of the poem, which complete the passage just quoted, Chris reacts to Gran's death in such a way as to suggest a rebirth of sorts:

She saw the shallows flood,
And the old house fell in the thundering wind
darkly to the dark sun. She crawled toward them,
Into them, and with a single vision they were one,
and sang ("'. . . of what is past, or passing,
Or to come.'")

The "single vision" that Chris has achieved indicates that she has integrated the parts of her experience, especially the experience of her grandmother's death, and that, while she sorrows over that death, she nonetheless has put it into perspective. The achievement of the "single vision," moreover, answers the question, already referred to, that Chris had put to her mother earlier in the poem: "*All you ever say is 'we'll see' . . . well, when* will/*we?*" Finally, the song that Chris sings (presumably the lines from "Sailing to Byzantium") is the rebirth that follows death; and it has the permanence of "such a form as Grecian goldsmiths make/Of hammered gold and gold enamelling," referred to in the same stanza of Yeats's poem as the lines which Chris sings.

Chris not only appears as a character in Chiron's narration, but, as an adult poet, she emerges as one of the three principal speakers in the poem. She speaks in a sort of inner monologue, which may be narrated by Chiron—the passages, like those Chiron speaks, are italicized—though the reader feels, partly because of the indentation of the lines, that Chris is speaking more directly than in the parts of Chiron's speech proper in which Chiron quotes her. The parts or fragments of the inner monologue—one is reminded of the "fragments" that the Fisher King in *The Waste Land* has "shored against [his]ruins"—moreover, are not chronologically organized as are the events of Chiron's narration (indeed, some events must have occurred after Gran's death). Rather, they are thematically organized, as Jacob Korg has suggested the "unassimilated quotations" of *The Waste Land* are organized.[3] And the theme that unifies the parts of Chris's monologue is a recapitulation of the three aspects of the main idea of the poem as a whole: life (often associated with or replaced by love in Chris's monologue), death, and rebirth (often identified with art).

The three aspects of the theme are symbolized in an early fragment that occurs as part of Chris's inner monologue:

Her grandmother came running with a rake
and killed a springing snake she was
Playing with on the road, but she got to keep
the injured dove and built a cage until
He died of oatmeal.

The running grandmother, the "springing snake," and the playing girl all represent life. The "injured dove," which finally dies, represents death. And the cage that Chris built represents rebirth; it is an art form born out of suffering and dying and, like the "form as Grecian goldsmiths make," outlives the mortal animal.

Though the fragment from Chris's monologue just discussed symbolizes all three aspects of the poem's theme, most of the fragments seem to focus on only one or two aspects. One section, for example, seems primarily to evoke the idea of death though it contains overtones of life:

Down the hill she saw her grandfather
Carry old Peach to the river with a shovel:
"Where you going with Peach, Gramp? Hey, Gramp,

What's the matter with him? Put him down,
Gramp; don't take him''
But he had something else on his mind.
She ran but the wind was thick and it pushed
her head back hard on her shoulders.

Peach has presumably died—this is one of the fragments the action of which occurs after the events of Chiron's narration, in which Peach is alive—so that the focus of the lines is on death. There is, however, undeniably a sense of vitality in Chris's running against the wind.

It is the sense of vitality, often in the form of sexuality or love, that informs most of the fragments represented as parts of Chris's monologue. In one place, for example, Chris recalls the sexuality of her mother and father: *"'how'rt/tha both Mary and Thais, ma cunt and/Mother, and I thy love and lover?'"* (These lines are almost exactly repeated in another fragment and alluded to in another.) It is not sexuality itself, however, that so much informs a number of Chris's fragments as it is sexuality shading into romantic love; for the reader becomes aware that Chris's inner monologue is also a love song, as indicated in the following fragment:

I want to wear it proudly, I want to wear it
on my face proud as autumn flames, stark as
Winter frames her black branches in a Christwhite
purity; this is no Gethsemane for solitary
Prayer. . . .

Very likely the reference of "it" is love—in the next fragment Chris says she is *"all innocence and Adam, huge and/unabashed having found you in the world/to love"*—and generally the overtones of the passage are positive or life-affirming though the diction is slightly ambiguous. In moving from the inflected adverb, "proudly," to the uninflected adverbs "proud" and "stark"—or are "proud" and "stark" adjectives?—the poet is concentrating her effect; she is also moving from a rather more conventional statement to a rather less conventional statement about love or life. The reader may wonder whether Chris wears love or life starkly because she has been ravished or exhausted by it.

The fragment just discussed ends with a reference to Gethsemane, which is picked up in another fragment of Chris's monologue. It is one of a group of fragments that emphasize eye imagery (one is reminded of Chris's achievement of a "single vision," which resolved the conflict of the principal narrative line of the poem):

And the sky hung like a full skin of ripe
wine. '. . . in thine eyes the Gethsemane
Gift and the envious sun scuttles thy
Kidron in fluted riffs of light . . .'

The lines give further evidence for the claim that Chris's inner monologue is a love song, for here Chris, quoting herself, addresses a lover. (The Keatsian diction of the lines, moreover, especially of those within quotation marks, testifies to the claim that Chris has grown up and become a poet.) The lines indicate that Chris sees in her lover's eyes *"the Gethsemane/Gift,"* which must be, judging from evidence in the first fragment alluding to Gethsemane, a reference to the privacy of the lovers' love. The meaning of the independent clause beginning with *"and the envious sun"* is rather complex, but Shumway-Chris must be using the intransitive sense of "scuttle"—to scurry—transitively to mean to chase something, not the usual, transitive sense of "scuttle," which means to sink a ship or boat. Kidron, usually Kedron, according to *Webster's New World Dictionary of the American Language,* College Edition, was once a stream flowing into the Dead Sea. So Chris means that the softness in her lover's eyes is like a river, the ripples of which are touched by the sun—perhaps are light itself.

The rather complex association of eyes, sexuality, and love is suggested in another of Chris's fragments (already partly quoted from). Chiron's lines, *"She turned and saw* *the deep wet sky/in her mother's eyes,"* blend into lines of Chris's:

. . . like two preachers at a spring revival
Intoning a weariness of sin, 'but she lay
her hand on my repentance and my blood
Sang salvation deep in my proverbs . . . how'rt
tha both Mary and Thais, ma cunt and
Mother, and I thy love and lover?'

The reference to Thais—presumably the grandmother's name—calls to mind Massenet's opera, alluded to elsewhere in the poem, and it specifically suggests the fusion of the sexual and religious, which the passage as a whole generally suggests. (In Massenet's opera, Thais is transformed from a life of sensuality to one of spirituality.)[4] This fusion, moreover, reminds the reader of the "single vision," which Chris has achieved at the end of the poem and to which the eye imagery may be symbolically related.

Eye imagery occurs in another fragment spoken by Chris, which recapitulates the idea of vitality and sexuality that one has come to associate with the fragments:

Weren't we always, Mother, or did we begin
somewhere? Her hair caught light like
Chestnuts do in falling suns, and the deep
cabala of the marvelous eyes[.]

Two fragments at the end of the poem, separated by a narrative passage but clearly continuous with each other, gather together the motifs and phrases that have been running through the poem and re-emphasize the sexuality and love that have been at the heart of Chris's monologue, here moving from (in the first fragment) Chris's parents' sexuality and love to (in the second fragment) Chris's own:

"How'rt tha both Mary and Thais, ma cunt
and mother, and I thy love and lover—
and in the falling suns, Oh Lord, how plentiful,
how plentiful thy. . . ."

. . . and I'll sleep in the wind, lie in the
belly of the sun for thy wisdom, thy wish,
thy gift. . . .

The use of the affectionate possessive pronoun in the second fragment echoes its use in an earlier fragment, already discussed, in which Chris seemed to be looking into the eyes of her lover. One may conclude, therefore, that Chris here, too, is addressing her lover.

In conclusion, Mary Shumway's "Song of the Archer" is structured according to three speakers—the chorus, which functions as a framing narrator; Chiron, who narrates the main action of the poem; and the poet Chris, who comments, in an inner monologue, on the main action of the poem and recapitulates its theme in her love song. That theme, we have seen, parallelling the theme of Yeats's "Sailing to Byzantium," which is quoted throughout "Song of the Archer," is that life gives way to death but that out of death something permanent (art) is reborn.

Acknowledgment

The author wishes to acknowledge the support of the University of Wisconsin, Stevens Point, in the publishing of this paper.

Notes

[1] According to the dust jacket of *Song of the Archer and Other Poems,* Mary Shumway is a "native of Wisconsin's 'Winnebago Country'," and she has taught at the University of Wisconsin, Stevens Point, since 1965.

[2] It is the title poem of *Song of the Archer and Other Poems* (Chicago: Henry Regnery Company, 1964). I am indebted to Mary Shumway for pointing out to me that "Song of the Archer" originally appeared as a short story in *motive,* 24 (January-February 1964), 45-50.

[3] "Modern Art Techniques in *The Waste Land,*" *The Journal of Aesthetics and Art Criticism,* 18 (June 1960), 456-463.

[4] See *Milton Cross' Complete Stories of the Great Operas* (Garden City, New York: Doubleday and Company, 1952), pp. 530-538.

FISHES OF NAVIGATION POOL NUMBER 7, UPPER MISSISSIPPI RIVER, I: LAKE ONALASKA

JOHN W. HELD
*Department of Biology,
University of Wisconsin-La Crosse*

Abstract

Lake Onalaska, a backwater of Navigation Pool No. 7 of the Upper Mississippi River, has experienced considerable habitat alteration since its creation in 1937. Management objectives for this multipurpose resource are currently being reevaluated by fish and wildlife resource planners. The objective of this paper is to provide needed information on the fish community in Lake Onalaska. Sixty-seven fish species were captured with several gear types used in the summer months of 1976 and 1977. The catch was dominated numerically by centrarchids (bluegill, 50.1%; black crappie, 2.5%; largemouth bass, 2.5%), cyprinids (spotfin shiner, 7.5%; spottail shiner, 3.2%; bullhead minnow, 2.6%), and atherinids (brook silverside, 9.1%). The majority of the total catch biomass was comprised of common carp (30.9%), northern pike (11.4%), shorthead redhorse (8.6%), spotted sucker (6.9%), and bluegill (5.0%). Of the 67 species, approximately equal numbers were represented by sport, rough, and forage species. This great ichthyofaunal diversity reflects the habitat heterogenity of Lake Onalaska.

INTRODUCTION

Navigation pools and their associated backwaters were created on the Upper Mississippi River by construction of locks and dams during the 1930's. The backwaters have subsequently been reduced in area due to sedimentation. The Upper Mississippi River Wildlife and Fish Refuge includes considerable backwater habitat, and the resultant habitat changes have prompted renewed interest in developing sound resource management objectives for critical portions of this system.

Lake Onalaska is a shallow (mean depth $\approx$ 1.5 m) backwater lake that comprises the lower third of Navigation Pool No. 7. Some areas of the lake have experienced a 50% decrease in depth since its creation in 1937, and Claflin (1977) predicted further severe loss of habitat diversity in the lake during the next 30 to 40 years because of continued sedimentation and eutrophication.

Historical information on the fishes of this region is generally inadequate. Existing data is limited either by its age, or by the short sampling time and insufficient gear types used in past surveys. Rasmussen (1979) listed 80 fish species for Pool 7, including those that occurred by accidental introduction and those that had not been collected in more than 10 years. Rasmussen's tabulations included fish taken from all habitats of Pool 7; no distinction was made between species of the riverine portion of the pool and those of Lake Onalaska. His species list was compiled primarily from annual reports of the Upper Mississippi River Conservation Committee, much of what had previously been summarized by Smith *et al.* (1971). A more recent lake inventory by the Wisconsin Department of Natural Resources documented the presence of 41 species in Lake Onalaska (Holzer and Ironside 1977).

The intent of this investigation was to

determine the current species composition of the fish community in Lake Onalaska. Results will help provide guidelines for the development of management plans for this multipurpose resource.

Methods and Materials

Fish sampling was conducted in Lake Onalaska at 13 sites selected as being representative of major extant habitat types (Fig. 1). The sites ranged in substrate composition from finely divided organic material to large rocks, in depth from 0.5 to 2.6 m, and in current velocity from undetectable to 28.2 cm/sec.

The size of Lake Onalaska (2185 ha) and the diversity of its habitats and ichthyofauna dictated the extensive use of several gear types and collection methods. Both active and passive methods were used for approximately seven days in the middle of each summer month (May through August) during 1976 and 1977.

More than 4900 hours of netting were conducted during the two years with experimental multifilament nylon gill nets (50 × 1.8 m, with 10-m sections of 3.8, 5.0, 6.4, 7.6, and 10.0-cm² mesh). Large frame nets (1.8 × 0.9 m with 0.6-cm² mesh and 15 × 0.9 m leads) were fished in 1976 and 1977 for 4618 hr. Small frame nets (0.9 × 0.6 m with 0.6-cm² mesh and 5.6 × 0.6 m leads) were added in 1977 and accounted for 1481 hr of effort. All nets were fished for 20 to 25 hr, and duplicate net sets of the above gear types were made at each site.

All sites were sampled with electrofishing gear (250 V, 3-phase AC). More than 1250 minutes of electrofishing were conducted during nighttime hours. Eight sites were sampled with a 10-m bag seine (0.3-cm² mesh) during 1977. One to three seine hauls were made at separate locations at each site, and up to three locations were established in each of the eight accessible sites.

Quantification of fish catch was based on effort. Catch per unit of effort (CPUE) for gill and frame nets was expressed for 24 hr

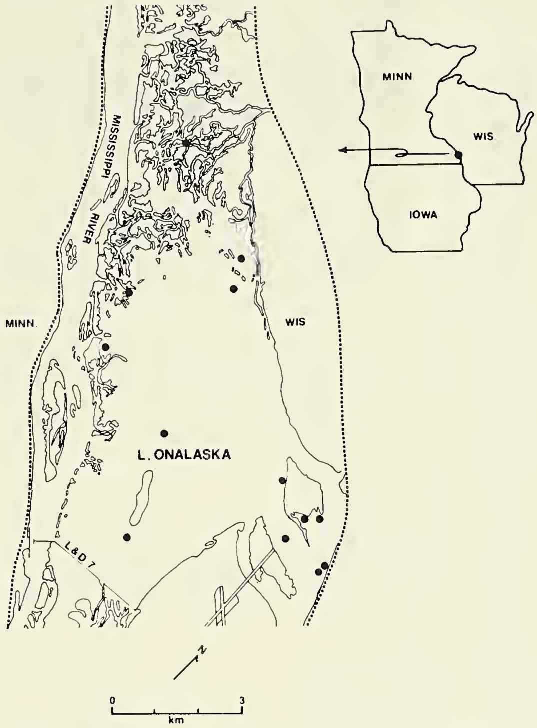

Fig. 1: Thirteen sites in Lake Onalaska (Navigation Pool Number 7, Upper Mississippi River) sampled for fishes during 1976 and 1977. Sampling locations = ●.

and for 0.25 hr with electrofishing gear. All data for each gear type were combined. Wet weights were empirically determined.

Results and Discussion

Sixty-seven species of fish were captured in Lake Onalaska during the two-year study (Table 1). Nineteen species could be classified as rough fish, 21 species as sport fish, and 27 species as forage fish.

The Family Cyprinidae was represented by 17 species, numbering nearly 20% of all fish collected. Five minnow species (golden shiner, spottail shiner, spotfin shiner, weed shiner, and bullhead minnow) were the most numerous cyprinids. Cyprinidae species constituted 31.2% of the total collection biomass, due primarily to the presence of common carp (30.9% of total weight; Table 1).

Ten catostomid species were caught during the study. Shorthead redhorse and

Table 1: Fish species collected from Lake Onalaska (Pool 7, Upper Mississippi River) during 1976 and 1977 with experimental gill nets, large and small frame nets, electrofishing, and seining. The numbers in parentheses indicate the rank of the most important species captured by each gear type. Designation: R = rough; S = sport; F = forage.

		Catch Per Unit of Effort						
Species	*Design*	*Gill (No./24 hr)*	*L. Frame (No./24 hr)*	*S. Frame (No./24 hr)*	*Electrofish. (No./15 min)*	*Seine*	*Total Number*	*Total Weight(kg)*
Ichthyomyzon castaneus								
Chestnut Lamprey	R	0.02	0.01	0.03	0.01	0	10	0.1
Ichthyomyzon unicuspis								
Silver Lamprey	R	0.02	0.01	—	0.01	0	6	<0.1
Lepisosteus osseus								
Longnose Gar	R	0.51	0.05	—	0.10	1	122	114.2
Lepisosteus platostomus								
Shortnose Gar	R	0.05	0.08	0.13	0.05	3	40	27.0
Amia calva								
Bowfin	R	0.33	0.07	0.07	0.14	186	283	207.0(6)
Anguilla rostrata								
American Eel	R	—	—	—	0.04	0	3	3.7
Dorosoma cepedianum								
Gizzard Shad	F	0.54(10)	0.28	—	3.43(5)	0	451	62.0
Hiodon alosoides								
Goldeye	R	0.03	0.01	—	—	0	9	2.6
Hiodon tergisus								
Mooneye	R	1.53(3)	0.01	—	0.12	2	328	150.2(9)
Esox lucius								
Northern Pike	S	1.32(4)	0.09	—	0.29	4	316	537.0(2)
Cyprinus carpio								
Common Carp	R	3.46(1)	0.38(7)	0.23	0.16	18	909(10)	1,452.0(1)
Hybopsis storeriana								
Silver Chub	F	—	—	0.02	0.01	0	2	<0.1
Notemigonus crysoleucas								
Golden Shiner	F	—	0.52(6)	2.37(4)	2.36(6)	327(8)	770	3.7
Notropis atherinoides								
Emerald Shiner	F	—	0.02	0.02	0.08	28	39	0.1
Notropis blennius								
River Shiner	F	—	—	—	—	113	113	<0.1
Notropis cornutus								
Common Shiner	F	—	—	0.02	—	0	1	<0.1

Table 1 (Continued)

Species	Design	Catch Per Unit of Effort: Gill (No./24 hr)	L. Frame (No./24 hr)	S. Frame (No./24 hr)	Electrofish. (No./15 min)	Seine	Total Number	Total Weight(kg)
Notropis emiliae								
Pugnose Minnow	F	—	—	0.71(7)	0.08	146	197	0.1
Notropis heterolepis								
Blacknose Shiner	F	—	0.01	0.15	0.06	36	51	0.1
Notropis hudsonius								
Spottail Shiner	F	—	4.87(2)	1.43(5)	1.14	363(7)	1,483(4)	6.6
Notropis spilopterus								
Spotfin Shiner	F	—	0.04	0.60(8)	0.07	3,420(3)	3,470(3)	1.8
Notropis stramineus								
Sand Shiner	F	—	—	—	—	114	114	0.1
Notropis texanus								
Weed Shiner	F	—	—	2.45(3)	0.05	376(6)	531	0.6
Notropis volucellus								
Mimic Shiner	F	—	—	—	—	1	1	<0.1
Pimephales notatus								
Bluntnose Minnow	F	—	—	—	—	200(10)	200	0.3
Pimephales promelas								
Fathead Minnow	F	—	—	—	—	1	1	<0.1
Pimephales vigilax								
Bullhead Minnow	F	—	0.03	0.57(10)	0.46	1,134(4)	1,213(5)	1.1
Rhinichthys cataractae								
Longnose Dace	F	—	—	—	—	1	1	<0.1
Carpiodes carpio								
River Carpsucker	R	0.02	—	—	0.02	19	24	3.3
Carpiodes cyprinus								
Quillback	R	0.08	0.18	—	0.88	1,039(5)	1,162(8)	24.9
Carpiodes velifer								
Highfin Carpsucker	R	0.01	—	—	—	0	2	2.1
Catostomus commersoni								
White Sucker	R	0.02	0.01	—	0.01	0	6	9.3
Ictiobus bubalus								
Smallmouth Buffalo	R	0.11	0.01	—	0.05	0	27	9.1
Ictiobus cyprinellus								
Bigmouth Buffalo	R	0.47	0.01	—	0.16	0	110	114.1

Table 1 (Continued)

Species	Design	Catch Per Unit of Effort: Gill (No./24 hr)	L. Frame (No./24 hr)	S. Frame (No./24 hr)	Electrofish. (No./15 min)	Seine	Total Number	Total Weight(kg)
Minytrema melanops								
Spotted Sucker	R	1.13(5)	0.13	0.10	1.86(7)	44	460	322.6(4)
Moxostoma anisurum								
Silver Redhorse	R	0.20	0.01	—	0.84	5	117	80.9
Moxostoma erythrurum								
Golden Redhorse	R	0.03	0.01	—	0.14	0	20	9.9
Moxostoma macrolepidotum								
Shorthead Redhorse	R	2.11(2)	0.15	0.03	1.49(10)	5	590	402.5(3)
Ictalurus melas								
Black Bullhead	S	0.13	0.07	0.02	0.10	0	45	19.9
Ictalurus natalis								
Yellow Bullhead	S	0.78(6)	0.29(10)	0.60(9)	0.38	8	292	99.9
Ictalurus nebulosus								
Brown Bullhead	S	0.02	0.02	0.30	0.02	34	62	3.8
Ictalurus punctatus								
Channel Catfish	S	0.77(8)	0.01	0.02	0.08	0	166	170.7(7)
Noturus gyrinus								
Tadpole Madtom	F	—	0.31(9)	0.26	0.01	33	109	0.4
Pylodictis olivaris								
Flathead Catfish	S	0.10	—	—	—	0	20	29.2
Aphredoderus sayanus								
Pirate Perch	F	—	0.01	0.02	0.04	17	22	<0.1
Percopsis omiscomaycus								
Trout-Perch	F	—	0.01	0.02	0.01	0	4	<0.1
Labidesthes sicculus								
Brook Silversides	F	—	0.02	0.08	1.25	4,081(2)	4,194(2)	2.1
Morone chrysops								
White Bass	S	0.32	0.15	—	1.80(9)	18	262	47.6
Morone mississippiensis								
Yellow Bass	S	0.20	—	—	0.22	0	23	3.0
Ambloplites rupestris								
Rock Bass	S	0.34	0.36(8)	0.29	1.82(8)	11	319	29.7
Lepomis cyanellus								
Green Sunfish	S	—	0.01	—	0.01	1	3	0.1

Table 1 (Continued)

Species	Design	Catch Per Unit of Effort: Gill (No./24 hr)	L. Frame (No./24 hr)	S. Frame (No./24 hr)	Electrofish. (No./15 min)	Seine	Total Number	Total Weight(kg)
Lepomis gibbosus								
Pumpkinseed	S	0.58(9)	1.41(4)	2.56(2)	4.02(3)	132	1,016(9)	49.8
Lepomis gulosus								
Warmouth	S	0.01	0.03	0.05	0.02	0	12	0.9
Lepomis macrochirus								
Bluegill	S	0.39	5.78(1)	14.99(1)	54.83(1)	16,510(1)	23,197(1)	233.6(5)
Micropterus dolomieui								
Smallmouth Bass	S	0.01	—	—	0.04	0	4	1.2
Micropterus salmoides								
Largemouth Bass	S	0.31	0.08	0.21	9.53(2)	277(9)	1,163(7)	134.0(10)
Pomoxis annularis								
White Crappie	S	0.08	1.25(5)	0.21	0.58	2	319	32.2
Pomoxis nigromaculatus								
Black Crappie	S	0.21	3.26(3)	0.78(6)	3.74(4)	137	1,167(6)	78.7
Ammocrypta clara								
Western Sand Darter	F	—	—	—	—	8	8	<0.1
Etheostoma asprigene								
Mud Darter	F	—	—	—	0.01	1	2	<0.1
Etheostoma exile								
Iowa Darter	F	—	—	—	—	3	3	<0.1
Etheostoma nigrum								
Johnny Darter	F	—	—	0.11	0.16	31	51	0.1
Perca flavescens								
Yellow Perch	S	0.37	0.21	0.11	0.97	29	232	28.8
Percina caprodes								
Logperch	F	—	0.01	0.02	0.19	5	24	0.2
Percina shumardi								
River Darter	F	—	—	—	—	1	1	<0.1
Stizostedion canadense								
Sauger	S	0.03	0.03	—	0.48	0	51	7.4
Stizostedion vitreum vitreum								
Walleye	S	0.06	0.01	0.02	1.00	1	99	23.7
Aplodinotus grunniens								
Freshwater Drum	S	0.78(7)	0.17	—	0.64	0	245	159.5(8)
						28,926	46,297	4,705.6

spotted suckers were important in terms of biomass and comprised 8.6% and 6.9% of the total collection weight, respectively (Table 1). The apparent importance of quillback (2.5% of the total number) was due primarily to the collection of 984 young of the year in one seine haul.

Lake Onalaska supports nine species of centrarchids. The most abundant species was bluegill which accounted for 50.1% of all fishes collected. Other centrarchids that contributed significantly to total catch numbers were black crappie (2.5%), largemouth bass (2.5%), pumpkinseed (2.2%), rockbass (0.7%), and white crappie (0.7% (Table 1).

Ictaluridae accounted for 1.5% of the number and 6.9% of the collection biomass. Yellow bullhead and channel catfish were the most abundant of the six ictalurids.

Although nine species of Percidae were collected, their importance in the lake in terms of numbers (1.0%) and biomass (1.3%) was small. The most abundant percids were yellow perch and walleye.

The combined catch from all collection methods indicated that bluegill was the most numerous species (50.1% of total numbers caught), followed by brook silversides (9.1%) and spotfin shiner (7.5%) (Table 1). These three species accounted for two-thirds of the total numbers of fishes collected. Other numerous species were spottail shiner (3.2%), bullhead minnow (2.6%), black crappie (2.5%), and largemouth bass (2.5%). The dominant species in terms of biomass was common carp (30.9%), followed by northern pike (11.4%) and shorthead redhorse (8.6%). These three species accounted for over half of the total collection biomass.

Gill net CPUE indicated that common carp was the most abundant species (Table 1). Shorthead redhorse, mooneye, northern pike, and spotted sucker were also frequently captured in gill nets.

Data from large and small frame nets emphasized the importance of centrarchids and cyprinids in Lake Onalaska. In terms of large frame net CPUE, the most abundant species, in descending order, were bluegill, spottail shiner, black crappie, pumpkinseed, and white crappie (Table 1). Although bluegill, pumpkinseed, and spottail shiner were also frequently taken by small frame nets, this latter gear type more effectively sampled other cyprinids; weed shiner, golden shiner, and spottail shiner followed by bluegill and pumpkinseed in order of importance (Table 1).

Electrofishing CPUE again emphasized the importance of centrarchids in Lake Onalaska. Bluegill, largemouth bass, pumpkinseed, and black crappie were taken most frequently by this method (Table 1).

No attempt was made to standardize seine hauls. The variable efficiency of seining in the different littoral habitats made these results incomparable. It is interesting to note, however, that bluegill also dominated the catch by this method (Table 1). Several forage species, taken infrequently by other methods, were important in seine catches; namely, brook silversides, spotfin shiner, and bullhead minnow.

Summary

Intensive sampling during 1976 and 1977 indicated that Lake Onalaska supported a diverse fish community of 67 species, indicative of a heterogenous environment. The rough, sport, and forage species were approximately equal in number.

The lake is apparently well suited for centrarchids (especially bluegill, pumpkinseed, and crappies), as well as predator game fish species (northern pike and largemouth bass). In addition to young of the year centrarchids, several forage species provide a diverse food base for piscivores. Common carp and a significant catostomid fauna also play a major role in the fish community.

These results suggest that management objectives should include the maintenance of habitat diversity in Lake Onalaska.

Acknowledgments

I am most grateful to the many students who worked so diligently on this project. Funds were provided by the Faculty Research Committee, University of Wisconsin-La Crosse.

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FISHES OF NAVIGATION POOL NUMBER 7, UPPER MISSISSIPPI RIVER, II: THE RIVERINE PORTION

JOHN W. HELD
Department of Biology
University of Wisconsin-La Crosse

Abstract

Adequate fisheries information does not exist for the riverine portion of Navigation Pool No. 7 of the Upper Mississippi River because of the overriding interest in its backwater lake (Lake Onalaska) and because of the difficulties in sampling the riverine portion of the pool. The objective of this paper is to report total catch data from sampling sites associated with the main channel of Pool 7. Seventy-one fish species were captured with several gear types used in the summer months of 1978 and 1979. The most abundant fishes were cyprinids (emerald shiner, 25.9% of total numbers; spotfin shiner, 8.2%; spottail shiner, 7.2%; bullhead minnow, 6.3%) and centrarchids (bluegill, 8.0%, and black crappie, 5.7%). Major contributors to the total catch biomass were common carp (18.1%), shorthead redhorse (9.2%), northern pike (8.9%), and silver redhorse (7.4%). Of the 71 species, 23 could be classified as rough fish, 19 as sport fish, and 29 as forage fish. This variety of ichthyofauna is an indicator of the habitat diversity in the riverine portion of Pool 7.

INTRODUCTION

Navigation Pool No. 7 of the Upper Mississippi River was formed in 1937 by the closure of Lock and Dam 7 at Dresbach, Minnesota. The pool extends from river mile 702.5 (miles above the mouth of the Ohio River) to river mile 714.3, a distance of 19 km. The pool has an area of 5443 ha, a perimeter of 60 km, and is up to 7.8 km wide.

Little fisheries information exists on the riverine portion of Pool 7. Investigators have either concentrated their efforts on Lake Onalaska (Held 1983; Holzer and Ironside 1977) or they have combined the fisheries data from all areas of Pool 7 (Rasmussen 1979). Also, comprehensive fish surveys have likely been discouraged because of sampling difficulties associated with the riverine portion of the pool, i.e., problems caused by significant current velocities, fluctuating water levels, and heavy commercial and recreational use of the main channel.

The intent of this study was to sample several lotic sites in the riverine portion of Pool 7. This report provides baseline information on the fish community found in this part of the river.

METHODS AND MATERIALS

Twelve sampling sites were chosen in the tailwater, middle, and lower reaches of Pool 7 (Fig. 1). The sites were sampled midmonth from May through August, 1978, and June through August, 1979.

Multifilament nylon experimental gill nets (50 × 1.8 m, with 10-m sections of 3.8, 5.0, 6.4, 7.6, and 10.0-cm^2 mesh) were fished in all areas for a total of 3726 hr. Large frame nets (1.8 × 0.9 m with 0.6-cm^2 mesh and 15 × 0.9 m leads) and small frame nets (0.9 × 0.6 m with 0.6-cm^2 mesh and 5.6 × 0.6-m leads) were set in littoral habitats for 2488 hr and 2324 hr, respectively. Hoop nets (0.75-m diameter with 2.5-cm^2 mesh) were used in open water areas for a total of 2317 hr. Duplicate sets of the above gear types were made at each site, and each net was fished for 20 to 25 hr.

All areas were sampled at night on most dates with electrofishing gear (250 V, 3-phase AC) for a total of 752 min. Seven to 10 of the areas were sampled with a 10-m bag seine (0.3-cm^2 mesh) when water level conditions permitted.

Quantification of catch was based on effort. Catch per unit of effort (CPUE) for gill, frame, and hoop nets was expressed for 24 hr. CPUE for electrofishing was number per 0.25 hr. Seine hauls were not standardized. All data for each gear type was combined. Wet weights were empirically determined.

Results and Discussion

Over 28,000 fish of 71 species were sampled by all methods from the riverine portion of Pool 7 during the summers of 1978 and 1979 (Table 1). The total catch biomass was nearly two metric tons. Of the 71 species, 29 could be classified as forage fish, 23 species as rough fish, and 19 as sport fish.

Seventeen cyprinid species accounted for 59.7% of total catch numbers. Emerald shiner (7342), spotfin shiner (2327), spottail shiner (2045), bullhead minnow (1798), and golden shiner (1560) together comprised 53.1% of the total catch (Table 1). Common carp contributed the majority of the biomass (360.1 kg, or 18.1% of total catch biomass).

Catostomidae were represented by 12 species in the riverine portion of Pool 7. Their numbers (1313) accounted for only 4.6% of the total catch, but their combined biomass (584 kg) represented 29.4% of the total. The most numerous catostomids were shorthead redhorses (1.6% of the total), and spotted sucker (1.1%) (Table 1). Several catostomids contributed significantly to the total biomass, including shorthead redhorse (9.2%), silver redhorse (7.4%), spotted sucker (4.9%), and quillback (3.1%). The collection and first documentation of two river redhorse (*Moxostoma carinatum*) from Pool 7 was of special note.

Nine species of Centrarchidae contributed 18.2% of total catch numbers and 13.6% of the biomass. Bluegill was the predominant component of the sunfish catch and accounted for 8% of the total numbers and 2.7% of the biomass (Table 1). Other important centrarchids were black crappie (5.7% by number and 5.2% by weight) and white crappie (1.9% by number and 3.1% by weight).

Fig. 1: Twelve sites in the riverine portion of Navigation Pool No. 7 (Upper Mississippi River) sampled for fishes during 1978 and 1979. Sample sites = ●.

Ictaluridae were not very important numerically (1.1% of the total), but their combined biomass comprised 9.6% of the total. Prominent among the five ictalurid species were flathead catfish (128.9 kg, or 6.5%) and channel catfish (55.1 kg, or 2.8%) (Table 1).

The Family Percidae was represented by 10 species, but their combined number (1808) and weight (47.3 kg) were not great (6.4% and 2.4% of the totals, respectively).

Table 1: Fish species collected from the riverine portion of Navigation Pool No. 7 (Upper Mississippi River) during 1978 and 1979 with experimental gill nets, large and small frame nets, electrofishing and seining. The numbers in parentheses indicate the rank of the most important species captured by each gear type. Designation: R = rough; S = sport; F = forage.

		Catch Per Unit of Effort							
Species	*Design*	*Gill (No./24 hr)*	*L. Frame (No./24 hr)*	*S. Frame (No./24 hr)*	*Electrofish. (No./15 min)*	*Hoop (No./24 hr)*	*Seine*	*Total Number*	*Total Weight (kg)*
Ichthyomyzon unicuspis									
Silver Lamprey	R	—	—	—	0.04	0.01	—	3	<1
Scaphirhynchus platorynchus									
Shovelnose Sturgeon	R	0.39(2)	—	—	—	—	—	60	72.7(9)
Polydon spathula									
Paddlefish	R	0.01	—	—	—	—	—	1	1.9
Lepisosteus osseus									
Longnose Gar	R	0.15(8)	0.22(10)	0.03	0.70	—	13	97	62.0
Lepisosteus platostomus									
Shortnose Gar	R	0.08	0.03	0.02	0.10	—	2	24	19.1
Amia calva									
Bowfin	R	0.04	0.06	0.08	0.16	—	1	29	61.7
Anguilla rostrata									
American Eel	R	—	0.01	0.02	—	—	—	3	4.0
Dorosoma cepedianum									
Gizzard Shad	F	0.03	0.07	0.03	1.24	—	872(7)	948(8)	6.9
Hiodon alosoides									
Goldeye	R	0.01	—	—	—	—	—	2	1.1
Hiodon tergisus									
Mooneye	R	0.12	0.03	—	0.80	—	4	65	13.0
Umbra limi									
Central Mudminnow	F	—	0.02	—	—	—	8	10	<0.1
Esox lucius									
Northern Pike	S	0.39	0.09	0.14(10)	0.34	—	245	345	176.9(3)
Cyprinus carpio									
Common Carp	R	0.42(1)	0.18	0.02	1.77(10)	0.01	2	177	360.1(1)
Hybognathus hankinsoni									
Brassy Minnow	F	—	0.01	—	—	—	—	1	<0.1
Hybognathus nuchalis									
Mississippi Silvery Minnow	F	—	—	—	—	—	61	61	<0.1
Hybopsis storeriana									
Silver Chub	F	—	—	—	0.18	.03(9)	4	16	0.3
Notemigonus crysoleucas									
Golden Shiner	F	—	0.35(7)	0.36(7)	0.26	—	1,476(6)	1,560(7)	2.3

Table 1 (Continued)

Species	Design	Catch Per Unit of Effort: Gill (No./24 hr)	L. Frame (No./24 hr)	S. Frame (No./24 hr)	Electrofish. (No./15 min)	Hoop (No./24 hr)	Seine	Total Number	Total Weight (kg)
Notropis atherinoides									
Emerald Shiner	F	—	—	0.33(8)	1.04	—	7,258(1)	7,342(1)	3.5
Notropis blennius									
River Shiner	F	—	—	—	0.08	—	416	420	0.8
Notropis cornutus									
Common Shiner	F	—	0.01	—	—	—	—	1	<0.1
Notropis emiliae									
Pugnose Minnow	F	—	—	0.04	—	—	520(10)	524	0.2
Notropis hudsonius									
Spottail Shiner	F	—	0.02	0.46(3)	0.32	—	1,982(3)	2,045(4)	1.4
Notropis spilopterus									
Spotfin Shiner	F	—	0.15	0.44(4)	0.02	—	2,267(2)	2,327(2)	2.1
Notropis stramineus									
Sand Shiner	F	—	—	0.08	—	—	176	184	0.1
Notropis texanus									
Weed Shiner	F	—	0.03	0.10	—	—	353	366	0.2
Pimephales notatus									
Bluntnose Minnow	F	—	—	—	—	—	123	123	0.1
Pimephales promelas									
Fathead Minnow	F	—	—	—	—	—	8	8	<0.1
Pimephales vigilax									
Bullhead Minnow	F	—	0.02	0.06	0.08	—	1,786(4)	1,798(5)	0.7
Rhinichthys atratulus									
Blacknose Dace	F	—	—	—	—	—	1	1	<0.1
Carpiodes carpio									
River Carpsucker	R	0.15(7)	0.01	—	0.10	—	—	30	27.4
Carpiodes cyprinus									
Quillback	R	0.03	0.01	—	3.31(5)	—	12	184	62.2(10)
Carpiodes velifer									
Highfin Carpsucker	R	0.01	—	—	0.66	—	3	38	8.0
Catostomus commersoni									
White Sucker	R	0.04	—	—	0.02	—	—	7	6.6
Cycleptus elongatus									
Blue Sucker	R	0.01	—	—	—	—	1	2	2.0
Ictiobus bubalus									
Smallmouth Buffalo	R	0.08	—	—	0.22	—	—	24	21.8

Table 1 (Continued)

Species	Design	Catch Per Unit of Effort: Gill (No./24 hr)	L. Frame (No./24 hr)	S. Frame (No./24 hr)	Electrofish. (No./15 min)	Hoop (No./24 hr)	Seine	Total Number	Total Weight (kg)
Ictiobus cyprinellus									
Bigmouth Buffalo	R	—	—	—	0.14	—	1	8	11.4
Minytrema melanops									
Spotted Sucker	R	0.14(10)	0.16	0.10	3.53(4)	—	97	323	97.9(7)
Moxostoma anisurum									
Silver Redhorse	R	0.30(5)	0.04	0.01	2.63(6)	—	15	199	147.0(4)
Moxostoma carinatum									
River Redhorse	R	—	—	—	0.04	—	—	2	1.4
Moxostoma erythrurum									
Golden Redhorse	R	0.05	0.03	—	0.34	—	3	30	15.8
Moxostoma macrolepidotum									
Shorthead Redhorse	R	0.26(6)	0.11	0.08	7.49(2)	0.15(5)	17	466	182.5(2)
Ictalurus melas									
Black Bullhead	S	0.01	—	0.03	—	—	1	5	2.3
Ictalurus natalis									
Yellow Bullhead	S	0.01	0.09	0.12	0.04	—	18	43	3.8
Ictalurus punctatus									
Channel Catfish	S	0.14(10)	0.04	0.02	0.54	0.06(7)	—	61	55.1
Noturus gyrinus									
Tadpole Madtom	F	—	0.25(9)	0.42(6)	—	—	58	125	0.4
Pylodictis olivaris									
Flathead Catfish	S	0.08	0.05	0.01	0.20	0.38(1)	—	66	128.9(5)
Aphredoderus sayanus									
Pirate Perch	F	—	0.16	0.05	0.02	—	72	95	0.1
Percopsis omiscomaycus									
Trout-Perch	F	—	—	—	0.06	—	4	7	<0.1
Lota lota									
Burbot	R	—	—	0.08	—	—	1	9	<0.1
Labidesthes sicculus									
Brook Silversides	F	—	—	—	0.02	—	493	494	0.4
Morone chrysops									
White Bass	S	0.06	1.44(3)	0.14(10)	2.36(8)	—	107	398	20.0
Ambloplites rupestris									
Rock Bass	S	0.10	0.66(5)	0.32(9)	1.18	0.08(6)	100	282	23.4
Lepomis cyanellus									
Green Sunfish	S	—	—	0.01	—	—	—	1	<0.1

Table 1 (Continued)

Species	Design	Catch Per Unit of Effort: Gill (No./24 hr)	L. Frame (No./24 hr)	S. Frame (No./24 hr)	Electrofish. (No./15 min)	Hoop (No./24 hr)	Seine	Total Number	Total Weight (kg)
Lepomis gibbosus Pumpkinseed	S	0.02	0.33(8)	0.13	0.20	0.01	56	117	4.4
Lepomis humilis Orangespotted Sunfish	S	—	0.01	—	—	—	12	13	0.1
Lepomis machrochirus Bluegill	S	0.02	0.77(4)	0.99(2)	8.66(1)	0.05(8)	1,640(5)	2,258(3)	53.8
Micropterus dolomieui Smallmouth Bass	S	—	—	0.01	0.92	—	15	62	14.3
Micropterus salmoides Largemouth Bass	S	0.01	0.02	0.09	0.68	—	235	282	10.6
Pomoxis annularis White Crappie	S	0.15(8)	3.25(2)	0.43(5)	1.30	0.25(2)	51	542(10)	61.4
Pomoxis nigromaculatus Black Crappie	S	0.14	4.29(1)	1.17(1)	4.49(3)	0.23(3)	779(9)	1,605(6)	102.8(6)
Ammocrypta clara Western Sand Darter	F	—	—	—	—	—	230	230	0.1
Etheostoma asprigene Mud Darter	F	—	0.01	—	—	—	33	34	<0.1
Etheostoma exile Iowa Darter	F	—	—	—	—	—	1	1	<0.1
Etheostoma nigrum Johnny Darter	F	—	—	0.02	—	—	866(8)	868(9)	0.3
Perca flavescens Yellow Perch	S	0.01	0.12	0.03	1.42	0.01	285	373	5.7
Percina caprodes Logperch	F	—	—	0.02	—	—	46	48	0.1
Percina maculata Blackside Darter	F	—	—	—	—	—	—	1	<0.1
Percina shumardi River Darter	F	—	—	—	—	—	10	10	<0.1
Stizostedion canadense Sauger	S	0.03	0.05	0.04	2.18(9)	—	5	128	17.4
Stizostedion vitreum vitreum Walleye	S	0.03(2)	0.01	—	1.77(10)	—	21	115	23.5
Aplodinotus grunniens Freshwater Drum	S	0.34(4)	0.41(6)	0.03	2.59(7)	0.20(4)	4	252	83.7(8)
							22,870	28,379	1,988.4

The most numerous percids were johnny darter (3.1% of the total catch) and yellow perch (1.3%) (Table 1). Walleye comprised 1.2% of the total catch biomass and sauger, 0.9%.

Some other species that contributed significantly to the total catch biomass were northern pike (176.9 kg, 8.9%), freshwater drum (83.7 kg, or 4.2%), and shovelnose sturgeon (72.7 kg, or 3.7%) (Table 1). Another numerous forage species was gizzard shad (3.3% of the total catch).

In summary, the most numerous species, according to the total catch number of all gear types combined, were emerald and spotfin shiners, bluegill, spottail shiner, bullhead minnow, and black crappie (Table 1). Those species that contributed most to the total catch biomass (all gear combined) were common carp, shorthead redhorse, northern pike, silver redhorse, flathead catfish, and black crappie.

Gill net CPUE indicated that common carp, northern pike, shovelnose sturgeon, freshwater drum, and silver redhorse were the important species in the riverine portion of Pool 7 (Table 1). Large frame nets sampled the centrarchids more effectively and these data suggested the most abundant species were black and white crappies, white bass, bluegill, and rockbass. Small frame net CPUE also indicated that centrarchids were dominant (black crappie and bluegill) but also emphasized the importance of forage species, including spottail and spotfin shiner (Table 1). Electrofishing CPUE again signified the major role of bluegill and black crappie, but electrofishing was also effective in capturing some catostomids, namely shorthead redhorse, spotted sucker, quillback, and silver redhorse. Hoop nets appeared to be the most selective gear type. Hoop net CPUE, generally low, indicated that flathead catfish was an important riverine species.

CPUE was not calculated for seining because it was not possible to uniformly sample the different habitats. Ranking the combined seine catch, however, emphasized the major role filled by the forage species in the riverine portion of Pool 7 (Table 1). Emerald shiner, spotfin shiner, spottail shiner, bullhead minnow, golden shiner, and gizzard shad owe their high total catch ranking to seine haul results.

Summary

Sampling during 1978 and 1979 in 12 areas associated with the riverine portion of Pool 7 documented the presence of a complex fish community. Seventy-one fish species were taken by a variety of gear types. The numerical dominance of some minnow species and other young of the year signified a strong forage base for piscivores, although few large predators (other than northern pike) were prominent in the catch. The riverine portion of Pool 7 seems to be favorable habitat for several species of centrarchids and catostomids. These results reflect the habitat diversity of the river channel and its border. If habitat heterogeneity begets fish community complexity, then attempts to further alter the Upper Mississippi River should be restrained.

Acknowledgments

I express my appreciation to the many students who have contributed to this study, and to the University of Wisconsin-La Crosse Faculty Research Committee and Dairyland Power Cooperative (La Crosse) for financial support.

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MAMMALS OF FORT McCOY, MONROE COUNTY, WISCONSIN

Maj. Richard M. Pitts
Department of Military Science
Texas A&M University

Introduction

This study was initiated by the author during the summers of 1976 and 1977 to inventory the species of mammals present in Fort McCoy. Information on fur bearers and some of the larger game mammals was provided by Kim Mello, biologist at Fort McCoy, from data collected during the winters of 1979 and 1980.

Material and Methods

The fort grounds were sampled randomly with snap traps, live box traps and mist nets. Records from trappers were used when available. Trapping was conducted both diurnally and nocturnally. Allocations of specimens to subspecies followed Hall (1981). Specimens were verified by Dr. Herschel Garner. All specimens are on deposit in the mammal collection of Tarleton State University, Stephenville, Texas.

Study Area

Fort McCoy is located on 59,778 acres in Monroe County, in the unglaciated area of southwest Wisconsin (Martin 1916). The undeveloped habitat suitable for wild mammals consists of 261 acres in streams, ponds, and flowages, 51.1 miles of trout streams and 57,767 acres of varied terrestrial habitats. The altitude ranges from 850 to about 1,450 feet above sea level. The topography is nearly level to very steep with intermittent areas of rolling terrain. The La Crosse River and its tributaries drain most of the fort. Silver Creek drains the extreme south part and merges with the La Crosse River outside the fort boundary at Angelo, Wisconsin. Sparta, Stillwell and Tarr Creeks drain the south central part. All three merge southwest of the troop billeting area then join the La Crosse River. Squaw Creek and the La Crosse River proper drain the central and north-central area. The north end is drained by Clear Creek (Crispin, *et al.* 1976).

The soils of Fort McCoy are predominantly sands or rough stony land of little agricultural value. Only a few scattered areas of loam or silt loam exist. There are at least five different major soil types.

The average length of the growth season varies from 125 days on low-land to 140 on the uplands. The average killing frost date in the spring is April 25, and for the fall is October 16 (Whitson and Baker 1912). Records from the weather recording station indicate the mean annual precipitation for the fort is 31.16 inches; mean annual temperature is 46.29°F.

This region of Wisconsin consists principally of forest cover with some grassy openings. The native climax grasses are mainly big bluestem (*Andropogon gerardi*) and little bluestem (*Andropogon scoparius*). The principal species of native trees are jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), paper birch (*Betula papyrifera*), red oak (*Quercus rubra*), black oak (*Quercus velutina*), white oak (*Quercus alba*), red maple (*Acer rubrum*), box elder (*Acer negundo*), northern pin oak (*Quercus ellipsoidalis*), and quaking aspen (*Populus tremuloides*).

Synopsis of Species

Didelphis virginiana virginiana (Kerr) Common Opossum. Uncommon throughout the fort limits. Occasionally observed meandering around the buildings after dark, but primarily inhabitants of the deciduous woods. After the harsh winter of 1978, the number of opossums on post declined.

Sorex cinereus cinereus (Kerr) Masked Shrew. Uncommon. These shrews were found among the leaf litter of the deciduous or coniferous woods on post. Their greatest period of activity was during the crepuscular hours and at night. This shrew was difficult to catch using snap traps; it might prove to be more common if "pit fall" traps are used.

Blarina brevicauda brevicauda (Say) Shorttailed Shrew. Uncommon. Several were caught under log piles near the deciduous woods and in dense grass on the sides of the creeks. They are active primarily after sunset.

Scalopus aquaticus machrinus (Rafinesque) Eastern Mole. Very common. Mole workings occurred alongside the fort roads and in the grassy areas near the buildings. They were also common along the edges of the woods. Captures occurred during all hours of the day and night.

Myotis lucifugus lucifugus (Le Conte) Little Brown Bat. Very common. They are early flyers which were often seen coming from the attics of some of the buildings on post at twilight.

Eptesicus fuscus fuscus (Beauvois) Big Brown Bat. Very commonly seen flying around street lights at night. Many were found in the seldom-used halls of the old hospital. They were swift flyers, usually staying higher than 20 feet.

Lasiurus borealis borealis (Müller) Red Bat. Common. Red bats were seen flying up and down the creeks and around street lights shortly after dark. They are swift flyers and usually fly at a height of about twenty feet first, then at a height of about eight feet.

Marmota monax monax (Linneaus) Woodchuck. Abundant. Woodchucks were found in the grassy areas between the buildings, in culverts under the roads, and along edges of the woods. They were especially active in early morning and late afternoon.

Spermophilus tridecemlineatus tridecemlineatus (Mitchell) Thirteen-Lined Ground Squirrel. Abundant in the short dry grassy meadow and along the sides of the roads in the cantonment area. They seem to prefer the sandy soils. All specimens were trapped diurnally.

Tamias striatus griseus (Mearns) Eastern Chipmunk. Common in the woods and at the post recreation area by the lake during the day.

Eutamias minimus neglectus (J. A. Allen) Least Chipmunk. Rare. Several were observed at the post recreation area. They prefer the coniferous woods. They were active throughout the day, but their greatest activity was in early morning and later afternoon.

Sciurus carolinensis hypophaeus (Merriam) Eastern Gray Squirrel. Abundant in the deciduous woods.

Sciurus niger rufiventer (Geoffroy-Saint-Hilare) Fox Squirrel. Abundant in the deciduous woods.

Tamiasciurus hudsonicus minnesota (Allen) Red Squirrel. Abundant in the deciduous woods. A nest with four baby squirrels was found inside a rotten stump four feet above ground.

Glaucomys volans volans (Linnaeus) Southern Flying Squirrel. Flying squirrels were common in the deciduous woods, but due to their nocturnal habits, they were seldom encountered.

Geomys bursarius wisconsinensis (Jackson) Plains Pocket Gopher. Gophers were common in open areas with loam or sandy soils. Some mounds were observed along the edges of woods.

Castor canadensis michiganensis (Bailey) Beaver. Common. Colonies of beavers use the lakes on post and their dams have impounded water in several places. The beaver population has been estimated to be 130 using data from a biological survey. Sixty-three were trapped in 1981 by trappers.

Peromyscus leucopus noveboracensis (Fisher) Northern Whitefooted Mouse. These mice were very abundant in the wooded areas. Most were caught near tree stumps and fallen logs. Several were caught beside piles of limbs that had been stacked. All were trapped after dark.

Clethrionomys gapperi gapperi (Vigors) boreal Red-Backed Vole. Red-backed voles were very abundant among the fallen logs and tree stumps. This record is a range extension of 13 miles south from Millston, Jackson County and 22 miles southwest from Mather, Juneau County (Jackson, 1961). Six adults were caught in the same runway beneath a decaying stump, indicating that the red-backed vole could live in colonies and be gregarious. Manville (1949) concluded that the red-backed vole does not form colonies and is not gregarious. Two specimens were caught during the day, the others were caught at night.

Microtus pennsylvanicus pennsylvanicus (Ord) Meadow vole. Meadow voles were very abundant between buildings and tall grassy fields. Some were trapped inside buildings. The meadow vole was the most common microtine trapped on the post. These voles were active all day, but most were trapped at night.

Ondatra zibethicus zibethicus (Linnaeus) Muskrat. Common. Several colonies have become established on the lakes within the fort boundaries. In 1981, 94 muskrats were trapped by fur hunters. The estimated population is 1,000.

Rattus norvegicus (Berkenhout) Norway Rat. Uncommon. They are found under the barracks and also near the messhalls. None were trapped very far from areas frequently used by humans.

Mus musculus domesticus (Rutty) House Mouse. Common. They are found around buildings and under piles of decaying logs where timber had been cleared.

Zapus hudsonius intermedius (Zimmerman) Meadow Jumping Mouse. Common. Many jumping mice were trapped along the creeks with tall grass along their banks. All specimens were trapped between midnight and dawn.

Erethizon dorsatum dorsatum (Linnaeus) Canada Porcupine. Rare. Only a few have been seen in the wooded areas on the northern part of the post limits.

Lepus americanus phaeonotus (J. A. Allen) Snowshoe hare. Rare. Only one has been taken by a hunter in 1979 in the brushy woodlands area of the northern post limits.

Sylvilagus floridanus mearnsii (J. A. Allen) Eastern Cottontail. Cottontails were abundant throughout the post. They are very common around the buildings. The cottontails prefer thickets or dense brush. Most were sighted in the early morning hours and shortly before sunset. The biological survey estimated the cottontail population to be over 1,000.

Canis latrans thamnos (Jackson) Coyote. Uncommon. However, coyotes were found roaming brushy habitats of the impact area and outlying training areas. Only two were trapped by trappers in 1980.

Vulpes fulva fulva (Desmarest) Red Fox. Common around the creek bottoms with good concealment. Thirty-six were trapped in 1981 by fur hunters.

Urocyon cinereoargenteus ocythous (Bangs) Gray Fox. Gray foxes are common in the brushy areas, usually along streams. They were found in the woods more often than the Red Fox. Eighteen were trapped in 1981 by fur hunters.

Procyon lotor hirtus (Nelson and Goldman) Raccoon. Raccoons were very common in the deciduous woods, usually along streams. They frequently came into the cantonment area at night in search of food. Seventy were trapped by hunters in 1981.

Mustela rixosa allegheniensis (Rhoads) Least Weasel. Rare. They were sighted near streams in grassy fields. They were seldom found in the woods. Only one was captured on the post limits.

Mustela frenata noveboracensis (Emmons) Longtailed Weasel. Rare. The one Longtailed Weasel observed was in woodlands near streams.

Mustela vison letifera (Hollister) Mink. Common. Mink were found in wooded areas along streams and lakes. The biological surveys estimate a population of 200. Fur hunters trapped 2 minks in 1981.

Taxidea taxus jacksoni (Schantz) Badger. Common in the impact and training areas.

Mephitus mephitis hudsonica (Richardson) Striped Skunk. Skunks were commonly seen roaming at night throughout the post. More common in open wooded areas. Sixty-two were trapped by fur hunters in 1980.

Lutra canadensis canadensis (Schreber) Otter. Uncommon. Only a few sightings of otters on post have been documented. These sightings were along streams that were away from the normal areas used for training. A biological survey estimated a population of only 10 otters on the post.

Lynx rufus superiorensis (Peterson and Downing) Bobcat. Rare. Very few observations have been reported to biologists on post. These were in the heavily wooded area at higher elevation.

Odocoileus virginianus borealis (Miller) Whitetailed Deer. Deer were very common in the woods on post. They were seen roaming throughout the post limits in mornings and evenings. The 1981 deer census conducted on the post has estimated the deer population to be between 1800-2100. The number killed by hunters in 1981 was 839.

Conclusion

Although Fort McCoy is used as a training area for several thousand military personal the environment is still inhabitated by a total of thirty-nine mammal species, which were recorded on the post reservation; eleven of these species had not previously been officially recorded in Monroe County (Table 1). Most of these are fairly common to this part of Wisconsin but six represent species that are either at or approaching their distributional limits. (Jackson, H. T., 1961)

No records were obtained for four species which are believed to be present. *Spermophilus franklini, Peromyscus maniculatus, Synaptomys cooperi,* and *Microtus ochrogaster.* They are within the known ranges (Jackson 1961); with more intensive collecting, these species should be obtained.

Table 1. New Records of Mammals from Monroe County, Wisconsin.

Myotis l. lucifugus	
Eptesicus f. fuscus	Northeastern limit
Lasiurus b. borealis	
Tamias striatus griseus	Southern limit
Eutamias minimus neglectus	Southern limit
Glaucomys v. volans	
Geomys bursarius wisconsinensis	Eastern limit
*Clethrionomys g. gapperi**	Southwestern limit
Zapus hudsonius intermedius	Southwestern limit
Mustela frenata noveboracensis	
Lutra c. canadensis	

* Species representing small range extension.

Acknowledgements

I am grateful to Dr. Herschel Garner, Tarleton State University, for verifying the mammals captured and also for his critical reviewing of this manuscript and his advice and helpful suggestions. To Kim Mello, who compiled field data on some of the game and fur bearing mammals of Fort McCoy, Wisconsin, and also for reviewing this manuscript, I am also grateful. Finally, to Dr. Ruth Hine, for her helpful advice and review of this manuscript.

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A VASCULAR FLORA OF WINNEBAGO COUNTY, WISCONSIN

Katherine Dorney Rill[1]
Oshkosh, Wisconsin

Abstract

The major part of this study is a catalogue of vascular plants that were growing or now grow without cultivation in Winnebago County, Wisconsin. Catalogues of an area's vegetation are an important scientific record. They also serve a critical function in geographical areas where land is continually being converted for urban development and agricultural use. Winnebago County, which in presettlement days was largely covered by hardwood forests, scattered prairies with oak openings, and abundant wetlands, now is over 80 percent developed. Today only seven percent of the land area is wooded, remnant prairies are rare, and wetland acreage has been greatly reduced. While a large number of native species have been identified in the county, the quantity of many of these species has diminished over the years. One dramatic loss has been the disappearance of bogs and almost all bog vegetation. Steps have been taken by the state, the county, and other interested groups to protect several sites of botanical value, but the spread of non-native species, development pressures, and poor land use practices continue to threaten natural habitats.

Significance of a County Flora

A county flora is part of an old botanical tradition. As a record of the vegetation of a limited geographical area, it is a valuable reference for comparison with the flora of other areas and the same region at a future date. It documents both the disappearance of species and the introduction of new ones. Awareness of these changes in floristic makeup can initiate action to protect rare species, preserve native plant communities, and inhibit aggressive species which may pose a threat.

Concentrated efforts in a limited geographical area result in a more complete listing of species present than work done in a larger region. In the course of this study, many new county records were added. This does not so much reflect the rarity of these taxa as it does the bias of collectors for favorite places and the tendency to travel within easy distance from centers of botanical activity.

Since a flora of any region is in a constant state of change, a study of this type is never complete. It is anticipated that this beginning will be an incentive for others to add to this record.

Location and Land Use

Winnebago County, located in east central Wisconsin, is one of the smallest counties in the state, with a land area of 454 miles, or 285,920 acres. An additional 84,000 acres is water. One half of Lake Winnebago is included in the county and makes up most of its eastern border (Fig. 1). The parallel 44°05′ North Latitude and the meridian 88°40′ West Longitude intersect in the county.

About 10 percent of the land area is wetlands and about seven percent forested. Agriculture is a major land use, with over 70 percent of the land committed to farming. Most development is concentrated along the eastern edge of the county in the Fox River

[1] Publication of this paper has been supported by the Norman C. Fassett Memorial Fund.


WAUPACA CO.
OUTAGAMIE CO.
R-14-E
R-15-E
R-16-E
R-17-E
88°45'
88°30'
Appleton
Menasha
Neenah
Oshkosh
44°00'
WOLF RIVER
WINCHESTER
CLAYTON
MENASHA
NEENAH
VINLAND
WINNECONNE
POYGAN
OSHKOSH
RUSHFORD
OMRO
ALGOMA
UTICA
NEKIMI
NEPEUSKUN
BLACK WOLF
T-20-N
T-19-N
T-18-N
T-17-N
WAUSHARA CO.
CALUMET CO.
GREEN LAKE CO.
FOND DU LAC CO.
Lake Winnebago
Lake Poygan
Lake Winneconne
Lake Butte des Morts
Rush Lake
Omro
Eureka
Waukau
Fisk
Pickett
Zittau
Larsen
Allenville
Butte des Morts
Winchester
Mikesville
Winnebago
CIVIL TOWNS
WINNEBAGO CO.
WISCONSIN
0 1 2
MI.

Fig. 1

Valley, an urbanized area extending from Green Bay to Fond du Lac. Population in 1980 was 131,732.

Surface Water and Drainage

The county lies entirely within the Fox-Wolf River drainage basin. The Fox River enters the county from the southwest, emptying into Lake Winnebago at Oshkosh, and after being split into two channels by Doty's Island at Neenah and Menasha, flows through Little Lake Butte des Morts and out of the county at Menasha. The Wolf River, a tributary of the Fox, enters the county from the north, flowing into Lake Poygan and through Lake Winneconne to join the Fox River in Lake Butte des Morts. Lakes Butte des Morts, Poygan, Winneconne, and Little Lake Butte des Morts cover a total area of about 20 square miles. One other lake, Rush Lake, is located in the southwestern part of the county. This lake, with a maximum depth of approximately five feet, is drained by Waukau Creek which flows into the Fox River between Eureka and Omro.

Physiographical and Geological Features

Granitic rocks of Precambrian age underlie the county. These do not outcrop, but are the upper rock unit in one small area north of Lake Poygan (Olcott, 1966).

Above the Precambrian age rocks are four approximately parallel units of sedimentary rocks of Cambrian and Ordovician age. From west to east, the eroded edges of these rock units are exposed in this order: Cambrian age sandstones, Prairie du Chien dolomite, St. Peter sandstone, and Platteville-Galena dolomite. Because of differential weathering, the harder dolomitic layers form two cuestas with backslopes to the east. The west facing escarpments are relatively low, with the Prairie du Chien unit higher than the Platteville-Galena.

The land, fairly flat near the lake, tends to become gently rolling toward the west. The relief of the county is low with a range of altitudes between 750 and 950 feet above sea level.

The topography of the bedrock controls in part the topography of the county. Preglacial valleys cut into bedrock have been filled with glacial deposits so the landscape is relatively level. Glacial deposits in the county were laid down during the Cary and Valders stages of Wisconsin glaciation.

Soils

Soils in the county are classified predominantly as heavy clayey type soils. Sandy soils are limited to an area in the northwest part of the county. About 54% of the land area is classed as "wet" soils, i.e. saturated with water for long periods at a depth of three feet.

The county's soils fall into seven general soil associations. The major soil associations in parts of the county covered by the most recent glacier, the Valders ice sheet, are Kewaunee-Manawa-Hortonville, Zittau-Poy, Houghton-Willette and Oakville-Brem-Morocco. Valders drift, which covers about 86% of the county is a fine textured red clay material with a subdued relief. In the southwestern part of the county, which was primarily influenced by the Cary ice sheet, major soil associations are Kidder-McHenry, LeRoy-Ossian-Lomira, and Plano. Cary drift is characterized by yellowish brown, loamy till with more hills and ridges than Valders drift (Mitchell, 1977).

Climate

The climate of the county is continental, with long cold winters and warm humid summers. Mean yearly temperature is 45.9°F (7.7°C). The monthly averages range from 18.6°F (−7.4°C) in January to 72.4°F (22.4°C) in July. About five months of the year are usually free from freezing temperatures. May 9 is the average date of the last 32° temperature in spring and October 4, the

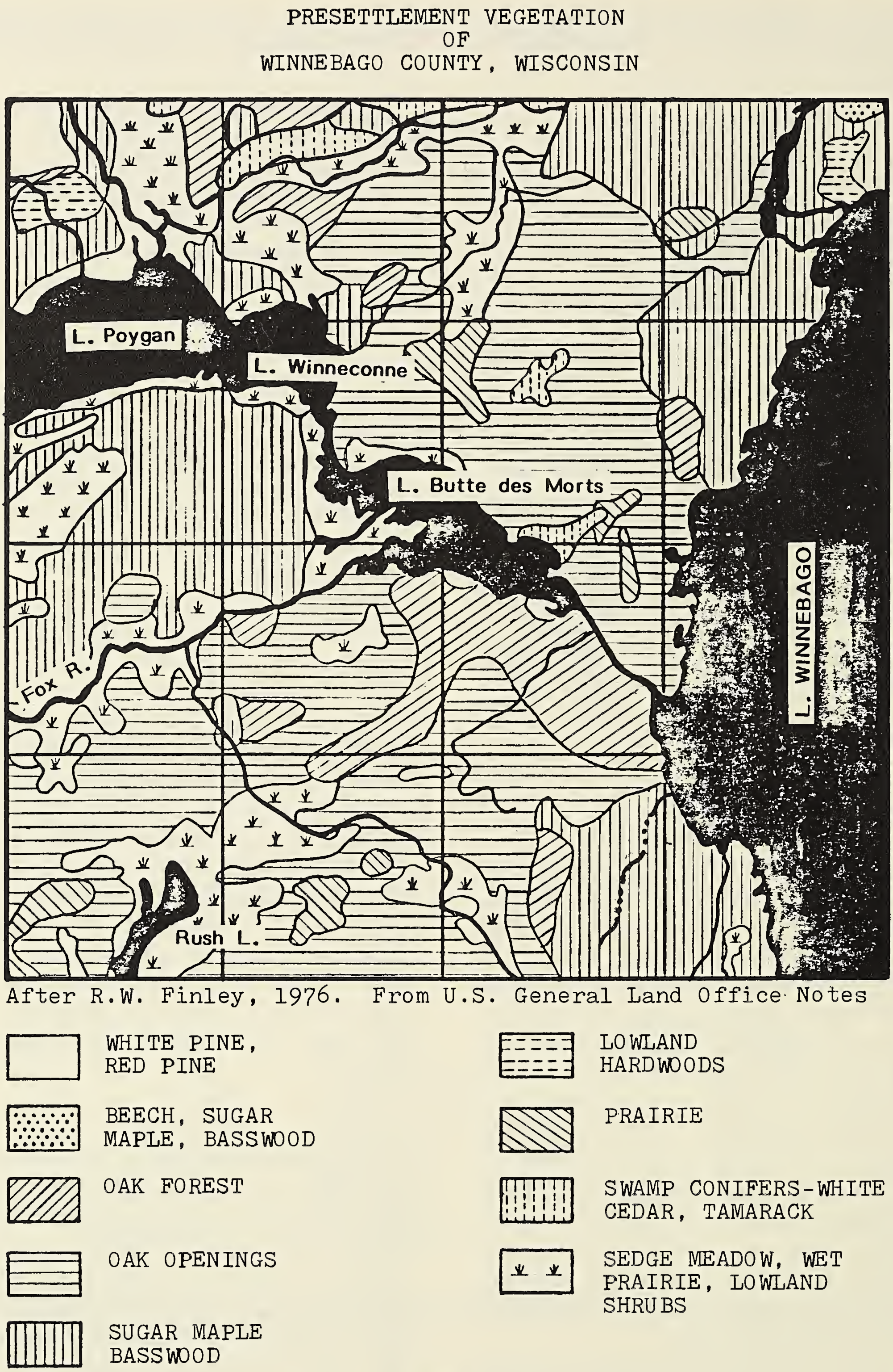
PRESETTLEMENT VEGETATION
OF
WINNEBAGO COUNTY, WISCONSIN
L. Poygan
L. Winneconne
L. Butte des Morts
L. WINNEBAGO
Fox R.
Rush L.
After R.W. Finley, 1976. From U.S. General Land Office Notes
WHITE PINE, RED PINE
BEECH, SUGAR MAPLE, BASSWOOD
OAK FOREST
OAK OPENINGS
SUGAR MAPLE BASSWOOD
LOWLAND HARDWOODS
PRAIRIE
SWAMP CONIFERS-WHITE CEDAR, TAMARACK
SEDGE MEADOW, WET PRAIRIE, LOWLAND SHRUBS

Fig. 2

first in fall. The growing season averages 148 days. Mean annual precipitation, including snowfall, is 28 inches.

Thomas Nuttall, First Botanist

Thomas Nuttall was the first botanist to travel through the Winnebago County area. On a trip in 1810, he included three species as having been collected somewhere between Green Bay and the Wisconsin River portage. These were *Smilacina trifolia* (L.) Desf., *Artemisia gnaphaloides* Nutt., which is now generally considered to be a variety of *A. ludoviciana* Nutt., and *Amorpha canescens* Pursh. [*A. pumila* of Nuttall's Diary (Stuckey, 1967), a new species (Graustein, 1967, p. 53).] As these plants are now considered "lost" it is impossible to know exactly where they were collected. Nuttall also recorded his interest in the making of maple sugar and the harvesting of wild rice by the Indians (Graustein, 1967).

Presettlement Vegetation

The presettlement vegetation of Winnebago County was primarily oak savanna interspersed with prairie, southern hardwoods, and in the northern part of the county, pine forests. Wetland plant communities were abundant along the water courses (Fig. 2).

While the field notes of government surveyors dating back to 1834 are the most accurate source of information about presettlement and early settlement vegetation of the county, earlier reports by explorers, traders, and missionaries give an indication of the nature of the county and the plants growing in the region.

Among the most revealing indicators were notes on the food habits of the Indians. Almost all written accounts mention wild rice (*Zizania aquatica* L.). This plant grew in great abundance along the Fox-Wolf and Rat River waterways. The Jesuit Allouez, wrote of his journey on the Fox River: "The banks of this river, which flows gently through the midst of these prairies are covered throughout with a certain plant bearing what is called here wild oats of which the birds are wonderfully fond." (Jesuit Relations, 1670-1671, 55:193). Jerusalem artichoke (*Helianthus tuberosa* L.) was also gathered by the Indians. In addition, wild plums, crab apples, and berries were reported as Indian food (Campbell, 1906, 2:55). All of these plants grow wild in the county today.

Foraging and gathering had little impact on the flora. Some activities of the Indians, however, brought about deliberate change from the natural condition. Early records describe Indian agriculture. "The Indians raised large quantities of Indian corn, beans and pumpkins, squashes, watermelons and some tobacco. . . ." (Carver, 1796).

In his field notes of the early survey of Poygan Township, in 1852, James Marsh records Indian cornfields and Indian planting grounds. Harney (1880, p. 279) also mentions Indian fields in Black Wolf Township.

Fires set deliberately by the Indians may have been an important factor in maintaining the prairies and oak openings in the county (Curtis, 1959, p. 361). Fuel gathering activities, which included felling trees as well as gathering downed wood, also had an effect on the nature of the woodland.

Curtis (1959, p. 463) claims that there is circumstantial evidence that Indians may have been responsible for the introduction of certain plants into Wisconsin. Among these are *Prunus americana* Marsh. (Canada plum), *Acorus calamus* L. (sweet flag), *Allium tricoccum* Ait. (wild leek), and *Apios americana* Medic. (ground nut). A tree with spotty distribution, associated with Indian village sites, is *Gymnocladus dioica* (L.) Koch (Kentucky coffee tree). The spread of this tree may have resulted from the use of its seeds in a kind of dice game played by the

Indians (Curtis, 1959, p. 463). The Kentucky coffee tree is present in the county today in a few scattered locations.

Government Survey Records

The government survey records indicate that some townships in the county were prairie and oak opening, with oak-hickory forests on the drier sites and maple-basswood forests on the mesic sites. *Pinus strobus* L. (white pine) was common in the northern part of the county as well as *Larix laricina* (Du Roi) K. Koch (tamarack) and *Thuja occidentalis* L. (white cedar) in the swamps. Survey records also identified marshes along rivers and lake shores.

The prairies are now mostly farm fields, but prairie plants still grow in some undisturbed roadsides and fields as well as along railroad rights-of-way. *Quercus macrocarpa* Michx. (bur oak), a common tree of the oak openings, is still an important tree in the county, but most of the surviving large trees are in yards or parks and in a few uncut oak woods. Oak-hickory and maple-basswood forests are still present but in greatly reduced acreage and mostly second growth. *Fagus grandifolia* Ehrh. (American beech), sometimes a member of the maple-basswood forest, was recorded as a witness tree in the early survey of Menasha Township. Costello (1931) showed American beech for Winnebago County on his distribution map. Except for a few beech trees on undeveloped city lots in Menasha and east of Little Lake Butte des Morts, native beech trees seem to have disappeared from the county.

When wetlands were recorded, surveyors listed numerous marshes containing marsh hay or grass and, as might be expected, wild rice. In the swamps, surveyors noted "alder swamp" and "tamarack swamp" in Wolf River Township, "willow swamp" and "black ash swamp" in Poygan Township, and "cedar and tamarack swamp" in Winchester Township. White cedar and tamarack still grow in the county, much of it on land which is in public ownership.

The surveyors were not botanists and the reliability of their identifications might be questioned. They used common names exclusively, but in only a few cases is there some doubt about what species is meant.

A tree often mentioned in the survey notes was "sugar." This was generally used to denote *Acer saccharum* Marsh. (sugar maple). Sometimes "maple" was used making it difficult to know what species of maple was intended. "Elm" was probably *Ulmus americana* L. (American elm) but in one instance "slippery elm" was mentioned (*Ulmus rubra* Muhl.). It is probably reasonable to assume that where "pine" was used, it referred to *Pinus strobus* L. (white pine) but in Wolf River Township, James Marsh, in 1852, recorded "yellow pine." He probably was referring to *Pinus resinosa* Ait. (red pine) which grows in the county along with white pine in some of the northern townships.

John Brink, in his surveys of the townships of Utica, Nepeuskun, and Nekimi, mentioned an undergrowth of "red root" and "rosen weed." "Red root" is probably *Ceanothus americanus* L. and "rosen weed." *Silphium laciniatum* L. (Parry, 1848). He also mentions "a growth of red top, cane" in the marshes. "Red top" probably was *Calamagrostis canadensis* (Michx.) Beauv. (blue joint). The European *Agrostis stolonifera* L., also called "red top," was not well established at the early date of 1834 when the townships were surveyed. The "cane" was probably *Phragmites australis* (Cav.) Trin. ex Steud. which is an obvious grass in low meadows.

Early Settlement

After the land was surveyed and became available for purchase, it was not long before the many advantages of the area attracted immigrants in increasing numbers. At the time the county was organized in

1842, the population was 143 (McLeod, 1846); in just eighteen years, by 1860, it had grown to 23,770 (Titus, 1930).

With settlement came accelerated changes in the vegetation. Trees were cut for cabins and fuel and the land was cleared for agriculture. As the towns grew into cities, much of the original vegetation of the town sites was destroyed. Harney (1880, p. 230) describes the Township of Menasha in the early days of settlement.

> Its surface, originally covered with a dense growth of timber, principally sugar-maple, white and swamp oak, beach [beech], hickory, ash and basswood, interspersed in the northwest portion of the town with groves of pine, has been to a large extent, cleared of timber and converted into excellent farming lands.

The coming of the settlers greatly reduced the amount of forested land in the more heavily timbered townships. Extensive logging depleted most of the virgin pines in the northern tier of townships, which lie at the southern edge of the famous "Wolf River Pinery." Settlement, however, was also responsible for an increase in the acreage of woodland in certain of the more open parts of the county.

> In the early days, the prairie and openings portion of the county was more open than at present. The annual fires kept down the young growth. Since they have stopped, a native growth has sprung up on the uncultivated ground, and especially in the towns of Utica and Nepeuskun that used to be considered prairie towns, large groves of good sized trees have grown up within the past twenty-five years (Harney, 1880, p. 130).

The luxuriant growth of marsh hay in the county's abundant lowlands was considered an asset when farm land was selected. Harney (1880, p. 261 and p. 275) describes land in the Township of Winneconne, ". . . where extensive marshes abound, of little value, save some which are sufficiently firm to produce good crops of grass and hay." and in Wolf River Township, ". . . good wild hay is cut on some of the marshes. . . ."

The abundant marshes in the county not only served the farmer as a source of marsh hay, but also stimulated the founding of a grass twine and grass rug industry. The "wire grass" was bound together with cotton thread to make binder twine. This enterprise proved unsuccessful because crickets ate the cotton thread and the twine fell apart. In 1902, the Oshkosh Grass Rug Company began weaving marsh grass into rugs which were sold in many places all over the country as "art squares." The last grass used for this purpose was harvested in 1929 but until 1935 rugs were made from supplies on hand. The waste grass, about 60 percent of the total, was sold for packing material. Although no record of the scientific names of the grass used for these purposes could be found, it was probably a sedge, *Carex stricta.*

Cranberries were harvested and raised with some success for a short time. Harney (1880, p. 275 and 248) writes, ". . . small tracts of marsh have been purchased for raising cranberries; although at the present time with indifferent success." and also in Rushford Township, "In the northwestern portion of the town are some very productive cranberry marshes." In 1907, Lawson (1908, 1:255), lists 512 bushels of cranberries for the county, produced on 110 acres. Today there is little if any evidence of the existence of these cranberry bogs. Tamarack still grows in some locations but without the bog species that might be associated with it.

Introduction of Exotics

Exotics were imported for landscaping at an early date. The survey records from about 1850 show English poplar (*Populus alba* L. ?) and Lombardy poplar (*Populus nigra* L.) as witness trees. Probably the immigrants felt more at home surrounded by familiar plants from the "old country." Norway spruce (*Picea abies* Karst.) was a very popular tree for landscaping and wind breaks.

Norway spruce trees are still growing near rural and urban homes. Also imported were cultivated plants that have since spread beyond the garden. The common dandelion (*Taraxacum officinale* Weber) and chicory (*Cichorium Intybus* L.) were imported as food plants and are now ubiquitous weeds. Water cress (*Nasturtium offinale* R. Br.) was planted in springs and now appears native. Loosestrife (*Lythrum salicaria* L.) and forget-me-not (*Myosotis scorpiodes* L.) were imported for the garden. Loosestrife now appears to be a threat to wetlands, spreading and replacing native wetland species. Of interest may be the early record of forget-me-not in the county. It was collected growing wild in 1894, one of the earliest dates for the State of Wisconsin (Johnson, 1972).

In more recent times, floristic additions to the county have included plants that have extended their ranges. Two of these are *Lycopus asper* Greene and *Aster furcatus* Burgess (Tans & Read, 1975). A very recent addition to the flora of the county is *Butomus umbellatus* L. found in the Wolf River south of Orihula.

Two other aquatics have recently become part of the flora of Winnebago County: *Potamogeton crispus* L. and *Najas marina* L. More recently a halophyte, *Juncus compressus* Jacq. has become established and is spreading along a roadside. This colony is located along a heavily traveled stretch of road that has undoubtedly been repeatedly salted. Possibly this salt tolerant species is better able to compete with other plants in this location.

Two recent intentional introductions are *Coronilla varia* L. (crown vetch) and *Lotus corniculatus* L. (bird's foot trefoil), both planted for erosion control, forage, and soil enrichment. *Lotus* appears to be spreading onto lawns from roadsides where it had been planted for erosion control.

Protected Areas

Poor land use practices, residential development pressures and conversion of wetlands to agricultural use continue to be responsible for loss of native plant communities. To offset these losses, steps have been taken by the State and other interested groups to protect several sites of botanical interest. These include High Trestle Scientific Area (Sec 12, T17N, R17E), Allen Marsh (Sec 4, T18N, R16E) on Lake Butte des Morts, Waukau Creek Nature Preserve (Sec 25, T18N, R14E), and prairie preserves along the county recreation trail (Sec 31, 32, T20N, R16E and Sec 5, 6, 17, T19N, R16E). In addition, the Department of Natural Resources has acquired natural lands as hunting areas and owns marshes adjacent to critical fish spawning beds. Some high quality natural areas in the county are still unprotected. Unless action is taken in the near future to preserve these areas, their unique scientific, historical, esthetic, and educational values will be lost.

Catalogue Sources

The major part of this report is a catalogue of vascular plants which have grown or now grow without cultivation in Winnebago County, Wisconsin. Included also are those cultivars that have escaped and are reproducing spontaneously.

The catalogue list is based principally upon specimens in the Herbarium of the University of Wisconsin-Oshkosh (OSH), the Buckstaff Collection, formerly housed at the Oshkosh Public Museum but now at the University of Wisconsin-Oshkosh, and my private herbarium, which for purposes of this report will be designated (RILL). All Winnebago County specimens in these herbaria have been examined and verified. Where specimens from other herbaria are cited, credit is given.

In addition to specimens from these herbaria, records from the literature have been included.

A search for species expected in the county, but not found in the above herbaria or during the course of field work, was made at the University of Wisconsin-Madison

(WIS), the Milwaukee Public Museum (MIL), and Ripon College herbaria.

Catalogue Design

Families are listed according to the Engler-Prantl System. The genera and species are listed alphabetically within each family.

Nomenclature follows Gleason and Cronquist (1963) except where names do not conform to the International Code of Botanical Nomenclature or where new scientific investigations have presented a convincing argument that different names are appropriate. Exceptions to this are *Viola* which follows Russell (1965) except for *Viola papilionacea* Pursh, which Russell does not recognize as a species; and *Salix* which follows Argus (1964).

Each species is recorded with its scientific name and authority. For many, familiar common names, habitat, and statements about frequency of occurrence are included.

The terms "rare," "uncommon," "occasional," and "common" are used to describe frequency of occurrence. "Rare" plants are those found at one or two locations, "uncommon," those seen infrequently, "occasional" refers to those found more often but at scattered locations, and "common," those seen almost everywhere within the county. Although these terms are subjective and inexact, they indicate the relative abundance of species.

Specimens collected in the course of this study are deposited in the Herbarium of the University of Wisconsin-Oshkosh (OSH) and my private herbarium (RILL).

Definitions of Terms

The definitions of terms used in this report are as follows: *native flora, native vegetation,* and *native plant* refer to groups of plants or plants that were part of the presettlement flora. They have developed here since the last period of glaciation and have special value because they represent a gene pool with proven adaptability. An *exotic* is a plant native to another country or continent. Although some native species may be aggressive, the term *weed* is used to indicate an aggressive exotic that is able to colonize disturbed soil.

Statistical Synopsis

The catalogue lists a total of 1024 species. Of these *Aethusa cynapium, Festuca myuros, Juncus compressus, Kickxia elatine,* and *K. spuria* are new for the state. The Compositae is the largest family with 125 species, the Gramineae next with 109, followed by the Cyperaceae with 80. Of the eight known orchids for the county, two are apparently extirpated. Broken down by major groups, there are 30 Pteridophytes, 7 Gymnosperms, 281 Monocots and 706 Dicots.

Catalogue of Species

LYCOPODIACEAE (Clubmoss Family)

Lycopodium dendroideum Michx. Ground cedar. Woods. Uncommon.

L. flabelliforme (Fern.) Blanch. Running pine. Uncommon.

EQUISETACEAE (Horsetail Family)

Equisetum arvense L. Common horsetail. Roadsides, railroad cinders, and gravel. Common.

E. ferrissii Clute. (*E. hyemale* x *laevigatum.*)

E. fluviatile L. Water horsetail. Marshes, wet ditches.

E. hyemale L. Railroad tracks.

E. laevigatum A. Br. Smooth scouring rush. Roadsides, railroads, damp woods in substrates as diverse as cinders and clay.

E. x *litorale* Kuhlw. (*E. arvense* x *fluviatile.*) Springy shore of Fox River, Eureka, 14 Sept. 1931, *Fassett* 13243 (WIS) (Hauke, 1965).

E. x *nelsonii* (A.A.Eat.) Schaffner. (*E. laevigatum* x *variegatum.*) Railroad tracks.

E. scirpoides Michx. Mapped for Winnebago County, Wisconsin (Tryon et al., 1953) and (Hauke, 1965) probably based on the same specimen (WIS), s.n., undated from the collection of J. J. Davis, collected by *Dr. Lewis Sherman,* labeled only Lake Poygan, Wisconsin. Lake Poygan is partly in Waushara County. Sight record, James Peck in cedar swamp. Northern part of County. Personal correspondence, 1981.

OPHIOGLOSSACEAE (Grapefern Family)

Botrychium dissectum Spreng. f. *obliquum* (Muhl.) Fern. Leather grape fern. One record.

B. lanceolatum Angstr. Low forest. Northern part of County.

B. matricariaefolium A.Br. Low Forest. Northern part of County.

B. virginianum (L.) Sw. Rattlesnake fern. In woods. Uncommon.

OSMUNDACEAE (Royalfern Family)

Osmunda cinnamomea L. Cinnamon fern. Woods. Uncommon.

O. claytoniana L. Interrupted fern. Occasional, in woods.

O. regalis L., var. *spectabilis* (Willd.) A. Gray. Royal-fern. Damp meadows, wet woods, and ditches. Uncommon.

POLYPODIACEAE (Polypody Family)

Adiantum pedatum L. Maiden hair fern. Occasional. Woods.

Athyrium angustum (Willd.) Presl. Lady fern. Deciduous woods.

Cystopteris bulbifera (L.) Bernh. Bulbet fern. Wet woods with yellow birch and white cedar. One record.

C. fragilis (L.) Bernh. var. *fragilis.* Fragile fern. Woods and limestone outcroppings.

C. fragilis (L.) Bernh. var. *mackayi* Lawson.

C. protrusa (Weath.) Blasdell. Woods. One record.

Dryopteris cristata (L.) A. Gray. Crested fern. Swamps.

D. intermedia (Muhl.) Gray. Florist fern. Woods.

D. spinulosa (O. F. Muell.) Watt. Low woods.

Matteuccia struthiopteris (L.) Todaro, var. *pensylvanica* (Willd.) Morton. Ostrich fern. Wet woods.

Onoclea sensibilis L. Sensitive fern. Wet woods.

Pteridium aquilinum (L.) Kuhn. Bracken. Light soil.

Thelypteris palustris Schott., var. *pubescens* (Lawson) Fern. Marsh fern. Damp meadows, wet woods.

PINACEAE (Pine Family)

Abies balsamea (L.) Mill. Balsam fir. Shown for the county near the northern shore of Lake Winnebago (Fassett, 1930). Dots based on Cheney's unpublished manuscript show this species near the north shore of Lake Winnebago.

Larix laricina (Du Roi) K. Koch. Tamarack. Wet woods in the northern part of the county and west near the Waushara County line south of Lake Poygan. Old survey records show it much more abundant in the past.

Pinus resinosa Ait. Red pine. Large trees present in the northern part of county.

Pinus strobus L. White Pine. There are still some remnant forests of pine and hardwoods on the southern edge of the "Wolf River Pinery" in the northern part of the county.

Tsuga canadensis (L.) Carr. Hemlock. One tree only in a woods.

CUPRESSACEAE (Cypress Family)

Juniperus virginiana L. Red cedar. Occasional in dry woods and pastures.

Thuja occidentalis L. White cedar. Only in the extreme northern part of the county.

TYPHACEAE (Cattail Family)

Typha angustifolia L. Narrow cat-tail. Less common than the following. Wet marshes, lake shores and sloughs.

T. latifolia L. Cattail. Common. Wet marshes, lake shores, and sloughs.

T. angustifolia x *latifolia.*

SPARGANIACEAE (Bur-reed Family)

Sparganium chlorocarpum Rydb. Bur-reed. Partially dry drainage ditch. One record.

S. eurycarpum Engelm. Bur-reed. Marshes, wet shores. Common.

NAJADACEAE (Pondweed Family)

Najas flexilis (Willd.) Rostk. & Schmidt. Naiad. A common plant in lakes.

N. marina L. Rush Lake. Examined for Wisconsin rare species list 1977. One record.

Potamogeton crispus L. Forming large beds. Becoming more common in rivers and lakes.

P. foliosus Raf. One location only near the mouth of drain tile at outlet of farm pond.

P. friesii Rupr. (?) Lake Butte des Morts. Probably this, although specimen is vegetative.

P. natans L. In lakes. Common.

P. nodosus Poir. In lakes and rivers. Common.

P. pectinatus L. Sago pondweed. In lakes and rivers. Common.

P. richardsonii (Benn.) Rydb. In lakes and rivers. Common.

P. zosteriformis Fern. In lakes. Fairly common.

Zannichellia palustris L. Lake Poygan. *Rill* 4223 (RILL). Not collected often. Probably more common than collections seem to indicate.

ALISMATACEAE (Water Plantain Family)

Alisma plantago-aquatica L., var. *americanum* Schult. & Schult. Water plantain. Shallow water and wet marshy shores.

A. plantago-aquatica L., var. *parviflorum* (Pursh) Torrey. Shallow water, wet marshy shores.

Sagittaria cuneata Sheldon. Arrow head. Marshes, shallow water, shores of lakes and rivers.

S. latifolia Willd. Marshes, shallow water, shores of lakes and rivers.

S. rigida Pursh. Shallow water.

BUTOMACEAE (Flowering Rush Family)

Butomus umbellatus L. Flowering rush. Wolf River. In shallow water with *Sagittaria, Spartina, Typha,* and *Scirpus.* Apparently spreading. First collection from Winnebago County, 1976.

HYDROCHARITACEAE (Frog's-bit Family)

Elodea canadensis Michx. Waterweed. Quiet water.

Vallisneria americana Michx. Tape grass. Shallow water. Submersed.

GRAMINEAE (Grass Family)

Agropyron repens (L.) Beauv. Quack grass. A common weedy grass in old fields, pastures, gardens.

A. smithii Rydb. Occasional along railroad tracks.
A. trachycaulum (Link.) Malte. Prairies and fields.
Agrostis hyemalis (Walt.) BSP. Weed in rock garden. One record.
A. stolonifera L. including *A. gigantea* Roth. Red top.
Alopecurus aequalis Sobol. Dry drainage ditch. One location.
A. pratensis L. Disturbed fields and lake shores.
Andropogon gerardii Vitm. Big bluestem, turkey foot. Prairies and undisturbed roadsides.
A. scoparius Michx. Little bluestem. Along RR tracks, prairies, undisturbed roadsides. Less common than the preceding.
Anthoxanthum odoratum L. Sweet vernal grass. Spontaneous in my garden.
Aristida basiramea Vasey. Along railroad tracks. Dry locations.
A. necopina Shinners = *A. intermedia* Scribner & Ball, auct. mult. Along railroad tracks. One record.
A. oligantha Michx. Railroad tracks.
Avena fatua L. Wild Oats. Railroad tracks in cinder and gravel.
A. sativa L. Oats. Railroad tracks in cinder and gravel.
Beckmannia syzigachne (Steud.) Fern. Slough grass. Marsh. One location.
Bouteloua curtipendula (Michx.) Torr. Grama grass. Dry gravelly hillside in the open. Collected twice only.
Brachyelytrum erectum (Schreb.) Beauv. *Pinus* and *Acer rubrum* woods in northern part of county.
Bromus ciliatus L. Brome grass. In woods. Occasional.
B. inermis Leyss. Smooth brome. Fields, roadsides and vacant lots. A common cultivated grass often escaped.
B. kalmii A. Gray. One collection.
B. latiglumis (Shear) Hitchc. = *B. altissimus* Pursh.
B. pubescens Willd. Canada brome.
B. tectorum L. Downy chess. Roadsides, railroads. A common grass of disturbed sites.
Calamagrostis canadensis (Michx.) Beauv. Bluejoint. Marshes, lake shores, wet places. Common.
C. stricta (Timm) Koeler. Undisturbed sedge meadow.
Cenchrus longispinus (Hack.) Fern. Sandbur. Sand along roadsides, railroads, and disturbed sites. Uncommon because of the lack of suitable habitat.
Cinna latifolia (Trev. ex Gopp) Griseb. Wood reed.
Dactylis glomerata L. Orchard grass. Fields and clearings.
Danthonia spicata (L.) Beauv. Oat grass.
Digitaria ischaemum (Schreb.) Muhl. Weed in gardens, lawns, and waste places.
D. sanguinalis (L.) Scop. Crab grass. Weedy grass of lawns, gardens, and disturbed sites.
Echinochloa muricata (Beauv.) Fern. var. *microstachya* Wiegand.
E. occidentalis (Wieg.) Rydb. = *E. crusgalli* (L.) Beauv. Barnyard grass. In damp soil. Common.
E. walteri (Pursh) Heller. A striking and attractive grass of wet muddy shores and marshes of the Fox River and in large lakes.
Eleusine indica (L.) Gaertner. In two separate parking lots on the Fox River at Eureka. Only known locations for county.
Elymus canadensis L. Wild rye. Railroad prairies, roadsides.
E. canadensis L. x *Hystrix patula* Moench.
E. villosus Muhl. in Willd. Weedy area between marsh and woods. One record.
E. virginicus L. Wet woods and lake shores.
Eragrostis cilianensis (All.) Link. Stink grass. Waste places. Weed.
E. frankii C. A. Meyer. Fields, gardens, along paths.
E. hypnoides (Lam.) BSP. Mud flats. Occasional.
E. pectinacea (Michx.) Nees. Fields, gardens. Weed.
E. poaeoides Beauv. ex R&S. Weed in landscape planting.
Festuca arundinacea Schreb. Roadsides.
F. myuros L. Gravel driveway. May have been introduced with fill. One location.
F. obtusa Biehler. Moist woods.
F. ovina L. Weedy in disturbed places.
F. rubra L. Red fescue. Roadside ditch. Garden weed.
Glyceria borealis (Nash) Batch. Moist soil.
G. grandis S. Wats. Marshes, damp places.
G. septentrionalis Hitchc. Wet grassy meadow.
G. striata (Lam.) Hitchc. Fowl meadow grass. Wet woods, marshes, shores. Common.
Hierochloe odorata (L.) Beauv. Sweet grass. Fields, prairies, roadsides. Not found often.
Hordeum jubatum L. Squirrel tail grass. Roadsides, vacant lots, waste areas. Common.
Hystrix patula Moench. Bottlebrush grass. Wet and mesic woods. Occasional.
Leersia oryzoides (L.) Sw. Cut grass. Marshes, wet shores.
L. virginica Willd. Wet woods.
Lolium perenne L. Roadsides. Probably introduced with grass seed.
L. perenne L., var. *aristatum* Willd. = *L. multiflorum* Lam.
Milium effusum L. Woods.
Muhlenbergia asperifolia (Nees & Mey.) Parodi. Mapped (Fassett, 1951).
M. frondosa (Poir) Fern., f. *commutata* (Scribn.) Fern. Shore of Fox River near Eureka locks.
M. glomerata (Willd.) Trin. Wet meadows.
M. mexicana (L.) Trin. Railroad prairies.
M. racemosa (Michx.) BSP. Railroad tracks.
Oryzopsis asperifolia Michx. Rice grass. Woods, Uncommon.

Panicum boreale Nash. Marshy woods. One record.
P. capillare L. Weedy grass common along railroads, in fields and gardens.
P. depauperatum Muhl. Railroad prairie.
P. dichotomiflorum Michx. Parking lots, waste places, roadsides. Weedy.
P. implicatum Scribn. Mapped (Fassett, 1951).
P. latifolium L. Woods, with oak, basswood and elm.
P. leibergii (Vasey) Scribn. Railroad prairie.
P. miliaceum L., var. *miliaceum*. Possibly from bird seed.
P. miliaceum L., var. *ruderale* (Kitagawa) Tzevelev. Proso millet. A new agricultural weed.
P. oligosanthes Schult. Edge of quarry. Railroad tracks.
P. philadephicum Trin. In marsh.
P. praecocius Hitchc. & Chase. Dry hillside.
P. virgatum L. Switch grass. Marshy roadside, prairies.
Phalaris arundinacea L. Reed canary grass. Marshes, low fields, pastures. Covering extensive areas and becoming almost a monoculture in low meadows. Introduced from Europe as a forage grass.
P. canariensis L. Canary grass. Apparently spontaneous near foundation of abandoned house. Probably introduced in bird seed.
Phleum pratense L. Timothy. Fields, roadsides, waste areas. Common.
Phragmites australis (Cav.) Trin. ex Steud. A grass of lakeshore marshes and wet ditches.
Poa annua L. Lawns, disturbed soil.
P. compressa L. Canada bluegrass. Roadsides, railroads, fields.
P. paludigena Fern. & Wieg. Around base of trees. Swamp with *Thuja, Larix. Rill* 4267 (RILL).
P. palustris L. Fowl meadow grass. Peaty wet meadow.
P. pratensis L. Kentucky bluegrass. Lawns, pastures.
Puccinellia distans (L.) Parl. Edge of pond.
Schizachne purpurascens (Torr.) Swallen.
Secale cereale L. Rye. Railroads.
Setaria faberi Herrm. Roadsides, fields, railroads, waste places. Especially abundant, edge of cultivated fields. A troublesome agricultural weed.
S. glauca (L.) Beauv. Foxtail grass. Roadsides, fields, railroads, waste places.
S. verticillata (L.) Beauv. Roadsides, fields, waste areas, railroads.
S. viridis (L.) Beauv.
Sorghastrum nutans (L.) Nash. Indian grass. Prairies, roadsides.
Sorghum halepense (L.) Pers. Johnson grass. Field.
S. bicolor (L.) Moench. Weed, soy bean field. Probably persistent from cultivation or accidentally planted.
Spartina pectinata Link. Cord grass. Marshes, wet prairies, shores.
Sphenopholis intermedia (Rydb.) Rydb. Wedgegrass. Mossy woods. One record.
Sporobolus asper (Michx.) Knuth. Dropseed. Railroads.
S. neglectus Nash. Garden weed. Roadsides, disturbed areas of dry, hardpacked, infertile soil.
S. vaginiflorus (Torr.) Wood. Prairies, railroads.
S. heterolepis (Gray) Gray. Railroad prairies. A native prairie grass.
Stipa spartea Trin. Needle grass. Prairies. Uncommon.
Triticum aestivum L. Wheat. Escape.
Zizania aquatica L. Wild rice. Rivers, lakes in shallow water.

CYPERACEAE (Sedge Family)

Bulbostylis capillaris (L.) Clarke. Adventive on fill.
Carex alopecoidea Tucker. Wet woods, damp ditches, marshes.
C. amphibola Steud., var. *turgida* Fern. Damp deciduous woods.
C. aquatilis Wahl. Marshes and wet meadows.
C. arctata Boott. Sandy woods.
C. atherodes Spreng. Floating bogs, marshes.
C. aurea Nutt. Wet "floor" of limestone quarry.
C. bebbii (Bailey) Fern. Wet prairies, fields, and marshes.
C. bicknellii Britt. Wet prairies.
C. blanda Dew. Mixed oak, maple, basswood forests and wet ditches.
C. brevior (Dewey) Mackenzie. Wet roadside ditch.
C. brunnescens (Pers.) Poir. In woods. Northern part of county.
C. buxbaumii Wahl. Wet prairies, ditches.
C. comosa Boott. Marshy shores, floating bogs.
C. conoidea Schk. Roadside prairie.
C. convoluta Mack. Woods.
C. crawfordii Fern. Shallow marsh.
C. cristatella Britt. Flood plain forests, marshes.
C. deweyana Schwein. Swampy woods.
C. debilis Michx. Pine and red maple woods.
C. emoryi Dew. Damp shores.
C. gracillima Schw. Wet woods, marshes.
C. granularis Muhl., var. *haleana* (Olney) Porter. Marshes, damp shores.
C. gravida Bailey. Small roadside marsh with *Larix*. One record.
C. grayii Carey. Seems to be confined to flood plain forests.
C. haydenii Dew. Wet woods, shores of lakes.
C. hirtifolia Mack. Woods, with *Pinus*.
C. hystericina Muhl. Marshes.
C. interior Bailey. Small roadside marsh with *Larix*.
C. intumescens Rudge. Wet woods, flood plain forests.
C. lacustris Willd. Open marshes.
C. lasiocarpa Ehr., var. *americana* Fern. Sedge meadow.

C. lasiocarpa Ehr., var. *latifolia* (Boeckl.) Gilly = *C. lanuginosa* Michx. Wet woods, prairies, and marshes.
C. laxiflora Lam. Swampy woods.
C. leptonervia Fern. Sandy woods.
C. lupulina Muhl. Wet places in woods, marshes and flood plain forests.
C. molesta Mack. Shallow marsh.
C. muskingumensis Schwein. Flood plain forests.
C. pensylvanica Lam. Edge of deciduous woods.
C. projecta Mack. Woods.
C. pseudo-cyperus L. Edge of bog. Peat soil.
C. retrorsa Schw. Open marshes and wet woods.
C. rosea Schk. In woods.
C. rostrata Stokes. Marshes, floating bogs.
C. sartwellii Dew. Wet marshes, lake shores.
C. sparganioides Muhl. Woods.
C. stipata Muhl. Marshes.
C. stricta Lam. Wet prairies, marshes, wet shores.
C. tenera Dewey. Sandy woods.
C. tetanica Schk. Near shore of Lake Butte des Morts.
C. tribuloides Wahl. Sandy woods.
C. trisperma Dew. Cedar swamp.
C. tuckermanii Boott. Flood plain forests.
C. vesicaria L. Floating bogs, sedge meadows.
C. vulpinoidea Boott. Damp woods, wet ditches.
Cyperus aristata Rottb. Awned *Cyperus*. Mapped (Marcks, 1974) and as *C. inflexus* Muhl. (Greene, 1953).
C. diandrus Torr. Low *Cyperus*. Sandy shore of Fox River, floating sedge mats.
C. engelmannii Steud. Mucky sand, marshes, floating sedge mats. Common.
C. esculentus L. Yellow nut grass. Weed in corn field.
C. erythrorhizos Muhl. Bank of Fox River.
C. filiculmis Vahl. = *C. lupulinus* (Spreng.) Marcks, comb. nov. Slender stemmed *Cyperus*.
C. odoratus L. Coarse *Cyperus* (Marcks, 1974).
C. rivularis Kunth. Shining *Cyperus*. Wet shores, wet sand.
C. schweinitzii Torr. Sandy farm lane. One record.
C. strigosus L. Straw colored *Cyperus*. Mapped (Marcks, 1974).
Dulichium arundinaceum (L.) Britt. Mucky soil. Uncommon.
Eleocharis compressa Sulliv. Wet meadow.
E. erythropoda Steudel. Common.
E. elliptica Kunth. Wet soil.
Eriophorum angustifolium Honckeny. Marshes. Uncommon.
Scirpus acutus Muhl. ex Bigel. Hardstem bulrush. Often in deeper water than *S. validus*.
S. acutus Muhl. x *S. heterochaetus* Chase.
S. acutus Muhl. x *S. validus* Vahl.
S. atrovirens Willd. Wet ditches and marshes.
S. cyperinus (L.) Kunth. Common in wet ditches, marshes and lake shores.
S. fluviatilis (Torr.) Gray. A common component of shore-land marshes of the large lakes.
S. heterochaetus Chase. Apparently rare.
S. pendulus Muhl. Marshes, damp soil, wet roadside ditches.
S. pungens Vahl. Three square. On sand bar in Fox River near Eureka and mixture of clay and sand on two lake shore locations.
S. validus Vahl. Softstem bulrush. Marshy wet soil.

ARACEAE (Arum Family)
Acorus calamus L. Sweet flag. Wet shores, marshes.
Arisaema dracontium (L.) Schott. Green dragon. Flood plain forests. Known from only two locations.
A. triphyllum (L.) Schott. Jack-in-the-pulpit. Woods.
Calla palustris L. Wild calla lily. Very wet ditches, swamps.
Symplocarpus foetidus (L.) Nutt. Skunk cabbage. Wet marshes, low places, especially in mucky soil.

LEMNACEAE (Duckweed Family)
Lemna minor L. Duckweed. Floating on water. The most common of the duckweeds.
L. trisculca L. Duckweed. Floating on water.
Spirodela polyrhiza (L.) Schleiden. Duckweed. Floating on water.
Wolffia columbiana Karst. Floating on water.
W. punctata Giseb. Floating on water.

COMMELINACEAE (Spiderwort Family)
Commelina communis L. Day flower. Aggressive escape.
Tradescantia bracteata Small. Dirt pile at excavation site. Garden escape.
T. ohiensis Raf. Prairies, fields, railroad rights-of-way. Uncommon.

PONTEDERIACEAE (Pickerel Weed Family)
Pontederia cordata L. Pickerel weed. Shallow water.
Zosterella dubia (Jacq.) Small. Water star grass. Floating in water.

JUNCACEAE (Rush Family)
Juncus alpinus Vill. Wet sand and along railroad tracks.
J. articulatus L. Heavy clay soil in roadside ditch.
J. balticus L. Toad rush. Wet sand and gravel.
J. canadensis J. Gay in La Harpe. Edge of partially dry drainage ditch, peaty soil.
J. compressus Jacq. A state and county record. A salt tolerant species found at edge of State Highway 21 near Highway 41 overpass where heavy road salting occurs annually.
J. dudleyi Wieg. Damp soil. Common.
J. pylaei La Harpe. One record.
J. nodosus L. Marshy places, sedge meadows with *Spartina* and *Typha*.
J. tenuis Willd. Path rush. Disturbed damp soil.
J. torreyi Cov. Marshy places, wet clay.
Luzula campestris (L.) DC., var. *multiflora* (Ehrh.) Celak. Grassy edge of woods and in woods.

LILIACEAE (Lily Family)

Allium canadense L. Wild onion. Roadsides, open fields.

A. tricoccum Ait. Wild leek. Woods.

Asparagus officinalis L. Asparagus. Escape from cultivation. Roadsides, railroads.

Clintonia borealis (Ait.) Raf. Blue bead lily. Woods Northern part of county only. Uncommon.

Convallaria majalis L. Lily of the valley. Spreading from cultivation.

Erythronium albidum Nutt. White dog tooth violet; trout lily. Woods Common in suitable habitats.

E. americanum Ker. Yellow dog tooth violet, trout lily. Common in suitable habitats.

Hemerocallis fulva L. Day lily. Garden escape. Dumps, roadsides.

Lilium michiganense Farw. Michigan lily. Wet prairies, damp roadside ditches.

L. philadephicum L. var. *andinum* (Nutt.) Ker. Wood lily. Rare in one undisturbed railroad prairie.

Maianthemum canadense Desf. Canada mayflower. Woods. Uncommon.

Medeola virginiana L. Indian cucumber root. In one pine woods where it is abundant.

Muscari botryoides (L.) Mill. Grape hyacinth. Spreading from cultivation and appearing naturalized.

Polygonatum biflorum (Walt.) Ell. Solomon's seal. Woods, hedgerows, railroad prairies.

P. pubescens (Willd.) Pursh. Solomon's seal. Woods.

Scilla sibirica Haw. Squill. Garden escape.

Smilacina racemosa (L.) Desf. False Solomon's seal. In deciduous woods.

S. stellata (L.) Desf. Starry false Solomon's seal. Roadsides, prairies, wood lots.

Smilax ecirrata (Engelm. ex Kunth) S. Watson. Carrion flower. Woods, roadsides.

S. hispida Torr. Greenbrier. Mixed evergreen and deciduous woods.

S. illinoensis Mangaly. Carrion flower. Woods, hedgerows.

S. lasioneura Hook. Carrion flower. Hedgerows, woods.

Trillium cernuum L. Nodding trillium. Woods.

T. grandiflorum (Michx.) Salisb. Trillium. Woods.

Uvularia grandiflora Sm. Bellwort. Woods.

DIOSCOREACEAE (Yam Family)

Dioscorea villosa L. Wild yam. Stream banks, woods.

AMARYLLIDACEAE (Amaryllis Family)

Hypoxis hirsuta (L.) Cov. Star grass. Prairies, open roadsides.

IRIDACEAE (Iris Family)

Iris germanica L. Railroad prairie. Garden escape.

I. pseudacorus L. Wet ditch. One location.

I. virginica L., var. *shrevei* (Small) E. Anders = *I. shrevei* Small. Wild iris. Wet places.

Sisyrinchium albidum Raf. Wet prairie.

S. atlanticum Bickn. Railroad prairie.

S. campestre Bickn. Blue-eyed grass. Railroad prairies, damp roadsides. Fairly common.

S. mucronatum Michx. Damp field.

ORCHIDACEAE (Orchid Family)

Aplectrum hyemale (Muhl. ex Willd.) Torr. Adam and Eve. Woods with maple, basswood, pine. One location.

Corallorhiza maculata Raf. Coral root. Woods. With oak, hickory, maple. One record.

Cypripedium calceolus L., var. *pubescens.* Yellow lady slipper. Old specimen with no date or location. Labeled, Winnebago County, Wisconsin, W. A. Kellerman.

C. candidum Muhl. White lady slipper. Mapped (Case, 1964).

C. reginae Walt. Showy lady slipper. Mapped (Fuller, 1933).

Habenaria leucophaea (Nutt.) A. Gray. Prairie white fringed orchid. Open wet prairie. Known from two locations.

H. psycodes (L.) Spreng. Purple fringed orchid. Rare. Open shrub marsh.

Spiranthes cernua (L.) Rich. Ladies' tresses. Railroad prairies. Known from two locations.

SALICACEAE (Willow Family)

Populus alba L. White poplar. Roadsides, escape (not apparently planted).

P. balsamifera L. Balsam poplar. Pioneer tree in disturbed soil in quarry, roadsides.

P. deltoides Marsh. Cottonwood. Damp places, shores.

P. grandidentata Michx. Big tooth aspen. Disturbed woods.

P. tremuloides Michx. Trembling aspen. Disturbed woods.

Salix alba L. White willow. Railroads, waste areas. Not planted.

S. amygdaloides Anderss. Peach leaved willow. Lake shores.

S. babylonica L. Weeping willow. Vacant lot. Appearing native.

S. bebbiana Sarg. Beaked willow. Roadside ditches, damp places.

S. candida Fluegge. Undisturbed wet meadows.

S. fragilis L. Roadsides, ditches, shores. The most common large willow tree.

S. glaucophylloides Fern. Blue leaved willow. Railroad prairie.

S. humilis Marsh. Upland willow. Railroad prairies, marshes.

S. interior Rowlee. Sandbar willow. Roadsides, ditches, shores, sandbars. A pioneer shrub.

S. lucida Muhl. Shown for the county by Argus (1954).

S. pedicellaris Pursh. Woods Northern part of county.

S. petiolaris J. E. Smith. Slender willow. Bottom lands along creeks, rivers.

S. rigida Muhl. Roadside ditches, railroad rights-of-way.

JUGLANDACEAE (Walnut Family)

Carya cordiformis (Wang.) K. Koch. Bitternut hickory. Woods.

C. ovata (Mill.) K. Koch. Shagbark hickory. Common component of oak-hickory forest.

Juglans cinerea L. Butternut. Woods.

J. nigra L. Black walnut. Woods, especially in the southern part of the county near Lake Winnebago.

BETULACEAE (Birch Family)

Alnus rugosa (Du Roi) Spreng. Speckled alder Swamps.

Betula glandulosa Michx. Bog birch. Swamps with *Larix, Rhus vernix, Ilex, Alnus.* Uncommon.

B. alleghaniensis Britt. Yellow birch. In northern part of county only.

B. papyrifera Marsh. Paper birch. Woods. In northern part of county.

Carpinus caroliniana Walt. Ironwood. Damp woods.

Corylus americana Walt. Hazel nut. Woods, low prairies.

Ostrya virginiana (Mill.) K. Koch. Hop hornbeam. Woods.

FAGACEAE (Beech Family)

Fagus grandifolia Ehrh. Beech. Uncommon, limited to an area east of Little Lake Butte des Morts near Fox River.

Quercus alba L. White oak. Woods.

Q. bicolor Willd. Swamp white oak. Wet woods.

Q. borealis Michx.f. Red oak. Woods.

Q. ellipsoidalis E. J. Hill. Hill's oak. Hedgerows, pastures, woods.

Q. macrocarpa Michx. Bur oak. Woods, prairies, roadsides.

Q. velutina Lam. Black oak. Woods.

ULMACEAE (Elm Family)

Celtis occidentalis L. Hackberry. Woods.

Ulmus americana L. American elm. Low woods, yards, city streets. Now becoming less common because of Dutch Elm Disease.

U. thomasi Sarg. Rock elm. Mapped (Costello, 1933)

U. rubra Muhl. Slippery elm. Woods, hedgerows.

MORACEAE (Mulberry Family)

Cannabis sativa L. Hemp. Waste places.

Humulus lupulus L. Hops. Hedgerows, railroads.

Morus alba L. White mulberry. hedgerows, waste places.

M. rubra L. Red mulberry. Mapped (Costello, 1933).

URTICACEAE (Nettle Family)

Boehmeria cylindrica (L.) Sw. Wet woods, flood plains of rivers.

Laportea canadensis (L.) Wedd. Wood nettle. Wet woods, flood plain forests.

Parietaria pensylvanica Muhl. Pellitory. Occasional. Damp soil.

Pilea fontana (Lunnell.) Rydb. Clearweed. Damp soil.

P. pumila (L.) Gray. Clearweed. Damp soil, marshes.

Urtica dioica L., var. *procera* (Muhl.) Wedd. Stinging nettle. Wet soil in woods, flood plain forests, marshy places. Common. Sometimes forming a monoculture.

SANTALACEAE (Sandlewood Family)

Comandra umbellata (L.) Nutt. Bastard toadflax. Railroad prairies, roadsides, woods.

ARISTOLOCHIACEAE (Birthwort Family)

Asarum canadense L. Wild ginger. Moist woods.

POLYGONACEAE (Smartweed Family).

Fagopyrum esculentum Moench. Buckwheat. Woods. Probably escaped from cultivation.

Polygonum achoreum Blake. Roadsides, railroads.

P. amphibium L., var. *natans* (Michx.) Eat. = *P. natans* Michx. An illegitimate name. See (Hitchc., C. L., 1964).

P. aviculare L. Lawn and garden weed.

P. coccineum Muhl. Water smartweed. Shallow water, shores, marshes.

P. convolvulus L. Black bind weed. Roadsides, hedgerows, railroads.

P. cuspidatum Sieb. & Zucc. Mexican bamboo. Barnyards, railroads. Garden escape.

P. hydropiper L. Marshes, mucky soil.

P. lapathifolium L. Most soil, marshes.

P. orientale L. Prince's feather. Waste places, disturbed fields, old dumps. Escape from cultivation.

P. pensylvanicum L. Waste places, moist soil.

P. persicaria L. Waste places, shores.

P. punctatum Ell. Marshes, shores.

P. sagittatum L. Tear thumb. Marshes.

P. scandens L. False buckwheat. One record.

P. virginianum L. Jumpseed. Flood plain forest, damp woods.

Rheum rhaponticum L. Rhubarb. Persistent after cultivation.

Rumex acetosella L. Sheep sorrel. Weedy in poor soil.

R. altissimus Wood. Water dock. Wet prairie.

R. crispus L. Sour dock. Roadsides, disturbed sites.

R. mexicanus Meissn. Wet soil, especially disturbed sites.

R. orbiculatus A. Gray. Great water dock. Marshes.

R. verticillatus L. Water dock. Marshes, shores.

CHENOPODIACEAE (Goosefoot Family)

Atriplex patula L. Disturbed soil.

Chenopodium album L. Roadsides, gardens.

C. hybridum L. Roadsides, gardens.

Cycloloma atriplicifolium (Spreng.) Coulter. Winged pigweed. Open sand.

Kochia scoparia (L.) Schrader. Summer cypress. Disturbed soil.

Salsola kali L. Russian thistle. Disturbed sites, especially sand or sterile soil.

AMARANTHACEAE (Amaranth Family)

Amaranthus blitoides S. Wats. = *A. graecizans* L. Tumbleweed. Disturbed sites.

A. retroflexus L. Pigweed. Disturbed sites, fields and gardens.

A. tuberculatus (Moq.) Sauer. Shores, bottom lands, marshes.

NYCTAGINACEAE (Four-o'clock Family)

Mirabilis nyctagineus (Michx.) MacM. Railroads, roadsides.

AIZOACEAE (Carpet-weed Family)

Mollugo verticillata L. Carpet-weed. Sand, sterile soil.

PORTULACEAE (Purslane Family)

Claytonia virginica L. Spring beauty. Woods.

Portulaca oleracea L. Purslane. Gardens, disturbed sites.

CARYOPHYLLACEAE (Pink Family)

Agrostemma githago L. Corn cockle. Old specimen labeled only Butte des Morts, 1900-1908.

Arenaria lateriflora L. Sandwort. Not uncommon in woods, and edges.

A. serpyllifolia L. Weed in cemetery lawn.

Cerastium nutans Faf. Weed. Disturbed sites.

C. vulgatum L. Weed in cemetery lawn.

Dianthus deltoides L. Pink. Probably an escape from cultivation.

Gypsophila scorzonerifolia Ser. in DC. In gravel at junction of Osborn Rd. and Morrissey Rd. near Rush Lake.

Lychnis alba Mill. Campion. Common weed of fields and disturbed sites.

Myosoton aquaticum (L.) Moench.

Saponaria officinalis L. Soapwort, bouncing Bet. Weed. Disturbed sites.

Silene antirrhina L. Catchfly. Sandy soil, waste places.

S. armeria. Sweet William. Escape from cultivation.

S. cserei Baumg. Railroads.

S. vulgaris (Moench.) Garcke. Bladder campion. Railroads, fields, roadsides.

S. noctiflora L. Garden weed. Fields.

Spergularia marina (L.) Grisebach. Shoulder of road.

Stellaria graminea L. Low meadow.

S. longifolia Muhl. Sedge meadow.

S. media (L.) Cyrill. Chickweed. Garden weed.

CERATOPHYLLACEAE (Hornwort Family)

Ceratophyllum demersum L. Coontail. Rivers, lakes.

NYMPHAEACEAE (Water-lily Family)

Nelumbo lutea (Willd.) Pers. Lotus. Scattered locations. Rivers, lakes. Forming extensive beds.

Nuphar variegatum Engelm. Spatterdock. Lakes, rivers.

Nymphaea odorata Ait. Quiet water.

N. tuberosa Paine. Quiet water.

RANUNCULACEAE (Buttercup Family)

Actaea pachypoda Ell. White baneberry. Woods.

A. rubra (Ait.) Willd. Red baneberry. Woods.

Anemone canadensis L. Windflower. Wet prairies, low fields.

A. cylindrica A. Gray. Railroad prairies.

A. quinquefolia L. Wood anemone. Woods.

A. virginiana L. Dry woods.

Anemonella thalictroides (L.) Spach. Rue anemone. In some woods so common it may form a ground cover.

Aquilegia canadensis L. Wild columbine. Woods.

Caltha palustris L. Marsh marigold. Swamps, wet soil.

Clematis virginiana L. Clematis. Hedgerows.

Coptis trifolia (L.) Salisb. Rare. Restricted to pine woods in the northern part of the county.

Delphinium ajacis L. Larkspur. Escape from cultivation. Persistent on dirt fill.

Hepatica nobilis Schreb., var. *acuta* (Pursh) Steyerm.

Isopyrum biternatum (Raf.) T. & G. False rue anemone.

Ranunculus abortivus L. Buttercup. Woods.

R. acris L. Weed in moist soil, roadsides.

R. aquatilis L. White water crowfoot. Quiet water.

R. circinatus Sibth. Slow moving water of Eight Mile creek.

R. fascicularis Muhl. Dry pasture.

R. flabellaris Raf. Shallow water.

R. hispidus Michx.

R. longirostris Godr. White water crowfoot.

R. pensylvanicus L.f. Moist soil.

R. recurvatus Poir. Woods. Moist soil.

R. repens L. In lawns and grassy areas.

R. rhomboideus Goldie. Pond edge.

R. sceleratus L. Cursed crowfoot. Moist organic soil.

R. septentrionalis Poir. Moist soil.

Thalictrum dasycarpum Fisch. & Ave-Lall. Meadow rue.

T. dioicum L. Maple-basswood woods.

T. revolutum DC., var. *glandulosior* Boivin. Wet prairies.

BERBERIDACEAE (Barberry Family)

Berberis thunbergii DC. Barberry. Escape, woods.

Caulophyllum thalictroides (L.) Michx. Blue cohosh. Maple-basswood forests. Uncommon.

Podophyllum peltatum L. May apple. Open woods.

MENISPERMACEAE (Moonseed Family)

Menispermum canadense L. Moonseed. Woods.

PAPAVERACEAE (Poppy Family)

Papaver rhoeas L. Corn poppy. Garden escape.

P. somniferum L. Opium poppy. Persistent, dump area.

Sanguinaria canadensis L. Bloodroot. Woods.

FUMARIACEAE (Fumitory Family)

Fumaria officinalis L. Fumitory. Well established in dump area and edge of baseball field.

Dicentra cucullaria (L.) Bernh. Dutchman's breeches. Woods.

CRUCIFERAE (Mustard Family)

Arabis glabra (L.) Bernh. Rock cress. Old Field.

Armoracia aquatica (Eat.) Wieg. In pool in intermittent stream. Collected once and not found again.

A. rusticana Gaertn., Mey. & Scherb. Horse-radish. Persistent along railroads.

Barbarea vulgaris R. Br. Winter cress. Roadsides, fields, railroad, waste places. Weed.

Berteroa incana (L.) DC. Hoary alyssum. Roadsides, fields, waste places. Weed.

Brassica hirta Moench. Woods. One location.

B. kaber (DC.) Wheeler. Roadsides, fields, disturbed sites. Weeds.

B. rapa L. sensu Fl. Eur. Railroads.

Capsella bursa-pastoris (L.) Medic. Shepherd's purse. Roadsides, fields. Weed.

Cardamine bulbosa (Schreb.) BSP. Wet meadows.

C. douglassii Britt. Moist woods and flood plain forests.

C. pensylvanica Muhl. Moist woods and flood plain forests. Mucky soil.

Dentaria laciniata Muhl. ex Willd. Toothwort. Woods.

Descurainia pinnata (Walt.) Britt., var. *brachycarpa* (Richards) Fern. Disturbed soil.

D. sophia (L.) Webb. Dump site. Probably from a garden.

Diplotaxis muralis (L.) DC. Disturbed site.

Draba reptans (Lam.) Fern. Limestone rock. One location.

Erucastrum gallicum (Willd.) O. E. Schulz. Roadside.

Erysimum cheiranthoides L. Roadside, Weed.

E. inconspicuum (S. Wats.) MacM.

Hesperis matronalis L. Dame's rocket. Garden escape.

Lepidium campestre (L.) R. Br. Disturbed soil. Weed.

L. densiflorum Schrader. Pepper grass. Disturbed soil. Weed.

L. ruderale L. Barn yard. One record.

L. virginicum L. Pepper grass. Disturbed soil. Weed.

Lobularia maritima (L.) Desv. Sweet alyssum. Garden escape.

Lunaria annua L. Honesty. Appearing spontanous. Garden escape.

Nasturtium officinale R. Br. Water cress. Moist ditch, springs.

Rorippa islandica (Oeder) Borbas. Marsh cress. Marshes, shores.

R. sylvestris (L.) Besser. Field, rip-rapped shore.

Sisymbrium altissimum L. Tumbling mustard. Dump area. Weed.

S. officinale (L.) Scop. Hedge mustard. Disturbed soil. Weed.

Thlaspi arvense L. Penny cress. Roadsides, fields, waste places.

CAPPARIDACEAE (Caper Family)

Cleome spinosa L. Spider flower. Garden escape.

Polanisia dodecandra (L.) DC. Railroads.

CRASSULACEAE (Orpine Family)

Penthorum sedoides L. Ditch stone crop. Damp soil. Woods.

Sedum telephium L. Stone crop. Railroad. Garden escape.

SAXIFRAGACEAE (Saxifrage Family)

Heuchera hirsuticaulis (Wheelock) Rydb. Alum root. Railroad prairies.

Mitella diphylla L. Bishop's cap. Rich woods.

M. nuda L. With *Thuja* in northern part of county. Rare.

Parnassia glauca Raf. Grass of Parnassus. Wet meadows and fens. Rare.

Ribes americanum Mill. Wild black currant. Woods.

R. cynosbati L. Gooseberry. Woods, thickets.

R. hirtellum Michx., var. *calcicola* Fern.

R. odoratum Wendl. Persistent from cultivation.

R. sativum Syme. Garden currant. Appearing native.

Saxifraga pensylvanica L. Swamp saxifrage. Woods, wet prairies.

ROSACEAE (Rose Family)

Agrimonia gryposepala Wallr. Agrimonia. Woods.

A. pubescens Wallr. Woods.

Amelanchier laevis Wieg. Juneberry. Woods.

A. sanguinea (Pursh) DC. Roadsides, hedgerows.

A. spicata (Lam.) K. Koch.

Aronia melanocarpa (Michx.) Ell. Chokeberry. Roadside ditch.

Crataegus calpodendron (Ehrh.) Medic. Hawthorn.

C. crus-galli L.

C. mollis (T. & G.) Scheele.

C. punctata Jacq.

C. succulenta Link.

Fragaria vesca L. Woodland strawberry. Mapped (Mason & Iltis, 1958).

F. virginiana Duchesne. Wild strawberry. In woods and edges.

Geum aleppicum Jacq., var. *strictum* (Ait.) Fern. Roadsides, woods.

G. canadense Jacq. Damp woods.

G. laciniatum Murr. Edge of field.

G. rivale L. Water avens. Swamps.

G. triflorum Pursh. Prairie smoke. Railroad prairies.

Physocarpus opulifolius (L.) Maxim.

Potentilla anserina L. Silver weed. Along railroad rights-of-way. Light soil.

P. argentea L. Silvery cinquefoil. Railroad prairies.

P. canadensis L. One location along railroad in Oshkosh.

P. fruticosa L. Shrubby cinquefoil. Edge of cedar bog. One record.

P. intermedia L. Dry cinders along railroad track.

P. norvegica L. Railroads, fields, waste places.

P. palustris (L.) Scop. Marsh cinquefoil. Marshes.

P. recta L. Drywoods, prairies, roadsides.
P. simplex Michx. Old field cinquefoil. Open woods, fields.
Prunus americana Marsh., var. *lanata* Sudw. Wild plum. Hedgerows, woods, railroads.
P. nigra Ait. Canada plum. Hedgerows, woods, railroads.
P. pensylvanica L.f. Pin cherry. Hedgerows, openings.
P. serotina Ehrh. Black cherry. Woods, hedgerows.
P. virginiana L. Choke cherry. Hedgerows, openings.
Pyrus ioensis (Wood) Carruth. Wild crab apple. Woods, railroads.
P. malus L. Apple. Persistent after cultivation.
Rosa acicularis Lindl. Prairies, roadsides.
R. arkansana Porter. Roadside.
R. blanda Ait. Meadow rose. Prairies, roadsides.
R. carolina L. Pasture rose. Prairies, roadsides.
R. palustris Marsh. Swamp rose. Prairies.
Rubus allegheniensis Porter. Common blackberry. Roadsides, railroads, fields, open woods.
R. idaeus L. Red raspberry. Open fields, roadsides.
R. occidentalis L. Black raspberry. Hedgerows, woods.
R. ostryifolius Rydb. Blackberry. Railroad prairies.
R. pubescens Raf. Moist woods, swamps.
Sorbaria sorbifolia (L.) A. Br. False spiraea. Damp roadside. Escape from cultivation.
Sorbus aucuparia L. European mountain ash. Hedgerows. Apparently planted by birds.
Spiraea alba Du Roi. Meadow sweet. Marshes, wet meadows, railroads.
S. tomentosa L., var. *rosea* (Raf.) Fern. Wet meadow. Northern part of county.
Waldsteinia fragarioides (Michx.) Tratt. Mapped (Mason & Iltis, 1958).

CAESALPINIACEAE (Caesalpina Family)
Gymnocladus dioica (L.) K. Koch. Kentucky coffeetree. Woods along creek, and lake shore at three locations.

FABACEAE (Bean Family)
Amorpha canescens Pursh. Lead plant. Railroad prairies.
Amphicarpa bracteata (L.) Fern. Hog peanut. Woods, thickets.
Apios americana Medic. Wild bean. Near Lake Winnebago.
Astragalus canadensis L. Milk vetch. Railroad prairies.
Baptisia leucantha T. & G. Wild indigo. Railroad prairies, roadsides, open woods.
Desmodium canadense (L.) DC. Tick trefoil. Railroad prairies and roadsides.
D. dillenii Darl. Railroad prairies, roadsides.
D. glutinosum (Muhl.) Wood. Woods.
D. illinoense Gray. Open roadside north of Oshkosh. *Buckstaff* 39-4 (Buckstaff Collection).
D. nudiflorum (L.) DC. Woods.
Glycine max (L.) Merr. Soy bean. One plant, roadside. Accidental. *Rill* 3349 (RILL).
Lathyrus ochroleucus Hooker. Vetch. Woods.
L. palustris L. Grassy marshes, wet prairies, damp roadsides.
L. venosus Muhl., var. *intonsus* Butters et St. John. Wet prairies.
Lespedeza capitata Michx. Bush clover. Railroad prairies.
Lotus corniculatus L. Bird's foot trefoil. Roadsides. Planted and spreading.
Lupinus x *regalis*. Fence line along Hw. 41. Probably site of abandoned farm.
Medicago falcata L. Roadside. One record.
M. lupulina L. Black medic. Lawns, roadsides, disturbed sites. Weed.
M. sativa L. Alfalfa. Roadsides, fields.
Melitotus alba Desr. White sweet clover. Roadsides, railroads, fields.
M. altissima Thuill. Roadsides, railroads, fields.
M. officinalis (L.) Desr. Yellow sweet clover. Roadsides, railroads, fields.
Petalostemum candidum (Willd.) Michx. White prairie clover. Railroad prairies. Uncommon.
P. purpureum (Vent.) Rydb. Purple prairie clover. Railroad prairies.
Robinia pseudoacacia L. Black locust. Hedgerows, forming thickets. Spreading from cultivation.
Trifolium aureum Pollich. Edge of field.
T. campestre Schreb. in Sturm. = *T. procumbens* L., nom. ambig. (Gillett & Cochrane, 1973).
T. hybridum L. Alsike clover. Roadsides, fields.
T. pratense L. Red clover. Roadsides, fields.
T. repens L. White clover. Roadsides, fields.
Vicia americana Muhl. Purple vetch. Railroads, fields, roadsides.
V. caroliniana Walt. Pale vetch. Woods.
V. cracca L. Tufted vetch. Low field.
V. sativa L. subsp. *nigra* (L.) Ehrh. as given in Fl. Europaea = *V. angustifolia* Reichard. Railroad prairies.
V. villosa Roth. Russian vetch. Roadsides, fields.

OXALIDACEAE (Oxalis Family)
Oxalis corniculata L. Field, woods. Two records.
O. dillenii Jacq. Roadsides, lawns, waste places, railroads.
O. stricta L. Roadsides, lawns, waste places, railroads.

GERANIACEAE (Geranium Family)
Erodium cicutarium (L.) L'Her. Filaree. Lawn weed.
Geranium bicknellii Britt. Marshy woods. One record.
G. maculatum L. Wild geranium. Woods.

LINACEAE (Flax Family)
Linum usitatissimum L. Common flax. Escape along railroad. One record.

RUTACEAE (Rue Family)
Zanthoxylum americanum Mill. Prickly ash. Forming thickets. Disturbed woods.
POLYGALACEAE (Milkwort Family)
Polygala senega L. Seneca snakeroot. Railroad prairies. Uncommon.
EUPHORBIACEAE (Euphorbia Family)
Acalypha rhomboidea Raf. Three seeded mercury. Roadsides, disturbed sites. Weed.
Chamaesyce maculata (L.) Small. Wartweed. Roadsides, lawns and gardens.
C. nutans (Lag.) Small. Occasional. Along railroad tracks.
C. vermiculata (Raf.) House. Roadsides, lawns. Weedy.
Euphorbia corollata L. Flowering spurge. Railroads and dry roadsides.
E. cyparissias L. Cypress spurge. Railroads, dry roadsides.
E. glyptosperma Engelm.
E. marginata Pursh. On fill. Garden escape.
E. myrsinites L. Adventive in garden.
E. peplus L. Disturbed roadside. One record.
E. podperae Croiz. Leafy spurge. Noxious weed.
Poinsettia dentata (Michx.) Kl. & Gke. Railroads.
CALLITRICHACEAE (Water-starwort Family)
Callitriche palustris L. Water starwort. Exposed mud, drainage ditches.
ANACARDIACEAE (Cashew Family)
Rhus glabra L. Smooth sumac. Roadsides, railroads, openings. More common than *R. typhina.*
R. radicans L., var. *rydbergii* (Small) Rehd. Poison ivy. Roadsides, hedgerows, woods, railroads, openings. Abundant.
R. typhina L. Staghorn sumac. Roadsides, railroads, openings.
R. typhina L., f. *laciniata* (Wood) Rehd. Cut leaf sumac. Escape from cultivation.
R. vernix Marsh. Poison sumac. Swamp, with *Ilex, Larix, Alnus.* One location in bog where it was abundant.
AQUIFOLIACEAE (Holly Family)
Ilex verticillata (L.) Gray. Holly. Uncommon. Swamps, with *Larix, Thuja, Alnus* and in moist areas in white pine, red maple forest in northern part of county.
CELASTRACEAE (Staff-tree Family)
Celastrus scandens L. Bittersweet. Hedgerows. Threatened by "clean farming."
Euonymus atropurpureus Jacq. Burning bush. Edge of swamp. Not apparently planted.
STAPHYLACEAE (Bladder-nut Family)
Staphylea trifolia L. Bladder-nut. Edge of Woods. Two locations near Rush Lake.
ACERACEAE (Maple Family)
Acer negundo L. Box elder. Hedgerows, woods, roadsides.
A. nigrum Michx.f. Black maple. Woods.
A. rubrum L. Red maple. Woods.
A. saccharinum L. Silver maple. Damp woods. Flood plain forests.
A. saccharum Marsh. Sugar maple. Woods.
A. spicatum Lam. Wet woods, flood plain forest of Rat River. One location.
BALSAMINACEAE (Touch-me-not Family)
Impatiens capensis Meerb. = *I. biflora* Walt. Jewelweed. Damp soil.
RHAMNACEAE (Buckthorn Family)
Ceanothus americanus L. Railroad prairies.
Rhamnus cathartica L. Buckthorn. Edge of woods, disturbed woods where it may form thickets.
R. frangula L. Edge of woods, and brushy places. Not as common as the former.
VITACEAE (Grape Family)
Parthenocissus vitacea (Knerr) Hitchc. Woodbine. Hedgerows, woods, shores.
Vitis riparia Michx. Grape. Hedgerows, woods, shores.
TILIACEAE (Linden Family)
Tilia americana L. Basswood. Large forest tree.
MALVACEAE (Mallow Family)
Abutilon theophrasti Medic. Velvet leaf. Common weed of corn fields, disturbed sites.
Alcea rosea L., var. *sibthorpii* Boiss. Hollyhock. Persistent in dump area.
Hibiscus trionum L. Flower-of-an-hour. A common weed of gardens, disturbed soil.
Malva neglecta Wallr. Common mallow. Gardens, disturbed sites.
HYPERICACEAE (St. John's-wort Family)
Hypericum canadense L. Peaty ditch.
H. majus (Gray) Britt.
H. perforatum L. Klamath weed. Oldest record for the county, collected 1900-1908 by *Mr.* and *Mrs. Jay Davis.*
H. punctatum Lam. Edge of woods.
Triadenum fraseri (Spach.) Gleason. Marsh St. John's wort. Marshes, swamps.
CISTACEAE (Rock-rose Family)
Helianthemum bicknellii Fern. Frost weed. Dry soil near railroad.
VIOLACEAE (Violet Family)
Viola adunca Sm. Sand violet. Woods, railroads.
V. affinis LeConte. Moist woods.
V. canadense L., var. *canadense.* Canada violet. Woods.
V. canadense L., var. *rugulosa* (Greene) C. L. Hitchc. Mapped (Russell, 1965).
V. conspersa Reichenb. American dog violet. Woods.
V. cucullata Ait. Marsh violet. Damp woods, swamps.
V. novae-angliae House. Northern part of county.
V. novae-angliae x *sagittata.*
V. odorata L. Lawn weed, Oshkosh.

V. papilionacea Pursh. Meadow violet. Railroad prairie, roadside.
V. pedata L. Bird's foot violet. Dry place in woods, sandy hillside. Two records, 1925 and 1930.
V. pedatifida G. Don. Uncommon. Railroad prairies and dry hillside.
V. pubescens Ait., var. *eriocarpa* (Schwein.) Russell. Yellow violet. Woods.
V. pubescens Ait., var. *pubescens*. Downy yellow violet. Woods.
V. sagittata Ait. Arrow leaved violet. Northern part of county. One record.
V. septentrionalis Greene. Woods.
V. sororia Willd. Woods.

LYTHRACEAE (Loosestrife Family)
Decodon verticillatus (L.) Ell. Water willow. Edge of Rush Lake.
Lythrum alatum Pursh. Railroad prairies, meadows.
L. salicaria L., var. *tomentosum* (DC.) DC. Purple loosestrife. Wet soil. Escape, becoming a problem in wetlands.

ELAEAGNACEAE (Oleaster Family)
Elaeagnus angustifolia L. Escape near Lake Butte des Morts bridge.

ONAGRACEAE (Evening Primrose Family)
Circaea alpina L. Enchanter's nightshade. With *Thuja*. One location.
C. lutetiana L., subsp. *canadensis* (L.) Asch. & Magnus.
Epilobium angustifolium L. Fire weed. Railroads, roadsides.
E. coloratum Biehler. Willow herb. Marshes, wet ditches.
E. glandulosum Lehm., var. *adenocaulon* (Haussk.) Fern.
E. leptophyllum Raf. Roadside marsh near Fox River.
Guara biennis L., var. *biennis*. Roadsides, railroads.
Ludwigia palustris (L.) Ell., var. *americana* (DC.) Fern. & Griscom. Water purslane. Cattail marsh.
Oenothera biennis L. Evening primrose. Roadsides.
O. oakesiana (A. Gray) Robins. Along railroad track.
O. parviflora L. Railroads, roadsides, fields. Common.
O. perennis L. Sundrops. Marsh, on higher ground, with shrubs. One record.
O. pilosella Raf. Landfill site. One record. Probably brought in with fill material.
O. villosa Tunb. = *O. strigosa* (Rydb.) Mack. & Bush of American authors.

HALORAGACEAE (Water Milfoil Family)
Myriophyllum spicatum L., var. *exalbescens* (Fern.) Jepson = *M. exalbescens* Fern. Lakes, rivers.

ARALIACEAE (Ginseng Family)
Aralia nudicaulis L. Wild sarsaparilla. Woods.
A. racemosa L. Spikenard. Moist soil.
Panax quinquefolium L. Ginseng. Woods. Rare.

UMBELLIFERAE (Parsley Family)
Aethusa cynapium L. Fool's parsley. Appearing as a weed in gardens. First Wisconsin record, 1968.
Angelica atropurpurea L. Angelica. Marshes, wet ditches.
Carum carvi L. Caraway. Railroads, roadsides, fields.
Cicuta bulbifera L. Marshes, ditches, damp meadows.
C. maculata L. Water hemlock. Marshes, ditches, damp meadows.
Cryptotaenia canadensis (L.) DC. Honewort. Woods.
Daucus carota L. Queen Anne's lace. Roadsides.
Heracleum lanatum Michx. Cow parsnip. Moist soil. marshes, wood lots.
Osmorhiza claytonii (Michx.) Clarke. Sweet cicely. Woods.
O. longistylis (Torr.) DC. Anise root. Woods.
Oxypolis rigidior (L.) Raf. Wet prairies, damp roadsides, wet meadows, wet woods.
Pastinaca sativa L. Wild parsnip. Weed. Railroads, meadows, roadsides.
Pimpinella saxifraga L. Roadsides, often with grasses.
Sanicula gregaria Bickn. Black snakeroot. Woods.
S. marilandica L. Woods.
S. trifoliata Bickn. Woods.
Sium suave Walt. Water parsnip. Wet meadows, marshes, wet forests.
Taenidia integerrima (L.) Drude. Prairies, dry woods.
Zizia aurea (L.) Koch. Golden alexanders. Railroad prairies, meadows.

CORNACEAE (Dogwood Family)
Cornus alternifolia L. Alternate leaved dogwood.
C. canadensis L. Canada dogwood. Rare. In northern part of county in pine and red maple woods.
C. obliqua Raf. Railroad prairies, roadsides. In damp soil.
C. racemosa Lam. Railroad prairies, roadsides. In damp soil.
C. rugosa Lam. Northern part of county in *Thuja* swamp.
C. stolonifera Michx. Red osier. A common component of shrub swamps.

ERICACEAE (Heath Family)
Chimaphila umbellata (L.) Bart. Prince's pine. Woods with *Pinus strobus*. Uncommon.
Gaylussacia baccata (Wang.) K. Koch. Huckleberry. Woods with *Pinus strobus*.
Monotropa hypopitys L. Pine sap. Woods with *Pinus strobus*.
M. uniflora L. Indian pipe. Woods. One plant.
Pyrola elliptica Nutt. Shinleaf. Woods. Uncommon.
P. rotundifolia L. Woods, northern part of county. Rare.
P. secunda L. Woods, northern part of county. Rare.

Vaccinium angustifolium Ait. Uncommon. In a few woods in northern part of county.
V. lamarckii Camp. Blueberry. Uncommon.

PRIMULACEAE (Primrose Family)
Anagallis arvensis L., var. *arvensis.* Pimpernel. Abandoned garden, waste area. Two locations.
Dodecatheon meadia L. Shooting star. Railroad prairies, roadsides, oak openings.
Lysimachia ciliata L. Fringed loosestrife. Marshes, wet meadows, flood plain forests.
L. nummularia L. Moneywort. Escape in cemetery, river banks, and flood plain forests. Forming a ground cover in some locations.
L. quadriflora Sims. Railroad prairies, roadsides.
L. terrestris (L.) BSP. Swamp candles. Marshes, swamps. Uncommon.
L. thyrsiflora L. Marshes, swamps.
L. vulgaris L. Mucky shore of Lake Butte des Morts. Not planted.
Trientalis borealis Raf. Star flower. Woods. Northern part of county. Uncommon.

OLEACEAE (Olive Family)
Franxinus americana L. White ash. Woods.
F. pennsylvanica Marsh., var. *pennsylvanica.* Red ash. Wet woods. The most common ash.
F. pennsylvanica Marsh., var. *subintegerrima* (Vahl.) Fern. Green ash. Wet woods.
F. nigra Marsh. Black ash. Swamps, low forests.

GENTIANACEAE (Gentian Family)
Gentiana andrewsii Griseb. Wet prairies, meadows and shores.
G. quinquefolia L., var. *occidentalis* (Gray) Gillett. Railroad. Damp clay. Uncommon.
Menyanthes trifoliata L. Buckbean. Swamps. Uncommon.

APOCYNACEAE (Dogbane Family)
Apocynum adrosaemifolium L. Dogbane. Railroads, roadsides. Common.
A. medium Greene. Railroad prairies.
A. sibiricum Jacq. Indian hemp. Railroads, roadsides.

ASCLEPIADACEAE (Milkweed Family)
Asclepias exaltata L. Poke milkweed. Edge of woods, quarry. Two records. Uncommon.
A. incarnata L. Swamp milkweed. Marshes, shores. Common in suitable habitat.
A. ovalifolia Decne. Prairie. One record. Rare.
A. purpurascens L. Mapped (Noamesi & Iltis, 1957).
A. syriaca L. Common milkweed. Railroads, roadsides, fields.
A. tuberosa L. Butterfly weed. Uncommon. Railroad prairies.
A. verticillata L. Whorled milkweed. Railroad prairies.

CONVOLVULACEAE (Morning Glory Family)
Convolvulus arvensis L. Bindweed. Roadsides, waste places. Weed.
C. sepium L. (*Calystegia sepium* (L.) R. Br.) Hedge bindweed. Roadsides, waste places. Weed.
Cuscuta cuspidata Engelm. Dodder. Twining on vegetation.
C. gronovii Willd. Dodder.
C. polygonorum Engelm.
Ipomoea hederacea Jacq. Railroad. Escape. One record.
I. purpurea (L.) Roth. Morning glory. Edge of marshy ditch. Six miles from Oshkosh on Hw. 110 Collected by *H. Buchholz,* Sept. 10, 1969, s.n. (WIS). Escape from cultivation.

POLEMONIACEAE (Phlox Family)
Phlox divaricata L. Wild blue phlox. Woods.
P. pilosa L. Prairie phlox. Railroad prairies.
P. subulata L. Moss pink. Roadside. Escape from cultivation.

HYDROPHYLLACEAE (Waterleaf Family)
Hydrophyllum virginianum L. Water leaf. Wet to mesic woods. Forming a ground cover at times.
Ellisia nyctelea L. Landscape plantings and dump area.

BORAGINACEAE (Borage Family)
Cynoglossum officinale L. Hound's tongue. Upland woods.
Echium vulgare L. Blue weed. Roadside.
Hackelia virginiana (L.) Johnst. Stickseed.
Lappula echinata Gilib. Stickseed.
Lithospermum canescens (Michx.) Lehm. Hoary puccoon. Railroad prairies.
L. officinale L. Weed in sidewalk crack.
Myosotis scorpioides L. Forget-me-not. Shore of Wolf River.
Symphytum officinale L. Common comfrey. Escape. Mapped (Kruschke, 1944).

VERBENACEAE (Vervain Family)
Phyla lanceolata (Michx.) Greene. Frog fruit. Riprapped shore of Wolf River.
Verbena bracteata Lag. & Rodr. Open ground.
V. hastata L. Vervain. Marshes and low forests.
V. x *illicita* Moldenke. Mapped (Tans & Iltis, 1979). Only location in Wisconsin. Collected in 1909.
V. stricta Vent. Along railroad tracks.
V. urticifolia L., var. *urticifolia.* Weed in moist soil.
V. urticifolia L., var. *leiocarpa* Perry & Fern. Weed.

LABIATAE (Mint Family)
Agastache nepetoides (L.) Kuntze. Giant hyssop. Woods, uncommon.
Dracocephalum parviflorum Nutt. Specimen collected by *Kellerman,* s.n., labeled only Oshkosh, Wis. (WIS).
Glecoma hederacea L. Ground ivy. Lawn weed.
Hedeoma hispida Pursh. False pennyroyal. Dry locations.
H. pulegioides (L.) Pers. American pennyroyal. Garden weed.
Isanthus brachiatus (L.) BSP. Railroads.

Lamium ampexicaule L. Dead nettle. Weed in gravel, around shrubs in landscape planting.
Leonurus cardiaca L. Motherwort. Disturbed weedy places.
Lycopus americanus Muhl. Damp soil.
L. asper Greene. Shore of Lake Winnebago, banks of Fox River. Two locations.
L. uniflorus Michx. Damp soil.
L. virginicus L. In marshes.
Mentha arvensis L. Mint. Damp soil.
M. cardiaca Baker. Mapped (Koeppen, 1957).
M. piperita L. Peppermint. Shore of Lake Winnebago. One record.
Monarda fistulosa L. Wild bergamot. Railroad prairies, roadsides.
Nepeta cataria L. Catnip. Disturbed weedy places.
Physostegia virginiana (L.) Benth. = *P. formosior* Lunell. False dragon head. Wet woods, marshy places.
Prunella vulgaris L. Self heal. Common. Weed in lawns, low meadows and woods.
Pycnanthemum virginianum (L.) Durand & Jackson. Mountain mint. Railroad prairies, meadows.
Scutellaria galericulata L. Skull cap. Wet soil, marshes, shores.
S. lateriflora L. Wet soil, marshes, shores.
S. parviflora Michx., var. *leonardii* (Epling) Fern. Railroad prairies.
Stachys hispida Pursh. Hedge nettle. damp soil.
S. palustris L. Damp soil. Common.
Teucrium canadense L. Germander. Damp soil. Common.

SOLANACEAE (Nightshade Family)
Datura stramonium L. Jimson weed. Waste area. One record.
Lycium halimifolium Mill. Matrimony vine. Railroad. One record.
Lycopersicon esculentum Mill. Tomato. Spontaneous in field. One record.
Nicotiana tabacum L. Spontaneous on dirt fill. One record.
Physalis heterophylla Nees. Ground cherry. Railroads, roadsides.
P. ixocarpa Brot. Spontaneous in garden.
P. longifolia Nutt. Edge of cornfield. One record.
Solanum carolinense L. Horse nettle. Railroads. One record.
S. dulcamara L. Bittersweet nightshade. Lake shores, hedgerows, gardens, marshes. Common weed.
S. nigrum L. Black nightshade. Disturbed sites.
S. rostratum Dunal. Buffalo bur. Disturbed site.

SCROPHULARIACEAE (Figwort Family)
Agalinis purpurea (L.) Pennell. In clay soil along railroad.
A. tenuifolia (Vahl.) Raf. Damp soil.
Aureolaria grandiflora (Benth.) Pennell, var. *pulchra* Pennell. False foxglove. Mapped (Salamun, 1951).
Castilleja coccinea (L.) Spreng. Indian paint brush. Mapped (Salamun, 1951).
Chaenorrhinum minus (L.) Lange. Railroads.
Chelone glabra L. Turtlehead. Marshes, wet meadows, shores.
Gratiola neglecta Torr. Hedge hyssop. Damp soil.
Kickxia elatine (L.) Dum. Cancer wort. Spantaneous in garden. First Wisconsin record.
K. spuria (L.) Dum. Spontaneous in garden. First Wisconsin record.
Linaria vulgaris Hill. Butter and eggs. Railroads, roadsides, disturbed sites. Common.
Lindernia anagallidea (Michx.) Pennell. Wet soil in fallow field.
Mimulus ringens L. Monkey flower. Marshes, shores.
Pedicularis canadensis L. Lousewort. Railroad prairies.
P. lanceolata Michx. Marshes, shores.
Penstemon digitalis Nutt. Beard tongue. Roadsides, fields.
Scrophularia lanceolata Pursh. Figwort. Railroads, roadsides.
S. marilandica L. Carpenter's square. Railroads, roadsides, woods.
Verbascum blattaria L. Moth mullein. Weed in planted shrubbery.
V. thapsus L. Mullein. Railroads, roadsides, open fields. Weed.
Veronica anagallis-aquatica L. Wet mucky shores.
V. arvensis L. Speedwell. Weed in lawns.
V. longifolia L. Garden escape. One record.
V. peregrina L. Roadsides, weedy fields.
V. persica Poir. Garden weed.
V. scutellata L. Partially dry drainage ditch.
V. serpyllifolia L. Lawn weed.
Veronicastrum virginicum (L.) Farw. Culver's root. Railroad prairies, wet woods.

LENTIBULARIACEAE (Bladderwort Family)
Utricularia vulgaris L., var. *americana* Gray. Shallow water.

PHRYMACEAE (Lopseed Family)
Phryma leptostachya L. Lopseed. Railroads, wet woods.

PLANTAGINACEAE (Plantain Family)
Plantago arenaria Waldst. & Kit. = *P. psyllium* L., nom. ambig., and *P. indica* L., nom. illegit. (See Tutin, *Flora Europaea,* 4:43.)
P. lanceolata L. English plantain. Lawns, disturbed sites. Weed.
P. major L. Common plantain. Lawns, disturbed sites.
P. rugelii Decne. Lawns, disturbed sites. Weed.

RUBIACEAE (Madder Family)
Cephalanthus occidentalis L. Button bush. River banks.
Galium aparine L. Cleavers. Woods.
G. boreale L. Northern bedstraw. Wet prairies.

G. circaezans Michx., var. *hypomalacum* Fern. Wild licorice. Woods.

G. concinnum T. & G. Shining bedstraw. Woods.

G. labradoricum (Wiegand) Wiegand. Undisturbed sedge meadow.

G. obtusum Bigel., var. *ramosum* Gleason. Damp roadsides, woods.

G. tinctorium L. Marsh.

G. trifidum L. Small bedstraw. Marshes, shores.

G. triflorum Michx. Sweet scented bedstraw. Woods.

Houstonia longifolia Gaertn. Mapped (Urban & Iltis, 1957).

Mitchella repens L. Partridge berry. Northern part of county. Woods in association with *Pinus strobus* Rare.

Caprifoliaceae (Honeysuckle Family)

Diervilla lonicera Mill. Bush honeysuckle. Uncommon. Roadsides, edges of woods.

Lonicera x *bella* Zabel. Bell's honeysuckle.

L. dioica L., var. *dioica*. Wild honeysuckle. Moist woods.

L. dioica L., var. *glaucescens* (Rydb.) Butters.

L. morrowii Gray. Escape.

L. prolifera (Kirchner) Rehder., var. *prolifera*. Grape honeysuckle.

L. tartarica L. Tartarian honeysuckle. Escape in woods.

Sambucus canadensis L. Elderberry. Railroads, roadsides, thickets.

S. racemosa L., ssp. *pubens* (Michx.) Hulten. In woods in northern part of county. Less common than preceding species.

Symphoricarpos occidentalis Hooker. Wolf berry. Railroads.

Triosteum aurantiacum Bicknell. Horse gentian.

T. perfoliatum L. Marshy woods.

Viburnum acerifolium L. Woods. Occasional.

V. lentago L. Nannyberry. Hedgerows, woods, and thickets.

V. opulus L., var. *americanum* Ait. American high bush cranberry. Woods.

V. opulus L., var. *opulus*. European high bush cranberry. Escape.

V. rafinesquianum Schult., var. *rafinesquianum*. Maple basswood forest.

Valerianaceae (Valerian Family)

Valeriana edulis Nutt. Railroad prairies. Uncommon.

V. officinalis L. Valerian. Freely spreading and persistent from cultivation.

Dipsacaceae (Teasel Family)

Cephalaria tatarica Schrad. Spontaneous in one location. No longer present. Site developed.

Dipsacus laciniatus L. Cut leaved teasel. Waste area near cemetery.

D. fullonum L. = *D. sylvestris* Hudson of Am. authors. Spontaneous in cemetery and one other area. A county record.

Cucurbitaceae (Gourd Family)

Echinocystis lobata (Michx.) T. & G. Wild cucumber. Hedgerows, marshes, thickets. Damp soil.

Campanulaceae (Harebell)

Campanula americana L. Tall bell flower. Occasional in woods.

C. aparinoides Pursh. Marsh bell flower. Marshes.

C. rapunculoides L. Escape. Roadsides, railroads, thickets.

C. rotundifolia L. Harebell. Rare in county. Along railroad track. One record.

Lobeliaceae (Lobelia Family)

Lobelia cardinalis L. Cardinal flower. Wet shores, flood plain forests.

L. inflata L. Indian tobacco. Field near Menasha. One record.

L. kalmii L. Sedge meadow. One record near Rush Lake.

L. siphilitica L. Great blue Lobelia. Marshes, shores.

L. spicata Lam. Spiked Lobelia. Railroad prairies, roadsides.

Compositae (Composite Family)

Achillea millefolium L. Yarrow. Railroads, roadsides, fields.

A. ptarmica L. Established along one roadside. Garden escape.

Ambrosia artemiisifolia L. Ragweed. Railroads, roadsides, fields. Common weed.

A. trifida L. Giant ragweed. Railroads, roadsides, fields.

Antennaria neglecta Greene. Pussy toes. Railroads, roadsides, woods.

A. plantaginifolia (L.) Richards. Railroads, roadsides, woods.

Anthemis cotula L. Dogfennel. Roadsides, waste places, marshy fields. Weed.

Arctium minus (Hill) Bernh. Common burdock. Disturbed sites. Common weed.

Artemisia absinthium L. Absinth. Railroads, roadsides, hard packed gravel.

A. biennis Willd. Disturbed sites.

A. caudata L. Wormwood. Edge of sand quarry.

A. ludoviciana Nutt. White sage. Railroad prairies. Uncommon.

Aster azureus Lind. Railroads.

A. brachyactis Blake. Clay fill, edge Lake Winnebago; railroad tracks on campus of University of Wisconsin, Oshkosh.

A. ericoides L. Heath aster. Railroad prairies, roadsides. Common.

A. falcatus Lindl. Near water filled pits in sand quarry. One location.

A. furcatus Burgess. Railroad. One record. Rare. A northern extension of range (Tans & Read, 1975).

A. hesperius Gray. Railroads, wet meadows.

A. junciformis Rydb. Undisturbed sedge meadow.

A. lateriflorus (L.) Britt. Woods, edge marsh.

A. laevis L. Railroad prairies, fields.
A. lucidulus (Gray) Wieg. Damp soil.
A. macrophyllus L. Large leaved aster. Moist woods.
A. novae-angliae L. New England aster. Railroad prairies, roadsides, fields. Common.
A. pilosus Willd. Roadsides.
A. prenanthoides Muhl. Woods. *Buckstaff* 38-56 (Buckstaff Collection).
A. sagittifolius Willd. Railroads, roadsides.
A. sericeus Vent. Railroads. Two records.
A. shortii Lindl. Dry woods.
A. simplex Willd. Woods, fields, waste areas.
A. umbellatus Mill. *Rill* 5597 (RILL).
Bidens aristosa (Michx.) Britt. Marshes, wet meadows.
B. bipinnata L. Yard weed. Probably introduced accidentally.
B. cernua L. Sticktight. Wet shores, ditches. The most common *Bidens*.
B. coronata (L.) Britt. Marshes, wet meadows.
B. frondosa L. Bur marigold. Marshes, wet meadow.
B. tripartita L. Waste area near Fox River. One record.
B. vulgata Greene. Waste areas.
Boltonia asteroides L'Her. Low ground. One record, 1935.
Carduus acanthoides L. Plumed thistle. Field. Also one white flowered plant. Introduced; not a common thistle at this time.
Centaurea maculosa Lam. Centaury. Railroads, roadsides, weedy.
Chrysanthemum leucanthemum L. Daisy. Railroads, roadsides.
C. uliginosum Pers. High daisy. Escape. Appearing native. Two records.
Cichorium intybus L. Chicory. Railroads, roadsides, disturbed sites. Common weed.
Cirsium altissimum (L.) Spreng. Wood thistle. Railroads, roadsides. Uncommon.
C. altissimum (L.) Spreng x *C. discolor* (Muhl.) Spreng. One location.
C. arvense (L.) Scop. Canada thistle. Common weed.
C. discolor (Muhl.) Spreng. Prairie thistle. Railroads. Uncommon.
C. muticum Michx. Swamp thistle. Wet meadows, damp roadsides.
C. vulgare (Savi) Tenore. Bullthistle. Roadsides, fields, waste places. Common weed.
Conyza canadensis (L.) Cron. Horseweed. Roadsides, disturbed sites. Weed.
Coreopsis palmata Nutt. Tickseed. Railroad prairies.
C. tinctoria Nutt. Disturbed site. Weed in landscaped planting.
Crepis tectorum L. Roadside. Weed of disturbed sites. Becoming more common.
Erigeron annuus (L.) Pers. Railroads, roadsides.
E. philadelphicus L. Daisy fleabane. Railroads, roadsides.
E. strigosus Muhl. Roadsides.
Eupatorium altissimum L. Tall boneset. Along railroads. Range extension and county record. One location.
E. maculatum L. Joe-pye weed. Damp soil.
E. perforatum L. Boneset. Damp soil.
E. purpureum L. Woods. One record.
E. rugosum Houtt. White snakeroot. Woods, roadsides, marshes.
Galinsoga ciliata (Raf.) Blake. Disturbed soil. Weed.
Gnaphalium obtusifolium L. Cudweed. Open sandy field, cinders near building, open woods.
G. uliginosum L. Planting near building. One record.
Grindelia squarrosa (Pursh) Dunal. Tarweed. Railroads, roadsides.
Helenium autumnale L. Sneezeweed. Marshes, wet ditches, wet meadows.
Helianthus annuus L. Escape or a remnant of cultivation.
H. hirsutus Raf. Railroads, roadsides.
H. giganteus L. Roadsides.
H. grosseserratus Martens. Railroads, roadsides.
H. laetiflorus Pers. Railroad prairie. One location.
H. maximilianii Schrader. Undeveloped field in city of Oshkosh.
H. strumosus L. Edge marshy woods.
H. tuberosus L. Railroads, roadsides.
Heliopsis helianthoides (L.) Sweet. Railroads.
Hieracium aurantiacum L. Orange hawkweed. Pastures, lawns. Weed.
H. kalmii L. Railroads.
H. scabrisculum Schwein. Railroads, woods.
Iva xanthifolia Nutt. Marsh elder. Beside driveway. One record.
Krigia biflora (Walt.) Blake. Dwarf dandelion. Uncommon. Undisturbed railroad prairies.
Lactuca canadensis L., var. *longifolia* (Michx.) Farw. Railroads.
L. pulchella (Pursh) DC. Railroad.
L. serriola L. Prickly lettuce. Railroads, roadsides.
Liatris aspera Michx. Blazing star. Prairies. Uncommon.
L. pycnostachya Michx. Prairie gayfeather. Wet prairies. Uncommon.
Matricaria chamomilla L. Disturbed site.
M. matricarioides (Less.) Porter. Pineapple weed. Disturbed sites.
Polymnia canadensis L. Marshy shore of Rush Lake.
Prenanthes alba L. Rattlesnake root. Damp woods.
P. racemosa Michx. Railroad prairies. Uncommon.
Ratibida columnifera (Nutt.) Woot. & Standl. Cone flower. One location. Railroad.
R. pinnata (Vent.) Barnh. Yellow cone flower. Railroad prairies, roadsides. A fairly common prairie element persisting along roadsides.
Rudbeckia hirta L. Black-eyed Susan. Railroad prairies, fields.
R. laciniata L. Roadsides.

R. triloba L. Occasional. Fields, roadsides.
Senecio aureus L. Ragwort. Woods.
S. pauperculus Michx. Woods, pastures.
S. plattensis Nutt. Dry upland woods.
S. vulgaris L. Weed in plantings and disturbed soil. Common.
Silphium laciniatum L. Compass plant. Railroad prairies, undisturbed roadsides.
S. terebinthinaceum Jacq. Prairie dock. Railroad prairies, undisturbed roadsides. More common than the former.
Solidago canadensis L. (Including *S. altissima* L.) woods, railroads.
S. flexicaulis L. Zig-zag golden rod. Woods.
S. gigantea Ait. Railroads, roadsides.
S. graminifolia (L.) Salisb. Railroads, roadsides.
S. juncea Ait. Wet woods, shores.
S. nemoralis Ait. Railroads, fields.
S. riddellii Frank. Railroads, damp clay soil.
S. rigida L. Stiff goldenrod. Railroad prairies, fields. A common prairie element.
S. speciosa Nutt., var. *rigidiuscula* Rydb. Showy goldenrod. Along railroad tracks.
S. uliginosa Nutt. Sedge meadow.
S. ulmifolia Muhl. Elm leaved goldenrod. Open fields.
Sonchus arvensis L. Sow thistle. Roadsides, disturbed sites. Weed.
S. asper (L.) Hill. Roadsides, disturbed sites.
S. oleraceus L. Roadsides, disturbed sites.
S. uliginosus Bieb. Roadsides, disturbed sites.
Tanacetum vulgare L. Tansy. Escape. Railroads, roadsides, fields.
Taraxacum officinale Weber. Dandelion. Lawns, disturbed sites. Common weed.
Tragopogon dubius Scop. Greater goat's beard. Railroads, roadsides, fields.
T. dubius Scop. x *T. pratensis* L. Field.
T. porrifolius L. Spontaneous in my garden, not planted.
T. pratensis L. Lesser goat's beard. Railroads, roadsides, fields.
Vernonia fasciculata Michx. Ironweed. Marshes, wet meadows.
Xanthium strumarium L. Cocklebur. Disturbed sites, waste places.

Acknowledgments

Special thanks is extended to Neil Harriman, Curator of the herbarium of the University of Wisconsin-Oshkosh who gave freely of his time and talent and was always available for consultation. I also acknowledge the assistance of the following who examined specimens and offered suggestions: Hugh H. Iltis and Theodore Cochrane; James Peck and Paul Taylor, for their help with the Pteridophytes; Peter Salamun for help with the Caryophyllaceae; James Richardson for help with Euphorbiaceae; and James Zimmerman for examining and annotating *Carex*.

I would also like to thank those who helped with field work: Russell A. Rill, Anita Carpenter, Robert Jansen, and Bruce Parfitt, and in addition, Janet Scalpone who examined and edited this manuscript.

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ADDRESSES OF AUTHORS: *Transactions* Wisconsin Academy, 1983 (Pt. 2)

ACKLEY, MEREDITH
2640 North Booth Street
Milwaukee, WI 53212

BOUSH, G. MALLORY
Department of Entomology
University of Wis.-Madison
Madison, WI 53706

DORNEY, JOHN R.
Weed Science Center
Crop Science Dept.
North Carolina State University
Raleigh, NC 27607

EVRARD, JAMES O.
Wetlands Wildlife Research,
D.N.R., Box 61
Baldwin, WI 54002

FISHKIN, KENNETH PAUL
Computer Science Division
University of Calif.-Berkeley
Berkeley, CA 94720

HELD, JOHN W.
Department of Biology
University of Wis.-LaCrosse
LaCrosse, WI 54601

HUTCHISON-CEELY, SALLY
4344 Bagley Parkway
Madison, WI 53705

JOHNSON, REED B.
50 Ver Bunker Avenue
Port Edwards, WI 54469

KAPLAN, LOUIS
5725 Elder Place
Madison, WI 53705

LAST, DONALD
Soil and Water Conservation
U.W. Extension/College of
Natural Resources
Stevens Point, WI 54481

MCCABE, ROBERT A.
Department of Wildlife Ecology
University of Wis.-Madison
Madison, WI 53706

MEYER, WAYNE
Department of Library Science
Ball State University
Muncie, IN 47306

MISSEY, JIM
Department of English
University of Wis.-Stevens Point
Stevens Point, WI 54481

PAYNE, NEIL F.
College of Natural Resources
University of Wis.-Stevens Point
Stevens Point, WI 54481

PELLITTERI, PHILLIP
Department of Entomology
University of Wis.-Madison
Madison, WI 53706

PIECHOWSKI, MARJORIE
Office of Research Support
Marquette University
Milwaukee, WI 53233

PITTS, MAJOR RICHARD M.
Department of Military Science
Texas A & M University
P.O. Box 3220
College Station, TX 77841

RILL, KATHERINE D.
1520 Bowen Street
Oshkosh, WI 54901

ROOT, DAVID A.
3017 Stanley Street
Stevens Point, WI 54481

SHIFFERD, KENT
Department of History
Northland College
Ashland, WI 54806

WILLIAMS, ELIZABETH
Department of English
University of Wis.-Milwaukee
P.O. Box 413
Milwaukee, WI 53201

ZIMMERMAN, JAMES HALL
Department of
Landscape Architecture
University of Wis.-Madison
Madison, WI 53706

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TRANSACTIONS

of

the Wisconsin Academy of Sciences, Arts & Letters

Volume 72
1984

TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

Volume 72, 1984

Co-editors
PHILIP WHITFORD
KATHRYN WHITFORD

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Established 1870
Volume 72, 1984

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THE WIFE'S PROLOGUE AS ROLE PLAYING

JAMES D. ALEXANDER
Department of English
University of Wisconsin Center—Marshfield

Ever since Chaucer created the Wife of Bath, she has taken on a life of her own. The sheer length of her own Prologue serves as a realistic portrayal of a person who talks too much, of one who simply takes too long to get to the point. As the Friar exclaims, hers is a long preamble to a tale (1. 837), and the modern reader tends to agree. Her Prologue is almost twice the length of her story and longer than the total of the introductory material to all the stories in the Canterbury cycle (Sedgwick 1934:263). Perhaps Chaucer allowed her to ramble on so long because even he became seduced by her astonishing complexity and lifelike autonomy. Of all the Canterbury Pilgrims, she is the one Chaucer refers to by name in his other poetry, as when he tells Bukton on the subject of marriage to *rede the Wyf of Bathe* (Robinson ed. 1961:539).

In this century alone the Wife has gone through several stages of interpretation. She has been seen as a one-dimensional figure, with a storehouse of medieval learning (Shumaker 1951); as an iconographic character made into a vehicle, or a butt, of antifeminist satire (Robertson 1962; Weissman 1975); as a woman whose speech shows she is in contention with the mores of her world (Schauber and Spolsky 1977); and most recently as a case study in neuroticism (Fritz 1980). Even the literature on the Wife has spawned a literature. Sands, for example, has a whole article comparing the views of critics on the Wife's personality, with only a passing glance at the primary source itself (1978).

But far too much of what has been said about the Wife is based on the substance of her report, often in isolation from the literary construct in which she is portrayed. Almost no one has testified to the dramatic properties of the Wife's discourse. No analysis of Dame Alison will be definitive unless it views her lines not as a text, but as an act. No critical assessment will be complete until it sees the Wife as being the speaker of lines, the player of parts, the central figure in a well-contrived dramatic monologue.[1]

Our ears should be able to make out the surface markers that give the Wife's lines the sound of talk. There is the colloquial "these" for a familiar referent, in *Thise wormes ne thise motthes ne thise mites* (586). Now we have been cautioned against concluding that a medieval character's syntax is "chaotic" simply because it is not like our own, since Chaucerians did use a different and apparently more colloquial syntax in their poetry than we do (Roscow 1981:1-9). Still, a number of syntactic shifts seem to be idiosyncratic to characters, as the shift from "us" to "she" in *Some for oure shape, and some for oure fairness, / And som for she can outher singe or daunce* (264-5) (Schlauch 1952). Other shifts in number (400-401, 568, 698) may not be salient only because they are integrated so naturalistically in the Wife's speech. There are numerous imperatives like *Now herkneth hou I bar me proprely* (230), most of which are superfluous because they command speakers to do something they are already doing, or do not need to do, but function as vocal indices of insistence. Emphasis comes from the frequent use of "will" in lines like *For sith I wol not kepe me chast in al* (52) and of double negatives,[2] like *I ne owe hem nat a word that it nis quit* (431). Other lines are intensified by vocal idioms, like *by my trouthe* in *For, by my trouthe, I quitte hem word for word* (428), which underscore the Wife's resolve to follow her own inclinations. Certain set phrases and set expressions, including proverbs, which occur so often in the Wife's talk are not just filler; they are what Ong calls *oral formulae,* marking discourse as having descended patently from an oral culture (1982: 26). Part of this complex are the oaths, like "God knows" in *For God it woot, I chidde hem spitously* (229), that in Alison's talk ironically call on God to witness her most un-Christian activities: her indulgence in fleshly pleasures and her tyranny over her husbands. Other indices of vocal strengthening are Alison's exaggerations, as her claim that she told everything to her confidante about her husband, even if he "did something that would have cost his life" (541); and the strength of language she uses in her sweeping dismissals, those one-or-two-liners, some blistering with invective: *With wilde thonder-dint and firy levene/ Mote thy welked nekke be tobroke!* (282-3).

The Wife's recourse to word play substantiates Chaucer's remark that she has a talent for laughing and talking in company (GP 476). There is the use of *dighte* in the senses of both 'copulated with' and 'dressed' in *t'espye wenches that he dighte* (404) and aside from *double entendres,* numerous puns [*flour* (119, 483), *ba* (439), *leek* (578), *croce* (490), *daungerous* (520)],[3] and those coarsely figurative expressions, like having 'delight in bacon' (424) which pass for "country talk."[4]

One item occurs so repeatedly that the hearer cannot but conclude that the Wife is preoccupied by the idea. The phrase *bere on honde* has as its primary sense 'to govern,' and as secondary senses 'to convince,' and 'to accuse falsely.'[5] Its frequent use (232, 238, 333, 386, 399, 581) is an index to the Wife's character, since it reflects how she sees herself in relation to her husbands: *thus . . . bar I stifly mine olde housbondes on honde* (385-6). Colloquial and physical, the idiom illustrates her propensity for having her husbands in her grasp; it shows her desire to dominate. The phrase is probably intended to be accompanied by a manual gesture. As such it functions as a stage direction, a way of establishing a setting in words, like Alison's reference to the "tun" the Pardoner is drinking from at the time (176).

It is in fact when we hear Chaucer's lines read by an actress that we become aware of how much they were designed for oral delivery. An example is lines 9 to 25 as read by Dame Peggy Ashcroft:

> But me was told, certain, nat longe agoon is,
> That sith that Christ ne wente nevere but ones
> To wedding in the Cane of Galilee,
> That by the same ensample taughte he me
> That I ne sholde wedded be but ones.
> Herke eek, lo, which a sharp word for the nones,
> Biside a welle, Jesus, God and man,
> Spak in repreve of the Samaritan:
> "Thou has yhad five housbondes," quod he,
> "And that ilke man that now hath thee
> Is nat thyn housbonde." Thus saide he certain.
> What that he mente therby I can nat sayn,
> But that I axe why the fifthe man
> Was noon housbonde to the Samaritan?
> How manye mighte she han in mariage?
> Yit herde I nevere tellen in myn age
> Upon this nombre diffinicioun.[6]

In line 9 we hear the voice begin low, remote, with a quality of wonder, and rise to the incredulity of *ne . . . wedded be but ones.* Then there is a break. With *Herke,* we hear a tone of querulousness, as the speaker passes into the second Biblical text, now moving more quickly through the quote as she builds to the climax. This is followed by a half-line, in a tone of childlike assurance, *Thus said he certain,* as if the speaker wants to testify to the fact that the strangest stuff does occur somewhere in Scripture. There is a sudden modulation, the lines afterward taking on different voice qualities in quick succession. *What that* is delivered with flippant jocularity. *But that I axe* is impatient. The two following questions are insistent. There is a break. The kicker then comes with the voice, now stretched to encompass all the Wifely experience, climbing to an authoritative ring, and then, with the word *diffinicioun,* the voice drops to the hint of a giggle. This quality of recitation, which enhances meaning and gives the impression that Alison is enjoying her own lines, is a tribute, of course, to the probity of the actress. But the fact that Chaucer can provide the literal basis for tonal changes, and thus for shifts and starts of feeling, shows that our full appreciation depends upon our tuning in upon Alison speaking.

As indicated above, *insisting* is one thing the Wife does, but she is also engaged in *confiding, arguing,* and *challenging.* These are the speech acts of the Wife, as identified by Schauber and Spolsky (1977:26), who conclude, "The overwhelming message we receive from Alison's Prologue is of her incessant struggle with the givens of her world, her indomitable revisionism, subversion, reordering." The writers hold that distinguishing her speech acts is a major way of "knowing" a character. It can also be held that the theory of speech acts, when applied to literature, aids us in knowing the text as well, for we then assume that the text is not merely words but part of an action intended by a speaker to have an effect on a hearer, however fictional they both are. There are indications, even surface features, that the first and second persons are foregrounded in Alison's lines.

The 17 or so questions that occur in the Wife's address to the Pilgrims all have the effect of drawing the hearers into her discourse. The earlier ones, those before line 168, like *How manye mighte she han in mariage?* (23) do give the Wife a tone of contentiousness. The later ones, however, like *What sholde I say?* (633) and *woostou why?* (568) momentarily halt and reverse the flow of her *confessio,* and thereby lend it some liveliness. The same quality comes from the exclamations she makes on her subject. There are the irreverent outbursts like *Which yifte of God hadde he for alle his wives!* (39), and asides like *Ye woot wel what I mene of this, pardee* (206), this one a leering reference to her old husbands' impotence while she tells how she taxed them. Once she interrupts herself to show her feeling of outrage: *Fy! speek namore—it is a grisly thing* (741). Here it is almost as if the Wife is briefly taking on the role of hearer of her words. A later couplet has her pulling herself back from mental rambling in the words, *But now sire—lat me see, what shal I sayn?/Aha, by God, I have my tale again* (591-2). In addition to these features of spontaneity are those that indicate the Wife's side of the interaction with the audience. A whole succession of first person pronouns may occur within a short space: *I wol . . . I nam . . . wol I . . . If I . . . me . . . My housbonde . . . wol I, I wol . . . my dettour . . . my thral . . . I am . . . I have . . . al my life . . . unto me* (154-66) all within 13 lines. Other lines show Alison personalizing the scriptural texts and proverbs, as 'Paul told me' and 'Christ taught me' (166, 12); *God bad us for to wexe and multiplye;/That gentil text can I well understonde* (28-9). Muscatine has remarked that the Wife "swallows" whole Biblical texts into her monologue and adapts them to her personality (1966:209). The rather frequent occurrence of the subjunctive is explained in that Alison continually inserts her own feelings into her lines: *the devel go therewith!* (482), *God his soule blesse!* (531), *Blessed be God that I have wedded five* (44). In these passages the interruptors,[7] the asides, the questions, all underscore the Wife's involvement in her material, imposing her personality on it, as well as stress her consciousness of an audience.

And the audience that Alison is in transaction with, the Canterbury Pilgrims, is one which, according to Kittredge, is taking a "lively interest" in what she says (1911-12:440). So compelling is her discourse that it actually provokes someone to respond, as when the Pardoner interrupts with his comments on his intended marriage. The audience contracts briefly to the "young man" alone whom the Wife addresses, assuring him she will warn him away from matrimony. At another point the Wife's concept of audience seems to shift to a class of people who are not on the Pilgrimage, those to whom she wants to confide the wiles she uses to keep men under dominance: *Ye wise wyves, that conne understonde,/Thus sholde ye speke and bere him wrong on honde* (231-2).

The dramatic monologue derives its quality from a person's speaking in a well-defined situation, conscious that she is before an audience. The person is in transaction with one or more listeners. The person is portrayed as a character by being caught in the act of revealing herself, with all of its implications for unreliability and dramatic irony. The speaker is dynamic, changing in time, becoming more and more complex as she reveals herself to us, and as we undergo successive realizations about her.

The unreliability of the Wife as a spokesperson is manifested by a number of rhetorical features. Readers have already commented on the distortions Alison gives to the Scriptures, especially to the Cana text and to the Samaritan woman *exemplum*[8] She then mounts a suspect analogy, on the issue of successive marriage, between the Biblical patriarchs (who were populating the earth) and herself (who never admits to having children). This, when it is concluded with her leering over the prospect of Solomon's wedding nights, must have made her hearers smile.

Alison's numerous repetitions serve to stamp a quality of spontaneity on her lines. She overuses the terms *bigamye* (33-102), *chastitee* (100-147), and *purvey* (566-91), and she belabors the notions of virginity (65-98) and procreation (121-43). As a debator she relies distinctly more on rhetoric than on logic. Whereas she claims to defend remarriage, she really defends the state of marriage. Whereas she has begun by insisting virginity is not obligated, she at length holds that she will not oblige procreation. Both assertions are a manifest shifting of the grounds of her argument.

Other features show that the Wife has not carefully edited her speech, mainly those instances of digression. She announces that she will speak from experience, and then undertakes a tour of the authorities. She refers at the outset to the *wo* in the wedded state (3), and does not arrive at the subject until about 200 lines later, after the Pardoner's interruption pulls her back. Then she promises to tell her *tale* (178, 199), but it has to wait. At line 458 Alison says she will speak of her fourth husband. The 30 or so lines that follow furnish us with an exposé rather of the Wife, her appetites and the loss of her beauty. She tries again. In line 486 she embarks on the subject of her fourth husband, but she actually explains what treatment the man got at her hands, purgatorial, and how stingily she buried him. In line 509 she moves on to her fifth husband, but then she really recounts how she courted Jankyn when her fourth was still alive. At this point she becomes so diverted by her anecdote of the fictive symbolic dream that she must catch herself from betraying something dangerous.[9] Finally, after illustrating her new husband's obnoxious habit of reading to her from the clerkly writings, she departs into a disquisition on clerks (694-716). By the end of her 834-line monologue she is again announcing her *tale.*

Among the more obvious dramatic features in the Wife's Prologue are those instances of exhibitionism. She demands the attention of others through histrionics: *Allas, allas that evere love was sinne!* (620). She climaxes her account of her marital experiences, and of her Prologue, with a line more melodramatic than any in the *Tales: O hast thou slain me, false thief?* (806).

When Alison cites others, she either gives her own digested version of the authorities or, with the exception of Jankyn's final lines, quotes herself. When she relates to the audience her confrontations with her husbands, all the lines are her own. She accounts for her husbands' words only in the report she makes of them in her sample of invective against her husbands. She punctuates her lines with *thou saist,* probably to keep the hearers aware that the accusations are consistently to be attributed to her husbands. She then abruptly dismisses the accusations, and thus her husbands, with steaming epithets. Here Alison is claiming the prerogative of the dramatist, in assigning lines, and that of the stage director, in disposing of the characters at will. As it happens, she has all the lines and she has the last word; she seems to be enjoying herself at her absent husbands' expense.

Now it is one thing to claim that the Wife's lines ramble and another to claim that her Prologue is disunified.[10] If the Prologue seems to lack unity, the impression comes only from viewing the content of the work and not the act the speaker is engaging in. There is a source of esthetic integrity in the succession of revelations the Wife gives to her listeners. They would first be familiarized with Dame Alison from her portrait in Chaucer's General Prologue. From this she appears as a type figure well known to medievals. She derives both from the character of La Vieille, the old lady, in The *Romance of the Rose,* who knows all the intricacies of amorous love, and from the type of the much remarried wife, "liberated," uninhibited about acting out in company (Rowland 1972:385). There are several clear references in her own Prologue keyed to her portrait in the General Prologue: her dress, her deafness, her gapped teeth, her being remarried five times, and her craft at seduction. Chaucer then adds elements to the Wife's character that serve to pull it away from the medieval stereotype. She launches into the subject of her frequent remarriage, a sore point among medievals, and so reveals herself to be assertive, argumentative. Here she adopts the role of *disputant.* She then promises to inform her audience of the hardships of marriage, but she really intends to inform wives from her own experience on how to keep the upper hand when they are accused by their husbands. The martial quality of her temperament, by which she has sought at all times to dominate her husbands, emerges. She has assumed the role of *domestic tyrant.* At this point while the Wife reveals she is strong-willed, she testifies to a powerful acquisitive instinct. It bristles in her many proverbs, with their mice that have more than one hole, their hands that lure hawks, their people who are the first to grind at mills. These and the ruthlessly commercial diction she applies to the marital arrangement, *paye his dette* (159), *dettour* (161), *raunson* (417), put the Wife in the role of *exploiter,* of opportunist who sees life as a series of business transactions for which she must be prepared. She has already given utterance to her promiscuity, with imagery variously comparing herself to a magpie, a nightingale, a colt, but it is in the later part of her Prologue that she reveals her erotic drive. She makes it clear that she has remarried most recently for this reason—out of the Venus instinct in her character. But this is directly in conflict with the desire to dominate, and this desire overwhelms her in her role of *lover,* so that the Wife then recounts her achievement of mastery over Jankyn. Chaucer seems to be presenting successive stages in our apprehension of the Wife's character almost as if he were peeling away the layers of an onion.

The Wife, then, is a dynamic figure, not of one who undergoes change quite so much as one who brings about change in her audience's awareness of her. What listeners earlier hear as defense of a life style, they now hear as lusty venturesomeness; what they earlier hear as resourcefulness, they now hear as exploitativeness; what they earlier hear as bold assertiveness, they now hear as aggressive self-interest.

This is not to say that the various roles the Wife assumes are mutually exclusive. Alison, who is complex, can play multiple roles. For instance, at the point when she passes from disputant to domestic tyrant (192), she disclaims all seriousness, and says her intent is for *to pleye.* The diversity of her character may in fact be the diversity of an abnormal personality. Recent psychological analyses of the evidence in the Wife's lines show that she is an authentic case study in neuroticism It is the neuroticism of the person who can at one moment speak in jest and at another disclose that she has somehow driven her husbands to the grave.[11]

Thus the integrity of the Wife's Prologue comes from the speaker's dynamic quality, a quality which is vital to the dramatic monologue: a character changes, or the audience's apprehension of a character changes, as the character gradually reveals himself. And as the audience for Browning's "My Last Duchess" modifies its estimate of the Duke, while he shows himself capable of more and more drastic measures to maintain his dominance, the listeners have an analogous experience as the Wife of Bath reveals herself more and more ruthless in the pursuit of her instincts.

For like Browning's Duke, the Wife is not to be trusted in what she reports of her life.[12] Of the many contradictions in the Wife's Prologue which she is unaware of, are these. Alison says that God commanded us to increase and multiply (as a defense of her marital yearnings), but nowhere does she admit to having borne children. She claims that she wants to live in a way that is little less than perfect, but she reveals that her appetites are wholly undisciplined. She says that she will comply with her husbands' sexual desires at any time, yet she later states that she would never satisfy her husband without a price. Her open confession of her marital tactics confirms the very accusations she claims clerks make scurrilously against women. The crowning contradiction of course is that Alison cherishes the memory of the period when Jankin was not to be mastered, but she claims that all was idyllic in their marriage only when he submitted to her.[13]

Such contradictions, when they are expressed by a character seemingly unaware of them, are the stuff of dramatic irony.

Another ironic element, which is situational, but which is compounded (because it is not recognized) into dramatic irony, comprises the reversals working through the Wife's Prologue. If she is standoffish with her husbands, she holds, may God give her sorrow. In fact she is standoffish, and in fact she comes in for a share of grief. She reveals that when she married Jankyn she turned over her possessions to him (636-7), a reversal of the situation of her prior marriages, one which she never quite realizes (Dempster 1959: 81). Then, we recall that the Wife earlier reminisces on the grief she has caused her husbands, in the line *O Lord! the paine I did hem and the wo* (390). Later she repeats the words, but in their mirror image form. Nothing so clearly underscores the reversion upon self of the same grief, now done her by Jankyn, than this line: *Who wolde weene . . . The wo that in myn herte was, and pine?* (792-3).

Readers do not tend to think of the Wife of Bath's Prologue as dramatic monologue. A look in Hugh Holman's *Handbook of Literature* (1972) under the entry *dramatic monologue* turns up illustrations of the genre in citations from Tennyson, Browning, and more recent poets, but Chaucer is not mentioned. Still, it is in her role playing that the confrontation emerges between the Wife of Bath and her world, and between her and herself. And it is in her speaking roles that we can account for Alison's boisterousness, her indomitability, her rampant individualism, her carnality, her acquisitiveness, her neuroticism, and her fascination with that last young man.

Notes

[1] *The Norton Anthology* (1975) is used for all citations to The Wife's Prologue.

[2] Rifaterre holds that the reality of a stylistic device is proved by its existence in a convergence with another feature of style (1959:172-3). Certain convergences, especially of *wol* with double negatives, seem to be stylistic indicators of assertiveness on the part of the Wife.

[3] The puns are explicated in MacLaine (1964:110-12). Also see Sanders (1968:192-5).

[4] There is a publication of such rural expressions, though many of the submissions come from the city: Dick Syatt, *Country Talk* (Secaucus, N.J.: Citadel Press, 1980).

[5] Duncan gives a concordance for *honde* as it occurs in the Wife's Prologue, which includes the senses cited (1966).

[6] Caedmon TC 1101, 1961.

[7] Muscatine writes that exclamations like *Herke eek* serve as well to "refresh the illusion of speaker and actual audience" (1966:209-10).

[8] Preston (1952:242); Speirs (1967:137-8) points out that the Wife misapplies quotations, ones especially from the Bible. Also, Bradley observes that the Wife garbles the Scriptural and sermon literature (1956: 625).

[9] There is a clear sign here of the fact that Alison and Jankyn were accomplices in the murder of the fourth husband, as explained by Rowland (1973:277). Sands (1973:179) corroborates this interpretation.

[10] Rowland reports this allegation (1972:385, 393).

[11] See Rowland and Sands above in 9. Fritz (1980:171) explains that an animus-possessed woman such as the Wife is quite capable of driving a husband to death by sickness or accident.

[12] Parker (1970) provides extensive evidence for the Wife's untrustworthiness.

[13] See Parker (1970:98). This contradiction is explained most eloquently by Magee (1971:41-2).

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HAWTHORNE'S CHILLINGWORTH: ALCHEMIST AND PHYSIOGNOMIST

Henry J. Lindborg
Marian College of Fond du Lac
Fond du Lac, Wisconsin

Transformation has special significance to those poet-prophets of the American Renaissance who themselves undergo a kind of shamanic initiation to perceive in the flux of nature those forces which "weave and warp and broider at the Godhead's living garb."[1] In *Walden,* for example, Thoreau reveals the poet not only shaping his vision but being shaped by it in the creation of sacred space and in ritual purification.[2] In linking the human and divine spheres in the organic cycle of nature, Thoreau draws upon a number of sources from mystery cults of antiquity to Eastern religions for patterns of metamorphosis in a complex symbolic framework, a method also employed by major fiction writers equally concerned with changes wrought upon men by the visions they embrace—Melville's practice with Ishmael in *Moby-Dick* being a signal example. Transformation is no less significant in the writings of Nathaniel Hawthorne, whose *The Scarlet Letter* evinces great sophistication in its use of the patterns of change.[3]

This study will explore the change of *The Scarlet Letter's* Roger Chillingworth, as he descends from a high-minded philosopher to a fiend. While Hawthorne outlines the old man's transformation in demonic terms recognizable as belonging to the romance's Puritan milieu, he includes elements which clearly suggest occult frames of reference which serve both to enhance the psychological revelations of the book and to provide ironic counterpoint to the limitations of the Puritan perspective. Before exploring the roles of Chillingworth as physiognomist and alchemist, however, it is necessary to discuss the complex narrative method of Hawthorne's most famous work in terms of both the processes of transformation and the presentation of the Puritan outlook.

The Scarlet Letter is premised upon renewal of the higher faculties of its narrator, who escapes the "enervating magic" of the Custom-House which he fears "might make me permanently other than I had been, without transforming me into any shape it would be worth my while to take."[4] His restored capacity "to live throughout the whole range of his faculties and sensibilities" (p. 40) frees him from the materialism and torpid senility of the Custom-House and enables him to create the romance through interpretation of the cabalistic letter.[5] This significant change in the inner life of the artist is presented by the narrator as a figurative death, a metaphorical decapitation through the loss of his Custom-House office (p. 43). Though the narrator's playful suggestion that he writes from the grave (p. 44) has obvious ironic overtones in terms of Hawthorne's loss of position, at the same time it establishes a pattern of death and rebirth which is important throughout the romance.[6]

In a sense, through his metaphorical death the narrator takes up the position of the deceased Surveyer Pue, from whose "ghostly hand" (p. 33) he receives the central symbol of the romance along with Pue's historical researches on it. Thus, at the verge of life, in the imaginative realm which ghosts inhabit (p. 36), the artist's power to interpret the letter and to gain control over the "corpses" (p. 34) of his characters is restored. Here the artist operates in "a neutral territory, somewhere between the real world and fairy-land, where the Actual and the Imaginary may meet, and each imbue itself with the nature of the other" (p. 36). But the Puritan mythos which underlies the action of *The Scarlet Letter* demands that the narrator deal in matters which link not only "the Actual and the Imaginary," but also the human and the divine.[7]

The romancer is seemingly thrust into the position of prophet, interpreting what appear to be the designs of Providence in the Puritan drama of salvation. But though he relies upon symbols which come out of the Puritan *Weltanschauung,* he employs them as revelatory of the human condition in this world, not the next.[8] In fact, all pretensions to prophetic offices which would attempt to see beyond that which is human meet with irony throughout *The Scarlet Letter.* The narrator provides overlapping interpretations of psychological transformations which reveal, often ironically, the depth and complexity of lived experience.[9] Elements of Christian and occult belief establish the place of the transforming power of the human imagination in history; they are discovered in a *Lebenswelt* in which imagination clothes under various guises the truths of the human heart.[10]

Presented as they are in a complex historical vision, the romance's transformation motifs rely on a code of communication which has, in common with allegory, an assumption of the reader's knowledge of religious tradition, as well as the practice of objectification of interior conflicts in symbolic terms. The romance's tragic design is enhanced by the irony of such motifs reflecting the action of human passions on a symbolic stage which transcends humanity. The narrator's objective stance gives full weight to the division between the roles characters play and their underlying humanity, a division which is significant to the tradition of the nineteenth-century realist novel as well as tragic drama.[11]

The principal transformations in *The Scarlet Letter* treat the activation of human potential through processes which include figurative deaths like that of the narrator in "The Custom-House." These are played against one another in highly controlled and balanced interactions of characters whereby change in one causes change in another.[12] Since multiple interpretations of such transformations are resolved dramatically rather than theologically, it is necessary to explore Chillingworth's metamorphosis within its dramatic context, while at the same time paying close attention to its connotative values, especially as Puritan vision is juxtaposed with unorthodox viewpoints.

Two secrets are the springs of the dramatic action which transforms *The Scarlet Letter's* principal characters: that Dimmesdale is Pearl's father, which Hester refuses to reveal before the Puritan community (III), and that Chillingworth is her husband, which she agrees to conceal during an interview in the privacy of her prison cell (IV). These, along with the symbolism associated with the Puritan point of view, are established by the romance's first four chapters, thereby providing a context in which the passions of a secret domestic triangle will be interpreted in terms of the Puritan drama of salvation.

Hester's transformation in the eyes of the Puritans is the book's first metamorphosis; the scarlet letter "drew all eyes, and as it were, transfigured the wearer," the narrator comments, "so that both men and women, who had been familiarly acquainted with Hester Prynne, were now impressed as if they beheld her for the first time" (p. 53). The term *transfiguration* in this passage connotes a mode of revelation present throughout the romance; in its broadest sense, it suggests a manifestation of that which has been present but heretofore hidden.[13] Here the community sees Hester for the first time in her role as adulteress, which is conditioned by Mr. Wilson's conventional sermon endowing the letter with infernal significance and reducing its wearer to what Chillingworth calls "a living sermon against sin" (p. 63).[14] However, the scene preserves an inward human reality as against the abstract Puritan interpretation of sin. Hester's life as a woman has indeed entered a new stage, and as she stands before the community the young woman contemplates the path which bought her to the scaffold.

In a series of "phantasmagoric" (p. 57) scenes which Hester calls up to relieve her agony on the scaffold, she traces her childhood, maidenhood, and marriage—presumably the last public festival at which she has been the object of attention. Her marriage has offered her "a new life," but one which nourished "itself on time-worn materials, like a tuft of green moss on a crumbling wall" (p. 58). This marriage, by betraying her into a relationship with "decay" (p. 75), set the stage for her adultery in a situation not uncommon in literature and folk tale. But in *The Scarlet Letter* these circumstances are given a tragic dignity. For throughout the romance, promises of a new life offer to the characters only stronger ties with death and illusory hopes of regeneration. The tragedy of the book lies in the opposition of Hester's passions to community imperatives which are imposed upon her through an ill-fated marriage.[15] No social forms permit her to act out the full range of her "faculties and sensibilities," to put her plight in the terms established in "The Custom-House."

Just as Hester seemingly becomes another person in her transformation, so her husband is also transformed by it. As he stands by the scaffold he suppresses the "writhing horror" which "twisted itself across his features, like a snake gliding swiftly over them" (p. 61), and signals Hester to be silent. He then meets with her in prison to demand that she "Let . . . thy husband be to the world as one already dead, and of whom no tidings shall ever come" (p. 76). With her consent, Prynne becomes another man who seeks a "home" (p. 76) in his secret connection with Hester as he had in his unfortunate marriage to her (p. 74). Prynne's transformation to Chillingworth thus takes place with a figurative death. With this death he activates his potential for hatred. He announces to Hester his purpose of discovering and gaining control over her paramour, leading her to ask if the old man is not "like the Black Man that haunts the forest round about us" (p. 77). And in fact, Chillingworth's degeneration to a demon is a principal transformation of the first half of *The Scarlet Letter.* Significantly, Hester's silence permits this change, as it allows the changes in the Rev. Mr. Dimmesdale under Chillingworth's baleful influence.

Chillingworth's means of discovery of Dimmesdale's secret and his purposes in doing so are purely personal and mortal; in fact, so linked to mortality is he that his interests are presented in metaphors of death and corruption. He works his way toward the minister from outward signs which offer to him clear clues of Dimmesdale's relationship to Hester and Pearl. Mid-way through the first half of *The Scarlet Letter* (VIII), at the inquest called by the ministers and magistrates to determine Hester's fitness to rear Pearl, Chillingworth remarks upon the "strange earnestness" (p. 115) with which the young minister defends Hester's right to custody of the child. He also observes Pearl's sympathetic response to her father (p. 115), an echo of her gesture toward him on the scaffold three years before (p. 67). But when he comments upon the possibilities of discovering Pearl's parentage from her person, the Puritans recoil.

The old physician exclaims: "A strange child! . . . It is easy to see the mother's part in her. Would it be beyond a philosopher's research, think ye, gentlemen, to analyze that child's nature, and from its make and mould, to give a shrewd guess at the father?" The Rev. Mr Wilson, though he had urged Hester to reveal the child's father on the scaffold, immediately rejects the knowledge offered by "profane philosophy;" he suggests that each man ought to act the part of Pearl's unknown father, leaving "the mystery as we find it, unless Providence reveal it of its own accord" (p. 116). The Puritan's unwillingness to explore

Pearl's riddle is in keeping with the scriptural injunction to "judge nothing before the time, until the Lord come; who will bring to light the hidden things of darkness, and will make manifest the counsels of hearts" (I Cor. 4:5). Chillingworth, however, moils about in the darkness seeking to read hearts, not to bring their secrets to light, but for personal revenge.

Chillingworth's attention to Pearl's "outward make and mould" indicates that he is a practicing physiognomist, gaining his knowledge from the body. The "science" he employs, condemned in Elizabethan England, was codified in the eighteenth century by Lavater, whom Hawthorne read, and offers explanations of the physician's methods; for example, according to Lavater, "illegitimate children tend to resemble one parent more than another, which likeness may become more evident over time."[16] This is in fact one of the possibilities Dimmesdale himself fears (p. 206). In addition, Lavater proposes that parents and children have natural affinities, a belief which Chillingworth announces when he visits Hester in prison and comments that tiny Pearl will not recognize him as her father (p. 72), only shortly after the infant has made a tell-tale response to Dimmesdale.[17]

According to Lavater, the physiognomist exercises his art with a "secret delight," discerning "those internal motives which would otherwise be first revealed in the world to come."[18] Chillingworth does in fact discover what the Puritans would leave to Providence, but he is limited to corporeal signs to the point that only a physical manifestation of the letter on the minister's person provides him with certain knowledge of Dimmesdale's guilt. Because Chillingworth has no higher motive than his quest for personal revenge, he is mired in the mortality which his vision comprehends. The new life which the old man adopts through his figurative death is allied to decay, and in the moral sphere his actions transform him into a "fiend."

The second quarter of *The Scarlet Letter* traces the effects of his quest for and discovery of Dimmesdale's secret upon Chillingworth himself (IX, X), and upon the unfortunate minister (XI, XII). Chillingworth's discovery activates his malice (p. 139) transforming him into a demon, while Dimmesdale is impelled toward madness as his undiscovered enemy subtly works on his conscience. Ironically, as the pivotal "The Minister's Vigil" (XII) dramatizes, Dimmesdale alone is unable to perceive his physician's demonic transformation. Having departed "out of life as completely as if he indeed lay at the bottom of the ocean, whither rumor had long ago consigned him" (p. 119), Chillingworth attaches all of his interests to the minister with a single-mindedness which limits him to the realms of sin and death.

In his investigations Chillingworth is presented by the narrator as a metaphorical grave robber, digging "into the poor clergyman's heart, . . . like a sexton delving into a grave, possibly in quest of a jewel that had been buried on the dead man's bosom, but likely to find nothing save mortality and corruption. Alas for his own soul, if these were what he sought!" (p. 129). He does in fact ignore all of the finer things he discovers in Dimmesdale's character while he seeks out guilt (p. 130); in St. Paul's terms, he is "a natural man" who "receiveth not the things of the spirit of God; for they are foolishness unto him" (I Cor. 2:14). But limited to mortality as he is, Chillingworth is interpreted by all but Dimmesdale in spiritual, though demonic, terms. And he does play a role which is appropriately so interpreted, but with a number of ironies and qualifications included in its explication.

Two points may be advanced concerning Chillingworth's role as fiend or demon; first, though it may be true that Hawthorne at points gothicised him into unbelievability through unfortunate dramatic emphasis, he is not the only character to act the part of the Black Man.[19] Hester ascribes that identity to

Dimmesdale when at Pearl's insistence she explains that she has met the Black Man in the forest and the letter is his mark (p. 185). This explanation comes shortly before she again meets the minister in the forest, and the child, not knowing whom they are to encounter, expects the devil (p. 187).[20] And after the forest meeting in which Hester helps Dimmesdale to resolve to flee the colony and take on a new identity, he feels that he has met Satan in the person of Hester (p. 222).[21] Though Chillingworth's identification as a demon may be more consistent than that of the other characters, it is not less subject to multiple interpretation and dramatic irony.

Second, Chillingworth does not share the Puritan system of belief; in fact, he regards Dimmesdale's view that in his anguish he is being tortured by a fiend as "the superstition common to his brotherhood" (p. 171). Through Dimmesdale's orthodoxy the physician is able to manipulate the minister in a way which exercises in Puritan terms "a devil's office" (p. 170); but only when Hester confronts her former husband with what he has become does he see himself, though fleetingly, as demonic (p. 172).

In an important scene, "Hester and the Physician" (XIV), Hester attempts to employ her influence for good to dissuade her former husband from further exercising the "quiet depth of malice, hitherto latent" (p. 139) which he has activated in the discovery of Dimmesdale's secret. Here she negates the promise she made during "The Interview" (IV) and attempts to steer the old physician from the course she foresaw for him when she first designated his purposes as those of the Black Man. Even in spite of that "glare of red light" (p. 169) which the narrator describes as emitted by Chillingworth's eyes, Hester does not see his demonic transformation as forever fixed. She employs a species of what Lavater calls *pathonomy:* "the knowledge of character" through "the signs of the passions." This is "character in motion," what a man "becomes at particular moments; or what he might be."[22] Knowing what Chillingworth has been, Hester attempts to restore his better nature.[23]

Hester's attempt is revelatory to Chillingworth. It is in describing his work on the minister that the physician sees what has become of his former self, benevolent and studious as both he and Hester recognize him to have been. He asks Hester, "What see you in my face . . . that you look at it so earnestly?" (p. 170). Through Hester's response that "hatred . . . has transformed a wise and just man to a fiend" (p. 173), he understands that he has in fact fulfilled a role drawn from the world-view of the "superstitious" minister. He reacts "with a look of horror, as if he had beheld some frightful shape, which he could not recognize, usurping the place of his own image in a glass" (p. 172). However, in scriptural terms, he is "like unto a man beholding his natural face in a glass: For he beholdeth himself, and goeth his way, and straightway forgetteth what manner of man he was" (Jas I: 23–24).

Since Hester's influence as a woman is brought to bear in an attempt to save Chillingworth from damnation, echoes of Goethe's *Faust* may come to mind; however, she operates in a dramtic situation which also recalls Marlowe's version of the Faust myth, in which the Old Man approaches Faustus even at the threshold of his damnation with:

> Though thou has now offended like a man,
> Do not yet perserver in it like a devil.
> Yet, yet, thou hast an amiable soul,
> If sin by custom grow not into nature.[24]

In both cases the appeal fails. But here Hester's response is as significant as Chillingworth's. She, too, can be changed by active passion, and her failure to win mercy from the physician breeds hatred of him. She mentally ascribes to him a whole catalogue of infernal attributes, expecting him to "spread bat's wings and flee away, looking so much the uglier, the higher he rose toward heaven'' (p. 176).

Chillingworth's transformation into a fiend, most directly evident in this scene, is presaged, as has been noted, by Hester in the prison interview, and again when she sees an ugly physical change in him at the Governor's mansion (p. 112). The people of Boston also discern his ''remarkable change'': ''At first, his expression had been calm, meditative, scholar-like. Now, there was something ugly and evil in his face, which they had not previously noticed, and which grew still the more obvious to sight, the oftener they looked upon him'' (p. 127). So sinister does Chillingworth seem that they see him as an evil spirit contesting with their minister in a battle from which they expect Dimmesdale to emerge ''transfigured'' (p. 128). Such a transfiguration does take place in the public imagination, which converts the hypocritical clergyman to an angel; but the conflict they discern has other ironic dimensions which the people cannot fully understand.

Paradoxically, Chillingworth does act the part the community assigns him, but he does so by moving Dimmesdale toward self-realization as Goethe's Mephistopheles does Faust, quite against his own aims.[25] His unwilling participation in the minister's ''salvation'' has further resonances than those which apply to the community's perceptions, however. For in taking up his home with Dimmesdale, ostensibly to act as his physician, Chillingworth establishes a laboratory which the town sees as a passage to hell: ''According to the vulgar idea, the fire in his laboratory had been brought from the lower regions, and was fed with infernal fuel; and so, as might be expected, his visage was getting sooty with smoke'' (p. 127). But the science of alchemy, which Chillingworth admits practicing and uses as an analogy for his quest for the truth about Pearl's father (p. 75), is traditionally a path of spiritual perfection, not of damnation.[26]

According to one writer whom Hawthorne may have encountered about the time he was working on *The Scarlet Letter,* ''the principal object of the alchemist was a perfection of that knowledge by which the secrets of nature could be laid open; and, so far, was not only lawful, but a laudable pursuit; particularly when associated with the prevailing and frequently repeated, opinion, that the initiated were working under the immediate sanction and guidance of the Almighty.''[27] For the alchemist as for the physiognomist, to ''make things that are not perceived, but lie hid in shadow, to appear, and to take from them their veil, is granted to an intelligent philosopher through nature.''[28] Chillingworth does not desire either the spiritual perfecting of Dimmesdale or the public exposure to which that would necessarily lead. But he does propel the minister toward a rebirth which fits patterns of both alchemical and Christian symbolism.

For the practitioner of alchemy, ''death was more a term implying transformation than destruction.'' ''The perfection of every thing . . . requires a new birth, as that which is sowed is not quickened except it die; but here death is taken for mutation, and not for rotting under the clods.''[29] Echoing as it does I Corinthians: 15, this passage is important in its elucidation of the multiple possibilities of *The Scarlet Letter's* symbolism of death and rebirth. That alchemical symbolism is indeed one of the possible methods of viewing the romance's spiritual dimensions is made clear by the narrator in his ''Conclusion'' (XXIV), in which he seeks to draw morals and settle destinies.

Though Chillingworth would finally seem to have unhumanized himself to the point of necessarily being packed off to hell, the narrator employs an alchemical analogy in an attempt to ''be merciful'' to his ''shadowy beings,'' including Chillingworth (p. 260). He writes of love and hate: ''Philosophically considered . . . the two passions seem essentially the same, except that one happens to be seen in a celestial radiance, and the other in a dusky and lurid glow. In the spiritual world, the old physician and the minister—mutual victims as they have been—may, unawares, have found their earthly stock of hatred and antipathy transmuted into golden love" (pp. 260-261). But this is a qualified attempt to provide a balance of forces in tragic resolution, not a theological assertion, and morally it does not condone Chillingworth's conduct.

Within the dramatic action of the romance Chillingworth may himself use alchemical typology in his own defense. When he perceives himself as a fiend but rejects Hester's suggestion that he can change (XIV), the old man says, "My old faith, long forgotten, comes back to me, and explains all that we do, and all we suffer . . . Ye that have wronged me are not sinful, save in a kind of typical illusion; neither am I fiend-like, who have snatched a friend's office from his hands. It is our fate. Let the black flower blossom as it may!" (p. 174). In alchemy the "black flower" is that stage in the process which is a harbinger of gold. Chillingworth may thus be recalling the high-minded alchemical faith which animated his more benevolent past pursuits.

In the human dimension Chillingworth does what can aptly be called devil's work. But in claiming a typical part in a fated process he throws off his identification with the demonic as it is seen by the Puritan mind; and in the spiritual realm he may be correct—just as Dimmesdale may be correct in his judgment, which seems confirmed by the power of his sermons, that a sinful man can do good in a ministerial office (p. 132). The tone and method of *The Scarlet Letter* are premised upon such ironies. But death shrouds from individuals the ultimate designs of Providence, and the roles of prophet and magician stand in ironic counterpoint to those who would play them. Death is the boundary of a drama in which characters summoned from the grave return to it. Though the narrator makes a spiritual disposition of his "shadowy people," the book's final revelations are of the passions which Hawthorne portrayed employing appropriate symbolic frames of reference beyond Puritanism.

Notes

[1] The words of the Earth Spirit in Goethe's *Faust,* Part I, lines 508-9, trans. Walter Arndt (New York: W. W. Norton, 1976), p. 14.

[2] The transforming initiation has religious significance, "for the change of existential status in the novice is produced by a relgious experience. The intiate becomes another man because he has had a crucial revelation of the world and life." Mircea Eliade, *Rites and Symbols of Intiation: The Mysteries of Birth and Rebirth* (New York: Harper and Row, 1958), p. 1.

[3] A study of literary transformation is Irving Massey, *The Gaping Pig: Literature and Metamorphosis* (Berkeley: University of California Press, 1976).

[4] Nathaniel Hawthorne, *The Scarlet Letter,* ed. William Charvat, Vol. I. *The Centenary Edition of the Works of Nathaniel Hawthorne* (Columbus: Ohio State University Press, 1962), p. 23. All subsequent references to this volume will appear in the text.

[5] The Custom-House, like "Circe's Palace" in *Tanglewood Tales* (Centenary Edition, Vol. VII), turns men like the old Inspector into animals. Only the artist's vision spares the "Custom-House" narrator this fate. The range of sensibilities suggested by him resembles the Renaissance Neo-Platonic scale upon which man has kinship with both the beasts and the angels, as expounded by Pico della Mirandola in *On The Dignity of Man,* for example.

[6] The importance of "The Custom-House" in establishing significant patterns for the romance as a whole has been noted in numerous studies. A few which stress the role of the narrator's imagination are Nina Baym, "The Romantic Malgre Lui: Hawthorne in 'The Custom-House,'" *ESQ: A Journal of the American Renaissance,* 19 (1973), 14-25, reprinted in *The Shape of Hawthorne's Career* (Ithica, N.Y.: Cornell University Press, 1976); John Paul Eakin, "Hawthorne's Imagination and the Structure of 'The Custom-House,'" *American Literature,* 43 (1971), 346-358; Harry C. West, "Hawthorne's Editorial Pose," *American Literature,* 44 (1972), 208-221.

[7] Millicent Bell, in Hawthorne's *View of the Artist* (New York: University Publishers, 1962), asserts that Hawthorne's "most deeply felt image of the artist" is that of a necromancer, "a worker of illicit black magic," p. 58, and as Harry C. West notes in "Hawthorne's Magic Circle: The Artist as Magician," *Criticism,* XXX, 16 (1974), 311-25, magic circles pervade his art. The magician works at the border of two worlds calling up characters like ghosts, but the ghostly border also suggests access to the next world's revelations. The fashion in which revelation comes in Hawthorne is close

to that discussed in a passage from Creuser in Joseph Ennemoser's *The History of Magic,* trans. Howett (London, 1854): "The strictly symbolical confines itself to the . . . middle line between Spirit and Nature; within these bounds it can avail to render visible to a certain degree even the Divine, and is so highly expressive. It obeys Nature, merges itself into her form, and animates it; the infinite becomes human, and thus the strife between the two is at an end" (II, 6). Creuser's discussion of symbols comes from his work on myth. Ennemoser's quotation of Creuser reflects a sense of the connections between myth and magic close to Hawthorne's. Hawthorne employs his "magic" art at a boundary in which he shapes myths which contain elements of relevation. Whether Hawthorne knew of Ennemoser's work, originally published in 1846, is not known. But he was influenced by Creuser at least to the extent of his admitted employment of Charles Anthon's *A Classical Dictionary* (New York: Harper, 1844), which in its preface (vii) acknowledges the primacy of Creuser's system of mythology, and extensively employes *Symbolik und Mythologie der alten Volker, besonders der Griechen* (Heidelberg, 1810), widely known through its heavily annotated French edition by J. D. Guigniaut, *Religions de L' Antiquite* (Paris, 1825). Hugo Mcpherson has done a reading of Hawthorne based on Anthon: *Hawthorne as Myth-Maker* (Toronto: University of Toronto Press, 1969).

[8] Hawthorne's work presents competing modes of vision, none of which is given supernatural validation. He solves problems psychologically rather than doctrinally. For studies of multiple interpretation in Hawthorne's narrative, see Elaine T. Hansen, "Ambiguity and the Narrator in *The Scarlet Letter,*" *Journal of Narrative Technique,* 5 (1975), 147–63, and John O. Rees, Jr., "Hawthorne's Concept of Allegory," *Philological Quarterly,* 54 (1975), 494–510.

[9] The best studies of dramatic irony and transformations respectively, remain Richard Harter Fogle, *Hawthorne's Fiction: The Light and the Dark,* rev. ed. (Norman: University of Oklahoma Press, 1964), and Roy R. Male, *Hawthorne's Tragic Vision* (Austin: University of Texas Press, 1957).

[10] *Lebenswelt* as here employed implies the sense which Merleau-Ponty gives it when he writes of his philosophy's effort to "return to the life-world this side of the objective world; . . . to give the thing its concrete physiognomy, to organisms their own manner of handling the world, to subjectivity its historical inherence" —*Phenomenology of Perception* as quoted in "Translator's Preface" to *Signs,* trans. Richard McCleary (Evanston: Northwestern University Press, 1964), p. xiii. Hawthorne's view of history restores to it a full range of belief systems, including the occult.

[11] The sense of division in tragedy is given emphasis by Robert B. Heilman's "Tragedy and Melodrama," *The Texas Quarterly,* 3 (Summer 1960), 36–50, reprinted in *Tragedy: Vision and Form,* ed. Robert W. Corrigan (San Francisco: Chandler, 1965), pp. 245–257. *The Scarlet Letter* reflects "the kind of division that seems inseparable from human community—from the fact that, in the ordering of life, we maintain different imperatives that correspond to different and perhaps irreconcilable needs" (p. 246). On tragedy, see Richard B. Sewall, *"The Scarlet Letter," The Vision of Tragedy* (New Haven: Yale University Press, 1961), 86–91; Bruce I. Granger, "Arthur Dimmesdale as Tragic Hero," *Nineteenth-Century Fiction,* 19 (1964), 197–203; Dan Vogel, "Hawthorne's Concept of Tragedy in *The Scarlet Letter," Nathaniel Hawthorne Journal* (1972), 183–93. Richard R. Brodhead, in *Hawthorne, Melville, and the Novel* (Chicago: University of Chicago Press, 1976), sees Hawthorne employing formal division through his use of the narrator's objective stance, which contrasts the fixed meanings of the Puritan community with the open-ended symbolism arising from life situations (pp. 64–65).

[12] This is a version of the principle of organization perceived by John C. Gerber, "Form and Content in *The Scarlet Letter," New England Quarterly,* 17 (1944), 22–55.

[13] Transfiguration usually implies an encounter with divinity. The Transfiguration of Jesus (Mt 17:1–8; Mk 9:1–7; Lk 9:28–36) is the central instance.

[14] Sermons gain in ironic significance throughout the romance. Hester is the living version of the message underlying all of Dimmesdale's sermons, which take power from his anguish. For an historical perspective on the ecclesiastical elements of the romance, see Frederick Newberry, "Tradition and Disinheritance in *The Scarlet Letter," ESQ: A Journal of the American Renaissance,* 23 (1977), 1–26.

[15] Hester has often been seen, in Darrell Abel's words, as typifying "romantic individualism," in opposition to the community, "Hawthorne's Hester," *College English,* 13 (1952), 303. A good examination of how themes of isolation inform Hawthorne's major romances is Arne I. Axelsson, "Isolation and Interdependence as Structure in Hawthorne's Four Major Romances," *Studia Neophilologica,* 45 (1973), 392–402. See also Nina Baym's "Passion and Authority in *The Scarlet Letter," New England Quarterly,* 43 (1970), 209–30, also reprinted in *The Shape of Hawthorne's Career.*

[16] According to Marion L. Kesselring, "Hawthorne's Reading," *Bulletin of the New York Public Library,* 53 (1949), 185, Hawthorne read Lavater's *Essays on Physiognomy* in October 1828. On the resemblance of children to parents, see *Essays* (Boston: Spotswood and West, n.d.), p. 117. Taylor Stoehr's "Physiognomy and Phrenology in Hawthorne," *Huntington Library Quarterly,* 37 (1974), 355–400, reprinted in his *Hawthorne's Mad Scientists* (Hamden, Connecticut: Shoe String Press, 1978), is a rich source of physiognomy in Haw-

thorne; however, it makes none of the points advanced in this study.

[17] Lavater also notes the influence of the mother's imagination on the child. "We also know," he writes, "that children most resemble the father only when the mother has a very lively imagination, and love for, or fear of the husband" (*Essays,* p. 115). Hawthorne makes clear the influence of Hester's imagination on Pearl throughout the romance.

[18] Lavater, p. 10.

[19] Chillingworth's demonic nature has long been the subject of discussion. The classic study is William Bysshe Stein's, in *Hawthorne's Faust* (Gainesville: University of Florida Press, 1953) pp. 104–22. See also Darrell Abel, "The Devil in Boston," *Philological Quarterly,* 31 (1953), 366–81, and Edward Stone's "Chillingworth and His Dark Necessity," *College Literature,* 4 :1977), 136–43, which answers points advanced by Martin Green's *Re-Appraisals* (New York: W. W. Norton, 1965).

[20] Witchcraft in general is well handled in Karl Wentersdorf's "The Elements of Witchcraft in *The Scarlet Letter,*" *Folklore,* 83 (1972), 132–53.

[21] For Hester's role within a Faustian framework, see Neal B. Houston, "Hester Prynne as Eternal Feminine," *Discourse,* 9 (1966), 230–44.

[22] Lavater, *Essays,* pp. 24–25.

[23] Lavater discusses the restoration of harmony in the character of a loved one through "cooperating with the yet unimpaired essential powers" *(Essays,* p. 37).

[24] Christopher Marlowe, *Doctor Faustus,* V, i, 40–43.

[25] Dimmesdale's confession ends his personal division through hypocrisy; whether or not he is "saved" is a point which has been disputed. If one employs a physiognomic interpretation of Dimmesdale's transfiguration during his final hours, no implications of salvation need be drawn. Employing a long tradition that persons are restored to nobility near death, Lavater writes, "I have observed some among the dying, who had been the reverse of noble or great during life, and who, some hours before their death, or perhaps some moments . . . , have had an inexpressible ennobling of the countenance. Every body saw a new man; coloring, drawing, and grace, all was new, all bright as the morning; beyond expression, noble and exalted." (*Essays,* p. 124). Among critics who focus on Dimmesdale's last moments are Terrence Martin, "Dimmesdale's Ultimate Sermon," *Arizona Quarterly,* 27 (1971), 230–40, and William B. Dillingham, "Arthur Dimmesdale's Confession," *Studies in Literary Imagination,* 2 (1969), 21-26.

[26] Critics have worked on alchemical patterns in a number of Hawthorne's works; for example, David M. Van Leer's "Aylmer's Library: Transcendental Alchemy in Hawthorne's 'The Birthmark,'" *ESQ: A Journal of the American Renaissance,* 22 (1976), 211–20; Mark Henelly, "Hawthorne's Opus Alchymicum: 'Ethan Brand,'" *ESQ: A Journal of the American Renaissance,* 22 (1976), 96–106.

[27] Hawthorne may have read "Alchymy" in the *Retrospective Review,* 14 (1826), 98–135, which according to Kesselring he checked out on November 12, 1849 ("Hawthorne's Reading," p. 189). The quotation cited appears on p. 107.

[28] "Alchymy," p. 127. Alchemy employed a theory of natural "sympathies" through which its adepts worked. As Walter Pagel explains, "Alchemy and Medicine . . . form two aspects of natural magic already in Hellenistic times. The Magus applies the principle of sympathy; everywhere like years to unite with like . . . The 'seat of magic' . . . lies in Nature in which as by a magic chain everything is interconnected and alive. It is the task of the Magus to adapt himself to Nature so closely that he can influence it by setting, as it were, a sympathetic chord into vibration." "Paracelsus and the Neo-Platonic and Gnostic Tradition," *Ambix: The Journal of the Society for the Study of Alchemy and Early Chemistry,* 8 (1960), 125–66. The importance of the concept of sympathy in general is treated by Roy R. Male, "Hawthorne and the Concept of Sympathy," *PMLA,* 68 (1953), 138–49.

[29] "Alchymy," p. 109.

NOAH IN INTERNATIONAL WATERS

KATHY PIEHL
Center for Children/Young Adult Books
Mankato State University, Minnesota

Tales of a huge flood sent by the gods appear in cultures throughout the world. North American Indians and Siberian peasants each have a legend about how a small group of animals and people were saved from a watery death. However, the two most famous accounts come from the Middle East. The *Epic of Gilgamesh* from Babylon tells how the King and his family were spared from the wrath of the storm god by heeding the instructions of the god of water to build a giant boat. More familiar to people in Western cultures is the Genesis account of Noah and the great flood.

Noah's story is the Old Testament tale most often retold in picture books. In fact, dozens of versions have been produced by authors and illustrators in the United States. But the fascination with Noah's story continues in other parts of the world as well, as a number of picture books demonstrate. Indeed, the continuing interest indicates that Noah indeed sails in international waters.

Probably the most familiar Noah's ark picture book, at least to audiences in the United States, is the one by Peter Spier, which won the Caldecott award in 1978. But even those who have examined Spier's book may have forgotten that he chose as its "text" a 17th century poem by Jacobus Revius, which he translated from Dutch to English. Using this poem from his native country, Spier amplifies both its simple text and the Biblical version through his marvelously detailed and evocative illustrations. The poem's long list of boarding animals, including

Cow and moose,
Hare and goose,
Sheep and ox,
Bee and fox

is reflected in pictures of the loading of the ark which teem with all kinds and sizes of animals. But neither the poem nor Spier ignores the reality of those who could not get on.

But the rest,
Worst and best,
Stayed on shore,
Were no more.
The whole host
Gave the ghost.
They were killed
For the guilt
Which brought all
To the Fall.

The illustrations show a throng of animals, young and old, watching the ark as the flood water rises. Inexorably they are covered, even those which climbed into trees to escape.

Spier's imagination takes over in his pictures of life on board since neither the Bible nor Revius' poem supplies details of the trip. But the reader senses the "rightness" of the portrayal because it is consistent with our knowledge of animal life. The animals must be fed and their stalls cleaned. They give birth, some, like the rabbits, with remarkable regularity. And they rejoice when the dove returns with green leaves. Spier enriches the reader's understanding of Noah's story, and the book well deserves its Caldecott medal.

As might be expected, the book that adheres most closely to the Old Testament comes from Israel. Yael Guiladi stresses God's anger about what people had done to his world, an emphasis apparent in most books that give God a prominent role. In Guiladi's version, God had given people a "general idea of how He expected them to behave,'' but they became wicked, dishonest, cruel, and corrupt. When God plans to destory the world, he tells Noah to take a pair of most animals but seven pairs of clean animals. This injunction, which is found in Genesis, is ignored in most retellings of Noah's story but would have significance for Jewish readers because of their religious practices. Other parts of Guiladi's story, such as the exact specifications of the ark's dimensions, reveal a faithfulness to Old Testament details not observed in most versions. The illustrations portray Noah and his family as inhabitants of the Middle East. All have slightly slanted eyes and dark hair and complexions. The women have large earrings and cover their heads with a garment that extends to their feet.

The illustrations for Swiss poet Max Bolliger's retelling also have an Eastern feeling. Helga Aichinger has used spare figures and muted colors to accompany Bolliger's text, which is close to Genesis. Again God is a dominant force, displeased with people because they disobeyed and then laughed at Noah for his obedience. "Their scorn did not trouble Noah. But God was angry with them because they did not fear Him, and because they laughed." These scoffers die a horrible death, as Bolliger emphasizes when he describes their flight to the hills and mountains in a futile attempt to escape. Dead bodies float in green and purple water in Aichinger's gruesome depiction of their fate. Bolliger's account of the trip's length and the various flights of raven and dove follows strictly the Genesis version. When the water recedes, all that people had built and planted has been destroyed. Certainly this is a grim tale, particularly for a picture book. But then Bolliger offers his readers hope, the same hope Noah feels looking at God's rainbow sign.

> God heard Noah's prayer of thanks
> He looked at the ruined earth
> and had pity
> on Noah, whom He loved,
> and on his family—
> his wife,
> his three sons,
> their wives,
> and children,
> and all the children of these children,
> who were not yet born.

This stress on life's continuity is clear in the picture of a small boy and girl playing with a miniature ark in a puddle. Noah and his family were spared so that life could go on.

Two more recent stories, also originally written in German, display similarities to Bolliger's retelling. Gertrud Fussenegger shares Bolliger's emphasis on the wickedness of humankind and its horrible destruction. In her story Noah prays every night that God would keep him safe from people who "lied and cheated and hurt one another . . . beat defenceless [sic] people with whips and sticks." These wicked men and women mock Noah and his family until the rain starts to fall. Then they pack their gold and head for the mountains. Inside the ark Noah hears their "pitiful wailing" as even "the last and strongest of the people, who had clung to the treetops or climbed mountain peaks, were washed away and drowned." Life on board the ark has its own discomforts, but at the journey's end, Noah and his family praise God for their deliverance and receive his rainbow and promise not to destroy the world again with a flood.

Margrit Haubensak—Tellenbach also includes the destruction of the doubters, who "cried and screamed and banged on the ark" as the waters cover them. But her account shares another theme with Bolliger's as well: the continuation of life. Animals give birth while they journey on the ark, and as they depart, Noah instructs them to "'Go and have lots of children.'" Two double-page spreads, one on shipboard and one on land, emphasize the theme. The pages are jammed with animals and their young in illustrations by Erna Emhardt, one of Germany's foremost "primitive painters."

The concern with reproduction is strongest in an Italian version by Jolanda Colombini

Monti, who emphasizes what happens *after* the flood. Once God has explained about the rainbow, the animals start to leave the ark. God instructs them to "wander over the Earth, grow and multiply." Many of them do not need those instructions. Baby mice and rabbits leave the ship with their parents. The text mentions that "even the ostrich alighting from the Ark showed Noah a little baby ostrich just a few days old who was still a little unsteady on his huge legs." The fertility of the animals is even more apparent in the fold-out illustration in which almost every species has been eager to follow God's command to "raise a family and multiply the species." This emphasis does not seem unusual for a country that is heavily Roman Catholic, particularly when we note that it was written in the mid-1950s. Another part of the story that seems to indicate the religious influence is the ending in which Noah becomes a farmer who is the first to discover the importance of bread and wine. Although Genesis acknowledges that Noah planted a vineyard, and Spier shows him on his hands and knees setting out vines, Monti is the only author to give such prominence to this part of the tale, linking it to the Roman Catholic sacraments.

Another strongly religious retelling comes in a Liberian version of Noah's story. While Lorenz Graham was in Africa, he heard the native people telling stories from the Bible, "recreating the tales in their own environment and telling them in their own words." In their version, God plays a crucial role. They begin by tying Noah's story to the creation.

> God make the time for Him Own Self.
> He make the rain
> He make the dry and wet.

Disappointed and angered by what people are doing to His creation, God decides that He must try again. He visits Noah and instructs him about preparations for the flood, then becomes an active participant in the boat's construction.

> God come walk about inside the ship
> And Noah hear God's Word and mind.

He advises Noah about bad boards that need replacement, locations of rooms, and other details. In keeping with the African origin of this version, the illustrations depict Noah and his sons as blacks and the boat as a kind of basket that might have been constructed of materials found in a tropical region. Noah and his sons fell palm trees to get building materials. When all the animals are on board in accordance with God's instructions, He makes the rain fall. After He is certain that everything has been destroyed except for Noah's ship, He opens new holes in the sea to drain away the water, sends dry winds to sweep the world, and sets the ship down softly. There are no raven and dove in this version. God is the one who provides for Noah and his company, and the flood has been for His benefit, giving a way to start again, as the book's ending makes clear:

> And in the sky He set Him bow
> And turn to make a better world.

The African story ignores the raven and dove but stays close to Genesis in plot and moral. A Japanese picture book gives the two birds a prominent place, and in so doing demonstrates how modern authors often move away from the Biblical tale. In 1964 *Pooke and Kark in the Ark* by Sekuja Miyoshi was voted the outstanding picture book in Japan. Although Miyoshi includes other animals in his story, he concentrates on two birds: Kark the crow and Pooke the dove. After God tells Noah that a drought will be followed by heavy rains, Noah constructs an ark and begins collecting animals. His neighbors laugh at the strange vehicle which looks like a large wooden box due to Noah's inadequate building skills. Kark refuses to board because his forest home is on a hilltop, and he is convinced no flood can reach it. Pooke urges him to follow Noah, and eventually the crow is forced to join the other animals on the boat. After the rain ends and the boat drifts for 150 days, the animals get restless. Kark decides to find land, and when he does not return, the animals begin to worry. Pooke volunteers to search for him, and eventually she finds dry land and Kark. Unlike the crow, she feels obligated to return to her shipmates. On the return trip she gets tired and cannot find the ark. Then she sees the rainbow, which gives her new energy. "She flapped her wings with all her strength, and passed under the rainbow toward the ark."

Miyoshi has kept many of the Biblical elements but given prominence to two birds which figure in that tale. They act independently of Noah and have definite personalities. The illustrations are brilliantly colored and exhibit a fine graphic sense. Bright orange, purple, brown, blue, green, and other hues are arranged in patterns that make the reader aware that this book is a product of the "modern" period which revises an ancient story. Yet Miyoshi's contrast of the believer versus the doubter echoes a theme of the original account. Here the contrast is between two birds instead of between Noah and his neighbors.

Like Miyoshi, Isaac Bashevis Singer uses the dove as a central character in his tale about the ark. Just as Spier returned to the language of his youth to find a text for his work, Singer used his childhood language, Yiddish, and let Elizabeth Shub translate the work into English. While Noah and his sons construct the boat at God's command, the animals argue because they "had heard a rumor that Noah was to take with him on the ark only the best of all the living creatures." Each stresses his own virtue such as strength, beauty, or cleverness. Almost the entire book is devoted to their bickering. Finally Noah appears and sees a dove silently perched on a branch. It explains why it didn't brag by saying, "'Each one of us has something the other doesn't have, given us by God who created us all.'"Then Noah tells all the animals that they can come on board, but because the dove had been modest, Noah chooses it to be his messenger. The flood itself doesn't appear. The text simply skips to the time when the rains stop, and Noah keeps his word by sending the dove. The story ends with the moral that "there are in the world more doves than there are tigers, leopards, wolves, vultures, and other ferocious beasts. The dove lives happily without fighting." Although Singer mentions God's promise not to destroy the earth again because of sin, the focus of Singer's tale is on the dove and the example it provides. His tale is designed to teach a moral that is not explicitly stated in the Old Testament but which he obviously feels is important for contemporary readers.

Similarly, British author Brian Wildsmith adapts Noah's story to address a modern problem, man's destruction of the natural world through pollution. While Wildsmith looks back to the ancient story for his central idea of the survival of animals from extinction, he sets his own tale in the future for a type of "science fiction" story of Noah. The animals who live in the forest are threatened by air pollution and meet to decide how to escape. Owl reports that he has seen a "huge and wondrous object" being built, and when the animals investigate, they find Professor Noah, who is constructing a spaceship to take the animals to another planet where the forests "'will be as beautiful as our forest once was before it was spoiled by pollution.'" The animals help Noah's robots finish the task and prepare for the voyage of 40 days and 40 nights. They clamber on board to escape a terrible forest fire set by man and blast into space. In the take-off a time guidance fin is damaged, and an elephant must don a spacesuit to adjust it for their voyage into the future. However, he miscalculates, and the ship is propelled backward. After they land, Noah realizes that the leaf the dove brings from her exploratory mission is from Earth—but what a difference! They have landed on Earth "as it was many hundreds of years ago, before it was polluted." As the animals emerge from the ship, the otter comments that there seems to have been some flooding.

While the problem and solution Wildsmith uses are "modern," his retention of certain conventions clearly reveals his awareness of the original: 40 days and 40 nights, the dove as explorer, the watery world. As in Miyoshi's and Singer's books, the animals here are active participants in the advancement of the plot. In fact, Noah is the only human and does not even take his own family on the voyage. Like all Wildsmith's picture books, this one is brightly colored. The many animals in the story give him a chance to exhibit his considerable talent in drawing wildlife.

The animals tell their own story in another English picture book about Noah by George Macbeth. In fact, inanimate objects get to speak too. Macbeth offers a series of short poems, each about a different plant, animal, or object encountered in Noah's story. After the descriptive poem *about* the story element, the subject makes its own comment on the situation. Oak and pine speak during the "Building of the Ark." Then 11 animals have their say while they enter. For example, Noah has this conversation with a roly-poly bear.

> are you there? Why you smell
> of honey. You voracious small bear!
> Why have you come with your paws all
> sticky? Go down to the sink.
> You must dance for your
> supper, and it won't be sweets.
> Coarse brown bread for omnivorous
> bears. And a beaker of brine
> if we have to keep washing you in drinking water.
>
> I am sorry, Noah. But I grew
> quite faint. So I stopped by a hive
> for a rest and a meal.
> Let me give you a hug.

During the storm a "Battle with the Elements" pits Noah against thunder, lightning, rain, and wind as all the creatures on board suffer.

> rain
> is the one who goes on. He is flung
> pita-pata-pita-pata from a
> tipped bowl of dry peas. Wet fur,
> wet wood, wet wings, wet canvas: the
> whole wide world is awash in a
> sluice of beans. Rattle, rush.
> Down comes the roof in a slush
> of cold glass bits. Below decks
> glum beasts peer out and steam dry slowly.

Finally, sand, rock, and grass welcome the voyagers when they come safely to their "Landing of Ararat." The dove and the raven feed peacefully in the thick grass filled with flowers, worms, bees, ants, butterflies, and a spider. Two pages of poetry are followed by two pages which illustrate the subjects of the verse. The ark is invariably portrayed as a small vessel, whether dwarfed by the whale that swims beside it or buffeted by wind.

Macbeth's use of short poems based on Noah's adventure is reminiscent of a much earlier English version by Fish, published in 1918. Each short poem is on a different topic, and the author claims that he was told about the trip by a teddy bear named Redder.

> He knew the Noahs very well
> And went with them to sea,
> And all that I am going to tell
> Young Redder told to me.

All the animals look as though they had stuffed toys as models, and even the people look like wooden dolls. The journey is idyllic, with time for the animals to swim in their striped suits and enjoy the outing immensely, rather as though the ark were a well-appointed yacht.

This portrayal of the ark as a kind of cruise ship appears in a modern British version of Noah's story by Judy Brook. After Noah learns about the impending flood from a well-informed dove, he hurriedly constructs a giant ship, complete with striped sails and a royal lion masthead. Noah and his family are sturdy English peasants, used to handling farm animals. The women have a cozy farm kitchen on board and geraniums in the windows. Rather than bringing the animals to the ark, the Noah family sails around the world to rescue a pair of each kind. They take polar bears and walrus on board before the ice floes melt and ferry zebras and lions from mountain tops. Each day the animals run around the deck for exercise and hear Mrs. Noah's bedtime stories. When land is sighted, everyone gratefully takes "a lovely hot sunny holiday" on the African coast, where the Noah family members lounge in beach chairs. Then the ark completes another round-the-world voyage to return the animals, who "always felt so sad when the Ark left them, they were almost sorry the flood was over." Clearly, Brook's story lacks any sense of punishment or destruction inherent in the original.

The same barnyard adventure format is obvious in *Norah's Ark,* also from Britain. Norah and her animals learn of the impending flood from a TV weatherman. They turn the barn upside down to form a makeshift boat and have a "holiday afloat." Despite a few minor complications, no one is hurt, and when the water subsides, the animals and their owner are left with an enlarged pond, something they had wanted for a long time. Like the rest of the British books, this lacks any theological dimension. Instead the flood is simply a diversion from everyday activities.

A similar attitude is evident in two French versions. The first, by Matias (Charles Henriod), has Noah invite all the animals to board his multi-storied yacht, which resembles a tiered apartment building. On top is a little house for Noah's family. The animals tell each other stories, and at night they "were very good and slept without making a sound." When the sun shines after 40 days, the elephants tip the ark to one side with their jumps of delight. The animals rush to disembark on Ararat and return to their countries when the water has receded. Because no reason for the flood is given and no word of hope offered at the end, despite the rainbow that appears in the sky, the story seems flat and strangely without purpose. Noah in his red beret and his wife in her long blue apron are undeniably French, but the illustrations are almost as unsatisfactory as the text with blobs of bright colors scattered randomly over figures drawn with black ink.

The other French version, by Etienne Delessert, reveals its kinship to some of the English versions in its title, *Sans Fin La Fete.* The party is to celebrate the launching of Captain Noah's boat, and the crows deliver the party invitations. All kinds of animals converge on the ark for a sea cruise. They eat cake and ice cream and watch the snake do acrobatics. The party is fine until they decide to hold a jumping contest. The flea jumps so high that it hits the sun in the eye, and the uncontrolled tears lead to a serious flood. The animals retreat inside but continue the party with story telling. As the days pass, they play games, take turns steering, and hold concerts, but eventually they become restless and irritable. They play practical jokes and plan a mutiny. While Noah listens to the centipede tell story after story, the seal changes course. The dove, a peaceful creature, dislikes the mutiny and flies in search of land. Soon she returns with a branch and a *postcard* showing a mountain she discovered. The animals once again have reason to celebrate.

Probably the strangest detail in the illustration of this version is the "human" sun which has facial features plus suit-coated arms and hands. His two-fingered V salute after the rain ends resembles the gesture of a politician, particularly since he also displays a toothy grin. Even this bizarre account reveals its derivation from the original Noah story although the elements are definitely transformed. For example, the rainbow appears at the end in the guise of a chameleon that "turned every color of the rainbow." The Biblical interpretation of its presence as a sign of divine promise has been replaced by a natural phenomenon. As in many of the books already discussed, God simply has no role.

Although these secular versions may be designed to satisfy modern audiences who no longer believe in traditional religion, the stories are unsatisfying. By removing God and religious overtones, the authors have removed much of the conflict and drama as well. Good and evil, struggle against the elements, rebirth and hope for the future are all part of the original story. The idea that representatives of all earth's animals could be crammed on a single vessel and somehow survive an overwhelming catastrophe is incongruous, unbelievable . . . and yet, we want to believe that escape from destruction is possible. Like the believers in various gods who told the original legends, we maintain our fascination with the story of one family that sailed the endless sea when the world was just beginning.

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THE ACCOMPLISHED LADY IN THE ENGLISH NOVEL

Susan Schoenbauer Thurin
English Department
University of Wisconsin—Stout
Menomonie

When Dorothea Brooke visits the Vatican museum on her honeymoon in Rome, she is seen by an artist who identifies her as a perfect model for a madonna. Romola, who is repeatedly apostrophized as a madonna, poses as Ariadne for a portrait. These descriptions of the heroines of *Middlemarch* and *Romola* as devotional figures and art objects allude to a view of woman often expressed in eighteenth- and nineteenth-century English novels, that a woman may be judged according to her ability to resemble a work of art, to emulate the idealized portrait of womanhood society holds up to her. Put another way, woman's aim is supposed to be self-perfection, with woman herself as both artist and artifact: To be a thing of beauty is the traditional role assigned her. However, just as the standard of beauty changes over the course of a century, so do the specifications of the traditional role. These changing specifications are illustrated in the characterizations of the accomplished lady in the English novel.

The ideal of the accomplished lady in the eighteenth-century novel incorporates an ornamental education with genteel housewifery, the willing acceptance of which is indicative of the moral character of the lady in question. The accomplishments of the lady include both the practical and the decorative crafts such as needlework and china painting. Because young ladies were taught music and drawing for specific domestic application rather than for purely aesthetic purposes, these too adorn the accomplished lady. For she ought to have been able to decorate her home with objects of her own making as well as be personally ornamental in her beauty, dress, conversation, and ability to entertain by singing a popular song or playing a reel for an evening's dance. In the nineteenth-century novel, this woman's role is still pervasive, but is accompanied by a dramatic change in the value assigned woman's work. As a result of this revaluation, woman's accomplishments increasingly go beyond the domestic sphere as a means of personal success.

Authors use fine distinctions within the range of activities accorded women to indicate the position of women in society, reflect upon changing marriage ideals, promote self-esteem among their heroines, and comment upon woman's contribution to society. The didactic attention given to women's accomplishments in the eighteenth-century novel makes them an easy target for satire in the nineteenth-century novel, but also evolves into a reassessment of the value of woman's work, the domestic craftswoman, and the woman artist. This evolution in woman's work and role forms the basis for the ensuing inquiry. Surveying a broad range of novels, including work by Richardson, Fielding, Burney, Austen, Dickens, Thackeray, the Brontes, and Eliot; and relying on the conduct books and Ruskin as reference points about the perceived role of women in the eighteenth and nineteenth centuries; I trace the evaluation of woman's work by focusing on the accomplished lady.

The conduct books present ornamental accomplishments as woman's duty along with piety, maidenly virtues like modesty, and domestic skills. The *Ladies Calling* juxtaposes ornamental and housekeeping skills with religious piety by advising women to "secure themselves by a constant serious

Employment'' with that which is ''worth their time: wherein as the first place is to be given to the Offices of Piety'' and next

> the acquiring of any of those ornamental improvements which become their Quality, as Writing, Needle-work, Languages, Music, or the like. If I should here insert the art of Economy and Household Managery, I should not think I affronted them in it; that being the most proper Feminine business, from which neither wealth nor greatness can totally absolve them.[1]

Further, the conduct books reason that the purpose of acquiring feminine accomplishments is to secure a husband as *The Ladies Calling* indelicately adjures: ''An old maid is now thought such a curse as no Poetic fury can exceed, look'd on as the most calamitous Creature in nature'' (II, i, 3). A few generations later, Hester Chapone softens the phrasing, saying that a lady's accomplishments will make her ''so desirable a companion'' that ''the neglect of them may reasonably be deemed a neglect of duty.''[2] According to this circular reasoning, then, a woman's duty includes becoming both accomplished and a wife, one dependent on the other.

While the focus of the various conduct books varies, they all provide advice on the same range of activities.[3] Hester Chapone's list has more breadth than others, for she argues that women are capable of a more demanding education than is usually afforded them. She emphasizes the need for reading on the subjects of religion, history, poetry (particularly Shakespeare and Milton), nature studies, moral philosophy, and books on taste and criticism in order to be a good conversationalist; dancing and French as of equal importance; Italian—optional; handwriting and common arithmetic ''indispensable''; music and drawing ''as genius leads''; and a warning against the study of classical languages (III, 129-174). *Sermons to Young Women* makes a virtue of developing these accomplishments. For example, rather than simply recommending drawing and music to those who have talent, Fordyce advises young women to take up these arts as a means of entertainment for themselves and others, as well as to prevent the folly and sin proceeding from idleness. If the lady be a musician, her art must have an inspirational value. Her music should ''prove a kind of prelude to the airs of paradise.''[4] Fordyce finds a ''moderate and discreet use'' of dancing tolerable since dancing is connected with Old Testament worship, but also because the dancer is a work of art. Dancing promotes health, good humor, sociability and ''that easy graceful carriage, to which Nature has annexed very pleasing perceptions in the beholders'' (I, 226).

On the subjects of dress and needlework, Chapone suffices with a few words about economy and good sense, but the male conduct book writers expound on the duty and virtue in them. Fordyce goes so far as to recommend that women do needlework during conversation so as to be continually busy and as a buttress against the emptiness and gossip to which conversation can descend—almost as if the needlework were a simultaneous reparation for the sinful conversation. He adds, of needlework, that ''We find it spoken of in scripture with commendation'' (I, 239 and 249). The kind of advice in *Sermons to Young Women* did not go unnoticed—Fanny Burney, Susan Ferrier, and Jane Austen all allude to the work. Mary Wolstonecraft's reaction is more encompassing: ''It moves my gall to hear a preacher descanting on dress and needlework.''[5]

Several novels seem to put to deliberate application some of this conduct book advice on the efficacy of education and acquiring of grace, polish, and skills in order to become a companionable wife by emphasizing its importance in the courtship process. Some of Austen's heroines display their individuality and intellectual acumen—and thereby their marriageability—by debunking the poetry of sensibility and carrying on critical conversations on literature. The heroines of *Pride and Prejudice* and

Persuasion are thus quite different from the young ladies in *Evelina* who are silenced by a rebuke for expressing their criticism of a bawdy comedy. In a Victorian novel, Charlotte Yonge's *The Heir of Redclyffe,* the young Morvilles and Edmonstones are idealized for putting their education to good use by engaging in long and frequent literary discussions.

Besides serving as a lure for prospective husbands, developing the lady into a display object, and refining her virtue, feminine accomplishments have a practical-religious application in the form of philanthropy. Novelists and conduct book writers alike wax eloquent on the desirability of young ladies saving some of their pin money for good works among the poor.[6] Burney's heiress-heroine Cecilia does this in a grand way by supporting several deserving poor folk and educating impoverished young girls. In Susan Ferrier's *Marriage, A Novel,* the exemplary Scottish lady, Mrs. Douglas, busies herself knitting stockings for poor children during the hours devoted to conversation (heeding Fordyce's advice), and turns her husband's wild Highland farm into a scenic wonder by directing the labor of otherwise idle and useless children under the age of twelve. Austen scales down such enterprising generosity in *Persuasion* where the invalid Mrs. Smith earns the admiration of the heroine by selling her needlework in order to help support families even poorer than herself. Even Anne Bronte's pathetic governess-heroine, Agnes Grey, derives her only satisfaction from her charities among the poor cottagers. George Eliot, in contrast, alludes to the hypocrisy in this kind of philanthrophy by making Dorothea's relatives obstruct or ignore her attempts to give away money and design more habitable cottages for her tenants. Dorthea finally realizes that she is using the poor and even her own charitable instincts to find an occupation for her time.

The early novelists mirror the values of the conduct book writers by portraying an easy acceptance of traditional woman's work—accomplishments, education, duties—as the hallmark of an approved character, while making a woman's rejection of it a signal of her unwomanliness or immorality. Richardson's *Sir Charles Grandison,* for example, affords numerous instances when women's traditional duties are discussed in relation to their education. Harriet Byron, the heroine, was taught French and Italian as well as feminine virtues like "not to start subjects."[7] Despite her observance of this modesty, she is assigned the task of debating the pedant Walden to whom she not only proves equal in intelligence, but also defends the world as a university since women are forbidden admittance to the formal university. However, Harriet's eloquence is carefully complemented by her cultivation of feminine crafts and housewifery, even when she becomes the wife of an extremely wealthy baronet. Miss Clements, a very learned lady in the same novel, wonders why knowledge, if it "makes a man shine, should make a woman vain and pragmatical," yet she too excells in housewifery (I, 69). In Richardson, approved characters universally uphold the right of women to be educated as ability and desire prompt them, but never at the expense of traditional women's work. Echoing *The Ladies Calling,* cited above, Richardson writes to a friend that a woman who despises domestic duties "is good for nothing."[8]

Fanny Burney supports Richardson's view of the learned woman by her attack on the learned Mrs. Selwyn in *Evelina,* albeit her wit and repartee evoke a certain amount of silent admiration in the circumspect Evelina and mortify her male party—Burney firmly advocates more emphasis on modesty than agility in conversation. Evelina spends a good deal of her time in dressing her hair and attiring herself appropriately for the various social functions to which she is introduced (not surprisingly, for Fordyce devotes much of one of his first sermons to the subject of women's dress). She minds her table manners, learns the decorum of the

Ranelagh tea room, the Vauxhall gardens, the Bath parties, and practices the art of letter writing. In short, she becomes a lovely ornament, thereby earning herself a titled husband and exercising her moral virtue at the same time. In *Camilla,* Burney shifts the focus away from the cultivation of social graces and toward the development of the fine moral distinctions and domestic crafts in her heroine, though the results for Camilla are the same as for Evelina. While the beautiful Camilla devotes herself to morality, housekeeping, and needlework, her younger sister, physically handicapped as a result of a childhood fall and scarred from small pox, studies classical languages and literature which her family feels is appropriate since they consider her unmarriageable. To complete the paradigm, then, Camilla marries a moral paragon who is also a wealthy landed gentleman, while her sister is cruelly deceived by a fortune-hunting rake.

Tom Jones and *Sir Charles Grandison* associate women's accomplishments with the marriage ideal by linking the accomplishment specifically to submission to male authority. The striking example is Sophia's filial devotion to her much-inebriated, coarse, and violent father which she demonstrates by cheerfully playing over and over his favorite bawdy songs without ever becoming the least tainted by them. Sophia's incorruptibility is directly linked with her ability to delight her father, be a dutiful daughter, and play the harpsichord. Her ornamental accomplishment is thus related to her submissiveness, her most admirable quality, according to Squire Allworthy, and that which makes her an ideal marriage partner. Even Sophia's riding to hounds with Squire Western is adduced as an act of submission to please him because he likes to have her with him as much as possible; Sophia would rather read a book, since the sport is too rough for her. Allworthy apostrophizes her for this quality as "an inestimable Treasure to a good husband," since "she always shewed the highest Deference to the Understandings of Men; a Quality, absolutely to the making a good Wife."[9]

Several of Richardson's female characters protest the inequalities between men and women, but they find approval by finally submitting to male authority. Harriet Byron is incensed when Greville, one of her early suitors, attempts to exert control over her by following her to London. Later, as Lady Grandison, she commiserates with Clementina being bullied by her brothers into marrying, "as if she were not to have a will" (VI, 151), yet she chastizes Charlotte for calling her marital squabbles a "struggle for my dying liberty" (III, 390). Moreover, she entirely approves when a newly meek Charlotte turns over her personal kitty of fifteen hundred pounds to her husband as a symbol of her acquiescence to masculine authority. Finally, though offended when called upon to sing a song ridiculing the ability of women to remain constant, Harriet fulfills the request; she is one of Sophia's sisterhood, after all.

The eighteenth-century ideal of women's accomplishments as ornamental and synonymous with a high moral sense, purity, and passivity, undergoes a dramatic revaluation in the nineteenth-century novel. Austen, Thackeray, Bronte, Dickens, and Eliot all assail the value of ornamental accomplishments in order to redefine woman's role in society. Austen objects to the purely ornamental education promoted by popular moralists and novelists alike on the basis of its indefensible intellectual vacuity. The great danger in the superficial education aimed at making women display objects lies in its contamination of the moral and intellectual training afforded women also. When Emma puts her slim talent for drawing to use as a matchmaking device for Mr. Elton and Harriet, she displays ignorance of her limitations as an artist and vanity in her understanding of other people's feelings. Similarly, in *Pride and Predjudice,* Mary

Bennet's musical performance embarrasses Elizabeth less for the eagerness of its display than for the affectation and conceit which it manifests. Mary's intellectual pretentions are absurd, not because she represents the learned woman so derided in the eighteenth-century novel, but because, being deficient in understanding, she is reduced to shallow moralizing and half-understood quotation from old conduct books. Her display is little different from that of Miss Bingley who likes to walk about a room to show off her figure. Worse, the display of their slim talents has made these women vain.[10]

The conversation at Netherfield about what constitutes female accomplishments contains the gist of Austen's ideas on the subject. Bingley asserts that netting purses, covering screens, and painting tables show how accomplished young ladies are. Miss Bingley elaborates:

> "No one can be really esteemed accomplished, who does not greatly surpass what is usually met with. A woman must have a thorough knowledge of music, dancing, drawing, singing, and the modern languages to deserve the word; and besides all this, she must possess a certain something in her air and manner of walking, the tone of her voice, her address, and expressions, or the word will be but half deserved."
>
> All this she must possess," added Darcy, "and to all this she must yet add something more substantial, in the improvement of her mind by extensive reading."
>
> I am no longer surprised at your knowing only six accomplished women. I rather wonder now at your knowing any."[11]

Elizabeth's rejoinder is sometimes taken as an ironic confirmation that Miss Bingley's definition of accomplishments is correct. Taking into consideration the qualifiers "thorough," "a certain something," "more substantial," and "extensive," Elizabeth's irony must be seen first of all as a plea for reasonableness. She is not necessarily adverse to the basis on which the worldly judge sophistication, but her irony does imply a criticism of sophistication as being necessarily desirable.

Notably, the above quotation from *Pride and Prejudice* discusses the definition of "accomplishment" without association with virtue. Nor does Austen connect the degree of accomplishment in a young lady with her desirability as a marriage partner—the most accomplished ladies lose the hero as Mary Crawford and Caroline Bingley illustrate. In these ways, then, Austen departs radically from the way in which ornamental accomplishments are treated by earlier writers; however, this does not mean that she rejects the value of traditional women's work. Austen satirizes the definitions offered by Bingley and his sister because of the narrow range and unintellectual nature of activities they accord women, but she does not attack the activities *per se.* Elizabeth Bennet takes up a piece of needlework as often as a book during evening hours at Netherfield when the conversation takes a frivolous turn. The needlework of Fanny Price, the nursing of the sick by Elizabeth Bennet and Anne Elliott, the babysitting of Jane Bennet and Anne Elliott, the household management of Emma Woodhouse and Elinor Dashwood, as well as the musical and artistic abilities of characters like Jane Fairfax all recommend the characters within the context of the novels. Austen is well aware that the daily requirements of the home must be met, and she accepts this as woman's role.

Austen's neutral presentation of ladies' accomplishments is followed by Thackeray's associating accomplishments with vice. In *Vanity Fair,* Thackeray develops a bifurcated Sophia Western in his dual anti-heroines, relegating Sophia's liveliness to Becky Sharp and her submissiveness to Amelia Sedley, then filling in the other half of the characterizations with egoism, vanity, vice, and shallowness. Becky and Amelia, like

Sophia, are musicians of sorts, but there the similarity ends. To Amelia, the piano gives pleasure to no one but herself. Significantly, the piano itself rather than any music she might produce on it interests Amelia, for she is convinced it is a gift from George. Thus Thackeray uses the paradigm from the eighteenth-century novel to reveal the vanity and folly of the character. The sentimental Amelia cannot perceive George's indifference or that he would be incapable of such a generous gesture as retrieving her piano from the auction block. The piano becomes one of the items in her shrine to George's memory that helps her avert a romantic involvement with Dobbin.

By contrast, Becky Sharp uses her accomplishments to secure social success. She captivates Jos Sedley with sentimental love songs, later entertains gentleman callers at her soirees with her music, once moves Lady Steyne to tears by her rendering of the Mozart religious songs, and unsuccessfully tries to support herself by singing professionally. The best that can be said of Becky in these instances is that she manages her own destiny; she is active and resourceful on her own behalf. But Becky's activity is as full of guile as that of the rest of Vanity Fair. Through her manipulations she provides for her little family "on nothing a year" while incurring little guilt and a great deal of debt. Ironically, of course, Becky's conventional gentlewoman's ornamental talents derive from her bohemian background which ordinarily would be a deterrent to her social goals. If the emptiness of ornamental education is satirized by Austen, Thackeray clearly links it to hypocrisy and immorality.

Thackeray also reverses the association of feminine accomplishments with the marriage ideal illustrated by Fielding. Sophia's submissiveness is replaced by Becky's predatoriness and Amelia's self-pitying manipulation. As a result, Becky stalks the innocent and decent Mr. Crisp as well as the preposterous collector of Boggley Wollah. That her values coincide with those of her society, however, is indicated by the fact that no one questions the latter match—Amelia is all sentimental flutter over the prospect; Mrs. Sedley regrets only the lowness of Becky's parentage, and George interferes out of snobbery. In view of Becky's goals, it is ironic that in marrying Rawdon she both secures a fairly compatible husband and fails to make an economically advantageous match. Amelia, on the other hand, ostensibly modest, submissive, and self-sacrificing, has two-edged virtues; their possessor is morally flaccid. That these virtues are counter-productive is nowhere so clearly revealed as when they manage to get her George Osborne for a husband.

While James Fordyce preaches needlework as a woman's moral obligation and Jane Austen accepts it as a fact in woman's life, Thackeray turns it into a display of hypocrisy and vanity. Whenever Becky wants to appear domestic, she applies herself to a dirty rag of a shirt she supposedly is sewing for little Rawdon. Amelia, on the other hand, assiduously cuts up all of her own clothing into clothes for little George. Becky's lack of interest in her son is as extreme as Amelia's smothering care of hers, and both attitudes are indicated by the abuse of a traditional woman's craft. Thackeray also explodes Fordyce's dictums about the moral and practical applications of drawing as a lady's occupation. As an impoverished young widow, Amelia thinks of selling her art work as a livelihood. Not only is the market glutted with amateur art, but Amelia's pathetic and childish pictures get no buyers. Her naivete about the value of her work soon turns into despair in her situation.

Dickens completes the dismantling of the old mythology regarding women's accomplishments, and along with other Victorian novelists, revalues women's crafts in relation to woman's role in society. In *David Copperfield,* Dora, modeled after the eighteenth-century ideal of the genteel lady with an ornamental education, exposes the impracticality of the ideal. Dora paints flowers while meals go unprepared, the servants pilfer from the larder, and Jip, her dog, wreaks havoc in the house. She uses her cookbook as a prop for one of Jip's tricks and bursts into tears when David attempts a few lessons in household accounts. The "indispensable" handwriting recommended by Hester Chapone, proves equally useless to Dora who copies David's manuscript by ending each page with her beautiful signature as if it were a school exercise. According to the old formulas for domestic order, the husband's duty is to develop his wife's abilities, but Dora is impervious to such help, subverting David's remonstrances by her alternate affectionate cajolement and irrational outbursts. The old ideals for the conduct of life simply do not work in *David Copperfield.*

Instead, David slowly comes to understand that the sister-angel-helpmeet, Agnes, represents the new ideal. Significantly, she is more desirable because she is more useful; her domestic accomplishments make life comfortable. She flourishes in motherhood while Dora is killed by it. The description of Dora's stillbirth is revealing: "I had hoped that lighter hands than mine would help to mold her character, and that a baby-smile upon her breast might change my child-wife into a woman. It was not to be."[12] David is interested in the efficacy of motherhood as an improver of character, but "It was not to be." Dora dies a short time after her stillborn child.

David's marriage to Agnes results in a redefinition of the feminine ideal. Romantic love, represented by David's marriage to Dora, leads to the loss of sexual innocence which in turn proves to have destructive emotional and physical effects, so David "disciplines" his heart to prefer a nonsexual mother-woman like Agnes. Agnes is the reliable counsellor to whom David turns for advice from childhood through his courtship and marriage to Dora and years of loneliness and spiritual growth. Agnes, with her little basket of keys, her father's competent housekeeper, becomes the preferred ideal. In David's second marriage, the more private and self-centered aims are submerged in the public roles of spouse, parent, and worker, epitomizing the individual as a thoroughly useful member of society.

Being useful and doing useful work is crucial to the ideal which Agnes represents. While her domesticity and motherliness might at first seem to be little different from the eighteenth-century ideal suggested by the typical happy-ever-after ending of novels like *Tom Jones* and *Sir Charles Grandison,* there is a difference. In the earlier novels, the usefulness of women's work ranks below the virtue with which it is performed—Lady Grandison's feminine submission and sense of moral obligation to be efficient and economical in her housekeeping surpass the usefulness of the work which she actually performs (the housekeeper seems to have kept up the grand establishment perfectly well for years before the arrival of Lady Grandison). However, in the work ethic promoted by Dickens and the other Victorian writers, characters actively respond to forces which affect their lives. To illustrate, when Agnes' father has financial misfortune, she takes the initiative by starting a little school.

The values approved in *David Copperfield* parallel those promoted in Ruskin's "Of Queen's Gardens," a central document on Victorian values. In this essay, Ruskin considers what portion of "power" falls to women and what kind of education prepares them for the proper exercise of this power. He urges that "a girl's education should be nearly, in its course and material of study, the same as a boy's; but quite differently directed," and he criticizes bringing up girls "as if they were meant for sideboard ornaments."[13] He does not intend that women seek knowledge for its own sake or even for their own, but rather that it will enable them "to understand, and even to aid, the work of men . . . but only to feel, and to judge" (sec.

72). Ruskin then applies this theory to the public and private duties of men and women:

> Now, the man's work for his own home is, as has been said, to secure its maintenance, progress, and defence; the woman's to secure its order, comfort, and loveliness.
>
> Expand both these functions. The man's duty, as a member of a commonwealth, is to assist in the maintenance, in the advance, in the defence of the state. The woman's duty, as a member of the commonwealth, is to assist in the ordering, in the comforting, and in the beautiful adornment of the state.
>
> What the man is at his own gate, defending it, if need be, against insult and spoil, that also, . . . in a more devoted measure, he is to be at the gate of his country, leaving his home . . . to do his more incumbent work there.
>
> And, in like manner, what the woman is to be within her gates, as the centre of order, the balm of distress, and the mirror of beauty: that she is also to be without her gates, where order is more difficult, distress more imminent, loveliness more rare.
>
> (sec. 86)

Though the modern reader may find much to fault in Ruskin's views, from the Victorian standpoint they have revolutionary significance. In effect, Ruskin assigns a social and political value to traditional women's work, making it a corollary to man's role of protecting the family and contributing to the empire. His recommendation that boys and girls be given the same course of study, though to different depths, is more progressive than the eighteenth-century idea that the subjects suitable for study by men and women are mutually exclusive. Ruskin, at least in theory, maintains that woman has a duty to the state "without her gates," although he offers no specific examples of what this duty might include.

This revaluation of woman's role manifests itself in a number of ways in the treatment of woman's work in the nineteenth-century novel. Most striking is that the purely amateurish craft, whose chief purpose is to take up time, is repudiated in favor of professionalism and useful work. In Eliot's *Middlemarch,* Dorothea's failure in her social welfare schemes and attempts to participate in Casaubon's intellectual work are all the more poignant because she rejects the old-fashioned ladies' busy work:

> . . . With some endowment of stupidity and conceit, she might have thought that a Christian young lady of fortune should find her ideal life in village charities, patronage of the humbler clergy, the perusal of "Female Scripture Characters," unfolding the private experience of Sara under the Old Dispensation, and Dorcas under the New, and the care of her soul over her embroidery in her own boudoir.[14]

Rejecting the shallow existence to be found in needlework and pious practices, Dorothea strives to overcome the disadvantages of her "toybox" education through her marriage to Casaubon. This bookish clergyman, she thinks, will open broad vistas of knowledge hitherto beyond her reach and allow her a substantive participation in his intellectual labors. However, her intelligence proves fatal even to her willingness to act as an amanuensis to her husband. Distrusted by Casaubon, disillusioned by the flaws in his "Key to All Mythologies," she suffers rebuff even in her attempts to offer him wifely consolation, affection, and understanding. Thus deprived of doing either useful work or providing psychological support to her husband, her relatives' advice that she spend her time riding and growing geraniums seems a mockery.

A strong argument for the readers who see Mary Garth as the feminine ideal in *Middlemarch* can be made of the fact that she, unlike Dorothea, succeeds at being useful. When necessity demands, Mary earns a living by doing needlework and nursing the sick. As a tribute to the ironies of life, Mary Garth writes children's books as an extension of her family life, while the large-goaled Dorothea finally has only her domestic life. For Dorothea errs in her understanding of the helpmeet role, expecting far too much from it. In perfect agreement with the description of a wife's duties offered by Ruskin, both Lydgate and Casaubon expect their wives to be uncritically admiring of their work, but not to have any responsibility for its actual performance. What seems revolutionary in Ruskin is reactionary for Dorothea.

A second salient issue in relation to Mary Garth arises from her rejection of a teaching job in favor of remaining at home to help her overburdened mother. She agrees to take the job because of her family's grim financial situation, but is overjoyed when her father regains his local position and receives lucrative employment, thus obviating her need to work for a living. A similar situation occurs in *Jane Eyre* when Jane, who has been doing an admirable job teaching girls in a rural school, closes the school and retires to her avocations of sketching, reading, and housekeeping, when she inherits a large sum of money. The actions of Mary and Jane align with the view that a genteel person does not work for a living, but at first sight appear at odds with more progressive ideas about women's work. St. John Rivers' criticism of Jane Eyre's action says as much:

> "It is all very well for the present," said he: "but seriously, I trust that when the first flush of vivacity is over, you will look a little higher than domestic endearments and household joys."[15]

St. John is particularly interested in what Jane should consider her religious duty, to teach the ignorant and to become a missionary. Jane not only rejects his cold idealism, but finds real joy in renovating Moor House, studying, and reading with her cousins.

Anyone who knows the drudgery in a dull and unrewarding teaching position can sympathize with Mary Garth's and Jane Eyre's rejection of it. The portrait of school life and the teacher's lot given in the first part of *Jane Eyre* and in *Villette* suggest that to Bronte teaching entails far more pain than joy. Moreover, the preference for domestic life by Jane and Mary indicates how limited their alternatives are as well as carrying a note of wish fulfillment. It is not only that Jane Eyre's life at Moor House seems to include an imaginary redecorating of the Brontes' Haworth parsonage and an idealization of life there, but also a longing for independence and the artist's struggle to be free. The artist needs both time and freedom from stultifying demands in order to work. Jane's allegorical pictures, her use of sketching as therapy in order to overcome her jealousy of Miss Ingram, and her skillful portraits reveal a commitment to her art, but she can only indulge it in moments stolen from her governness work and in the leisure of Moor House where she feels "a thrill of artist-delight" as she paints (373). So too, an aspiring novelist like Bronte might long to trade her teaching duties for a self-structured work routine.

Like Jane Eyre, Mary Garth rejects teaching because she dislikes it, but Eliot does not depict the alternative as idyllically as Jane's. Mrs. Garth's life, which Mary elects to ease, consists of a dawn-to-dusk multiplicity of chores and cares. Though Mrs. Garth cheerfully bakes pies, launders clothes by hand, and teaches her younger children their lessons all at the same time, her life is unenviable. Yet for Mary, a daughter's duty and family happiness offer more personal satisfaction than she can find in school teaching. Woman's traditional work has a positive value for her.

When traditional women's work has merely an ornamental value, however, Eliot wastes no effort in defending it. Unlike Dorothea who has the author's sympathy for endeavoring to make her life effective, Rosamund Vincy in *Middlemarch* and Gwendolyn Harleth in *Daniel Deronda* earn her censure for failing to recognize their limitations. For Rosamund, this means her assumption that her finishing at Mrs. Lemon's school, even including the "extras, such as the getting in and out of a carriage" (I, 143) prepares her for the exigencies of marriage. Marrying the nephew of a baronet "offered vistas of that middle-class heaven, rank" (I, 177), so great that she even discounts her own reservations about Lydgate's low-status medical profession and disgusting (to her) research. Having paid so much attention to furnishings and refinements, Rosamund responds predictably to Lydgate's revelation about their debts with "'What can I do?'" and with her attempts to subvert his professional goals by urging him to set up a fashionable practice in London.

Gwendolyn Harleth errs in confusing the depth and purpose of her lady's training. The utter folly of her belief that she can dominate Grandcourt indicates how little intellectual acuity her education has given her, nor has it given her any practical skills. An over-rated sense of her personal worth and character strength leads her not only into a devastating marriage, but numerous smaller mistakes. When Gwendolyn thinks she can become a professional singer because she is a lady—which she assumes qualifies her for "a high position" on the stage—Herr Klesmer lectures her at length on the qualifications of a professional actress and singer, starting with the need for talent and years of dedicated training.[16] After marrying, when Gwendolyn again thinks of taking singing lessons, Grandcourt scoffs at her motives and the likely result, that she will make a fool of herself by singing for her guests: "'Amateurs make fools of themselves. A lady can't risk herself in that way in company. And one doesn't want to hear squalling in private'" (III, 65). The element of justice in this chastisement stings her all the more by coming from the odious Grandcourt as well as vivifies the criticism of ornamental education for making women superficial and naive.

Occasionally, however, amateurism can lead to professionalism. Such is the thesis offered by Anne Bronte in *Tenant of Wildfell Hall,* one of the first portraits of a woman artist. Though the focus of the novel is on the plight of the innocent wife of an incorrigible dissipate, Helen Huntingdon's professionalism is well marked. She determines to become an artist in order to support herself and her son and escape from her husband. First, she realizes, she "must labour hard to improve [her] talent and to produce something worthwhile as a specimen of [her] powers."[17] She sets up her easel and works from morning to night until her husband destroys her work and prevents her from obtaining new materials. When he installs his mistress as his son's governess, she takes the bold step of decamping with her son, servant, and baggage.[18] Then posing as the widowed Mrs. Graham, she sets up a studio at Wildfell Hall, turns out landscapes, secures a London agent, pays her debts, and wins the admiration of her friends and relatives. Left a wealthy widow after her husband's death, Mrs. Huntingdon apparently abandons her art for the management of her estate, but this suits Bronte's characterization too. Mrs. Huntingdon is a professional, whatever her occupation is.

A second, rare consideration of the professional woman artist occurs in *Daniel Deronda.* In this novel, Daniel's mother consciously chooses her profession and achieves great success as a singer. To do so, though, she has had to flaunt convention. Explaining the difficulty of being both a woman and an artist, she makes a passionate defense of her abandonment of her son, husband, marriage, and religion in order to pursue her art, partly because marriage was forced upon her by her parents. She argues for a need and right to be free, for her talent and aspirations are unconventional:

> I was a great singer, and I acted as well as I sang. All the rest were poor beside me. Men followed me from one country to another. I was living a myriad of lives in one. I did not want a child.
>
> (III, 123)

> . . . you can never imagine what it is to have a man's force of genius in you, and yet to suffer the slavery of being a girl. To have a pattern cut out—"this is the Jewish woman; this is what you must be; this is what you are wanted

> for; a woman's heart must be of such a size and no larger, else it must be pressed small, like Chinese feet; her happiness is to be made as cakes are, by a fixed receipt."
>
> (III, 131)

Eliot allows the character to speak for herself. Daniel makes no comment on the validity of his mother's position. She has chosen her own life, defends it, accepts it; the reader may do the same. Eliot's presentation of this character takes us far from Fordyce's moralizing about needlework and music. If music be woman's work, Eliot's character implies, let it *be* work, and it will have value.

However, Eliot will not allow so simple an alternative as either to accept or reject the justice of the claims of Deronda's mother. Instead, she offers the portrait of Mirah Cohen, who on the verge of brilliant success as a singer also, abandons her career for marriage to Daniel and dedication to Zionism. Beautiful, talented Mirah marries the hero and opts for the conventional life; beautiful, talented Mrs. Deronda opts for her profession and forfeits the conventional life. A parallel situation arises in Eliot's earlier novel, *Adam Bede,* when Dinah gives up preaching after marrying Adam. In Eliot's novels, the roles of professional artist and wife are mutually exclusive.

In fact, it is the rare Victorian novel which explores artistic endeavor as a means of livelihood.[19] Instead, novelists prefer to use the commonplace activities of women to depict the position of women in society, the marriage ideal, and individual values. This preference may reflect the authors' attempt to present a realistic picture of middle class life, in effect, to preserve an artifact of the popular novel. The Victorian novelists depart from the didacticism of the eighteenth-century novelists by dissociating the personal rectitude of their heroines from the degree of their attainment of ornamental accomplishments as when Dickens separates the romantic and conjugal ideal in Dora and Agnes. Victorians, aware of the vapidness to which eighteenth-century ornamental education can lead a woman, disapprove of women who view themselves as works of art.

Woman in the eighteenth- and nineteenth-century novel tends to be defined by and confined to her traditional crafts. From an historical perspective, the novel offers few happy or realistic alternatives to being an ornament, an accomplished lady, or a genteel housewife. The genteel women's occupations which occur in novels, those of governess and school teacher, result in a dismal life joyfully traded at the earliest opportunity for those of wife or amateur artist.[20] The artistic professions mentioned in the novels are those which grow out of women's traditional accomplishments, but ironically, these professions offer one of the most difficult means to success: Who can assure the aspiring painter, novelist, actress, or musician a secure future? In reality, too, artistic professions are unlikely alternatives for they would undoubtedly result in a bohemian life outside the boundaries of the genteel characters who might be inclined to them. In the Victorian novel, women's traditional work may be either an ideal or a limitation, but seems to be one from which there is no escape.

Notes

[1] Richard Allestree, *The Ladies Calling* (Oxford: Theater, 1673), Pt. II, i, 7. Further references are in the text.

[2] Hester Chapone, *Letters on the Improvement of the Mind* in *The Works of Mrs. Chapone,* 4 vols. (London: Murray, 1807), III, 15. Further references are in the text.

[3] Thomas Gisborne has a somewhat hostile tone as he chides women who complain that men and women are given unequal education; he divides women's education into religious instruction and that "on the score of ornaments," but concentrates largely on woman's duty to provide for the needs of other family members in *An Enquiry into the Duties of the Female Sex,* 11th ed. (London: Cadell and Davies, 1816), pp. 10, 79, ff. Most conduct books, however, have a rather paternal tone.

[4] James Fordyce, *Sermons to Young Women,* 2 vols. (London: Cadell, 1791), I, 255 and 262. Further references are to this edition and are cited in the text.

[5] *Vindication of the Rights of Women* (New York:

Norton, 1975), p. 94. Without acknowledging his source, Villars uses Fordyce's words on woman's virtue in advice to Evelina in Fanny Burney's *Evelina* (London: Oxford Univ. Press, 1968), p. 164. Austen parodies the same advice in *Pride and Prejudice* when Mary moralizes on Lydia's elopement. In Susan Ferrier's *Marriage, A Novel,* Lady Juliana's refusal to read Fordyce's *Sermons* is one of many examples of her frivolity (London: Oxford Univ. Press, 1971), p. 60.

[6] E. g. Dr. John Gregory, *A Father's Legacy to His Daughters* (1774; rpt. Boston: Dow, 1834), p. 23.

[7] *The History of Sir Charles Grandison,* Shakespeare Head Ed., 6 vols. (Oxford: Blackwell, 1931), I, 20. Further references are to this edition and are cited in the text.

[8] *Selected Letters of Samuel Richardson,* ed. John Carroll (Oxford: Clarendon Press, 1964), p. 177. Moralists and novelists of the eighteenth century generally agree that women could be allowed to learn what men were taught if they had particular genius; however, the learned lady was supposed to conceal the fact of her learning and complement it with well-developed domestic skills. Cf. Lady Mary Wortley Montague cited in Robert Palfrey Utter and Gwendolyn Bridges Needham, *Pamela's Daughters* (New York: Macmillan, 1957), pp. 29-30; Lord Chesterfield, *Letters to His Son,* ed. Oliver H. Leigh, 2 vols. (New York: Tudor, 1941), I, 107-108; Gregory, p. 20; Charlotte Smith, *The Old Manor House* (London: Oxford Univ. Press, 1969), pp. 186-188.

[9] Henry Fielding, *The History of Tom Jones A Foundling,* ed. Fredson Bowers, Wesleyan Ed., 2 vols. (Middletown, Conn.: Wesleyan Univ. Press, 1975), II, 882-883.

[10] Lloyd W. Brown, "Jane Austen and the Feminist Tradition," *Nineteenth-Century Ficiton,* 28 (1973), 321-338; Brown compares Mary Bennet and Caroline Bingley in some detail.

[11] *Pride and Prejudice,* ed. R. W. Chapman, 3rd ed. (1931; rpt. London: Oxford Univ. Press, 1967), pp. 39-40.

[12] *The Personal History of David Copperfield,* The Oxford Illustrated Dickens (1948; rpt. London: Oxford Univ. Press, 1971), p. 698.

[13] "Of Queen's Gardens," in *Sesame and Lilies* (Boston: Houghton Mifflin, 1900), sec. 74 and 80. Further references are to sections and are noted in the text.

[14] George Eliot, *Middlemarch,* Cabinet Ed., 3 vols. (Edinburgh and London: Blackwood, 1878), I, 39. Further references are to this edition and are cited in the text.

[15] Charlotte Bronte, *Jane Eyre* (London: Oxford Univ. Press, 1973), p. 395. Further references are to this edition and are cited in the text.

[16] George Eliot, *Daniel Deronda,* Cabinet Ed., 3 vols. (Edinburgh and London: Blackwood, 1878), II, 375-398; Ch. 23. Further references are to this edition and are cited in the text.

[17] Anne Bronte, *The Tenant of Wildfell Hall* (Harmondsworth: Penguin, 1979), p. 358. No standard edition of this novel is available.

[18] The independence and decision of Helen Huntingdon should not be underestimated. The novel was written in 1848 when husbands had complete legal control over wives and children. When Dickens separated from his wife in the 1860's, he maintained control of all of his property, keeping his home, his children, and his wife's sister as housekeeper, while his wife was sent off to a small flat where all but her eldest son were forbidden to visit or correspond with her. See Edgar Johnson, *Charles Dickens His Tragedy and Triumph,* 2 vols. (New York: Simon and Schuster, 1952), II, 918-926 and 1064.

[19] Zelda Austen notes the consistency with which authors of autobiographical novels tend to cast their fictional selves as "something more commonplace than genius," preferring to universalize themselves for the sake of realism; "Why Feminist Critics Are Angry with George Eliot," *College English,* 37 (February, 1976), 553. In *Literary Women,* Ellen Moers argues that Mme. de Stael's *Corinne* served as a model for several other nineteenth-century works about "the woman as genius"; (Garden City, N.Y.: Anchor Books, 1977), Ch. 9.

[20] Nursing, a traditional woman's task noted in the conduct books, practiced by various characters within the domestic setting (e.g. Anne Elliott in *Persuasion* and Agnes in *David Copperfield*), and professionalized by Florence Nightingale during the Crimean War, fails to be recognized by novelists as an occupational alternative for a heroine, probably because of the generally low status of the medical profession up to the end of the nineteenth century.

THE CAPTAIN OF COMPANY K FIVE WARS LATER

KENT GRAMM
English Department
Ottawa University
Ottawa, Kansas

The Captain of Company K, by Joseph Kirkland, was published in 1891, four years before Stephen Crane's *The Red Badge of Courage.* Crane was not a veteran of the Civil War, but Kirkland was. While both novels exhibit the new tendency toward realism in American fiction, *The Captain of Company K* lacks the pervasive irony and naturalism of Crane—perhaps because Kirkland, a generation older than Crane, was also a veteran of The Great Sentimental Age. He is therefore an intriguing transitional figure, presenting war graphically but within the context of a conventional popular romance novel which would not have been out of place during and immediately before the Civil War. This may partly explain the artistic inferiority of *The Captain of Company K,* lacking as it does the unity, focus, and intensity of Crane's Civil War novel. Being an uncongenial juxtaposition of fiction and the author's feelings, attitudes, and recollections, *The Captain of Company K* may have little to offer as art, but as a statement and reminiscence by a Civil War veteran it has high historical and current interest.

Kirkland's novel deserves its neglect in literary history also because its characters are stereotypes—and this notwithstanding, many of them are still hardly distinguishable from each other at times without their highly artificial and overdrawn dialects, accents, and mannerisms—and because its plot is merely a series of individual incidents related to the unsatisfyingly predictable stock plot of a man winning a woman. Little illumination is thrown upon this man-woman dynamic, however; the book's interest lies in its war scenes and the author's attitude toward them.

Will Fargeon, a mild and humanitarian man, has been courting Sara Penrose, the typically beautiful and somewhat vain and heedless elder daughter of a well-meaning befuddled clergyman. Will is persuaded by a typical Scottish uncle, Colin, to back up his own Union rhetoric and enlist, whereupon Company K of Chicago's Sixth Illinois fills immediately and elects the sterling but peace-loving Fargeon its captain. Fortunately, Fargeon's first lieutenant is "Mac" McClintock, an ideal soldier and wise veteran of the Mexican War. Will becomes a new man, a real man perhaps, during the first year of the war, and Sara and he declare their love for each other. Meanwhile Will and Mac become closer than brothers. At Shiloh Will loses part of a leg and Mac is apparently killed. Lydia, Sara's younger sister and a typical second daughter, has fallen in love with an appreciative Mac, and the loss seems tragic. However, Mac had not been killed after all and returns from a Southern prison. There are two weddings, Will and Sara inherit Colin's fortune, Mac becomes a career soldier and never gets his deserved promotion, Will becomes a surgeon and continues to clump around on the same wooden leg he got after Shiloh and saves the bloody shirtsleeve he used as a bandage, and the public goes on with its booming postwar business and couldn't care less.

But the author invites us to look at his work as a personal document, and therefore we can go far beyond his vacuous plot and characters. He refers to the Union soldiers as "our" men and describes events as if he were an unnamed participant. He uses the first person at times: "God! If I wanted to magnify the pathos of all this, what could I say that would not belittle it?"[1] (220), and throughout makes direct statements about war: ". . . [which is] fortuitous death by an unseen missile from an unknown hand . . . But to the average American brutal battle is better than irksome idleness." (83)

It is not the empty wit of the characters' dialogue that is interesting; it is rather the dialogue within Kirkland's own voice (such as in the quotation above) that intrigues. On the one hand Kirkland gives the reader sometimes rhetorical, sometimes vivid, statements on the evil of war. "Why are men so foolish," is the unconsciously telling question that Sara asks as the story opens. As the company's first skirmish is described Kirkland asks, "Is not the time coming when the rank and file . . . will . . . learn good sense . . . [and] cry with one voice: 'It is enough. We will have no more of it.'" (83) In that skirmish one of the men is not permitted to stop and care for his brother, who has just been shot:

> "I don't care if he's your sister! Drop him and take your gun!"
>
> Poor Aleck obeyed; laid down his burden, tenderly kissed the pale face, rose with tears streaming down his face, loaded his piece, crying. Still crying, went forward to the firing line, and cried and fought, fought and cried, as long as there was any fighting to do. Country —duty—glory? (99)

In a crucial scene, a party of truce delivers news to a dignified Confederate (Kirkland declines to capitalize the c) officer that his son is mortally wounded. The boy is "Young, strong, handsome, high-bred—curls, that might have been the pride of a doting mother . . . Eyes fit to shine as the heaven of love and trust to some happy bride." This sentimental description is followed by: "A bullet had torn clean through his lungs, and the breath made a dreadful noise escaping through the wound at every exhalation." (104) A little later Will glimpses a man's wounded hand: ". . . a broken bone, and bloody skin and flesh both fat and lean," and feels "a little nausea." (118) "Oh, how can a just God permit such things?" he cries (119), and not for the last time. The brother of the man described earlier dies and is hastily buried:

> Our forces did not hold this position; and after we retired it is probable that some enemy found the spot and destroyed the simple record, or perhaps the wood-fires burned it, or hogs rooted it up. But what difference did that make? Nobody ever went back to look for it. (135)

In the description of the battle of Shiloh Kirkland writes:

> How do men fall in battle?
>
> Forward, as fall other slaughtered animals . . .
>
> As they fall, so they lie, so they die and so they stiffen; and all the contortions seen by burial details and depicted by Verestschagin and other realistic painters are the natural result of the removal of bodies which have fallen with faces and limbs to the earth, and grown rigid without the rearrangement of "decent burial." (279)

And he quotes Cowper: "War is a game which, were their subjects wise,/Kings would not play at."

Is *The Captain of Company K* an anti-war novel, then? Just before the Cowper quotation, Kirkland says, "Then one must pause to remind himself that war did not invent death; nor does even blessed peace prevent it." Then are the anti-war statements merely items which are conventional in a war story of the late nineteenth century? Kirkland suggests that his conscious purpose may have been to give his readers "an education . . . concerning the realities of war from the point of view of the front-line men." (158) This purpose would permit more than one feeling about war to be expressed, but perhaps Kirkland also has a less conscious attitude toward war which is not as ambiguous, and discoverable.

War does have its good aspects. Will Fargeon displays upon his enlistment a new and deeper quality, which others perceive in his face. (15) There is the bond Will begins to feel toward his men, and the affection and sense of responsibility that ensue: army life seems to be as pleasant as the feeling of love he has for Sara—in fact one day he doesn't even open a package from Sara as long as he is busy with the men (71); the conversation among soldiers can be sheer delight (73-74, for example); war teaches the difference between bravery and courage (86); nobility is tested and can be encouraged (112); civilian life is by contrast intricate and exasperating (152); the fatherly and brotherly aspects of a man can be brought out by army life: Will and Mac once went "stealing along the sleeping line of Company K, slipping two biscuits and a bit of pork into every sleeper's haversack" (183-4); and in a very effective scene where Will stays behind enemy lines with his bleeding Irish corporal and cradles the dirty, smelly body to his own against the wet and cold (194ff) we see the selfless devotion war can call up among fellow sufferers.

But more important than all these to Kirkland seems to be the summation: war, in its terrible glory and its tragic, brutal beauty, is larger than peace. We see the aging Will Fargeon at the end, still devoted to his war experiences, memories, and friend, and know that war was the main event of his life. We see almost nothing of his civilian, married life after the war. Was Will as bored by the Fargeon home as it seems Kirkland was? War was intense, it was *life;* if often horrible, then life, real life, is often horrible. Peace is blessed but pale; peace is a washed-out mere absence of war. Peace has offered little to the reader—contrived, wooden, and unreal conversations among stereotypes—but war was interesting; to the characters themselves peace offered little—but war developed them and gave them something to do and to feel.

Before a conclusion is drawn from this, some other valuable aspects of the novel should be outlined. An historian would find many fascinating items of Civil War minutae, ranging from how soldiers positioned themselves in sleep so as to keep their equipment dry in wet weather to how cannon fire sounded. The battle descriptions are excellent. Here is part of the description of how the surprise morning attack by the Confederate army at Shiloh looked to a unit not in a forward position:

> "Hellow, Mac! What's all this? Somebody else is reconnoitering I guess." For the sharp, untimely musketry persists in making itself heard from the outposts. Mac looks glum and anxious. He hurries up all the morning operations with asperity and profanity not usual with him.
>
> The rattle of musketry becomes more and more steady and continuous. Scattered men without muskets begin straggling down the road toward the rear. . . .
>
> . . . the road is growing fuller and fuller of fugitives; here and there a wagon or ambulance, but chiefly infantry-men walking or running toward the river. . . .
>
> Still that rising approaching rattle of musketry . . . The distant sound of cannon has been heard some time; now comes the welcome thunder of a battery which has opened fire from our own side . . .
>
> . . .
>
> As the men gather on the color line in response to the long roll, they see the other regiments in the brigade hurriedly striking tents and scrambling them into wagons as best they can . . .
>
> . . .
>
> By this time the road has become a pandemonium of flying forces. Wagons go galloping in the rear in a nearly continuous stream, while *twice* there comes a yet more harrowing sight—the flight of caissons, forge and battery wagon; *but no limbers and no cannon!*
>
> . . . Already bullets have made themselves heard . . .
>
> . . .
>
> Now the wild yell of the enemy is audible, beginning far away on the left and spreading toward them. Now it is directly in front . . .
>
> . . .
>
> . . . A movement in the underbrush is perceptible, a glimpse of butternut . . . (269-276)

It is also fascinating to see the soldiers described: the jokers, the skulkers, the officers, Grant, the enemy (gallant but blindly hostile), the soldiers from other states referred to with appreciation, the political appointee officers; what the soldiers did in camp and how they talked, and what they did and thought in battle. The helpful/indifferent home front is seen, along with painfully stereotypical blacks and Jews. Significantly, the war's issues are absent—which is realistic enough; blacks are not only unimportant but when seen are childish, ignorant and comical. Business is rapacious, newspapers are unscrupulous, Washington is incompetent—and after the war the soldiers are forgotten by all three. Women are sentimentalized, but we see how even in the North they helped inspire war. The surprising etiquette, even between enemies, of the early years of the war is shown. We glimpse immigrants and feel Kirkland's affectionate but condescending attitude toward them.

Of great importance is Kirkland's position relative to the sentimentality of the age he comes from and the realism of the age he is moving into. Women, Mother, grief and loss are sentimentally regarded, as is appropriate to American society of 1860, but battle, wounds, the political and economic systems are rendered realistically (and the author seems to be quite consciously doing so.) This is a key to evaluating Kirkland's attitude.

In the scene dealing with the Confederate officer learning of his son's mortal wound we read:

> The grief-stricken father never raised his hand to his eyes; but his frame wavered a little, and from time to time he bowed his head and shook it slightly, when one or two scattered drops would shine for an instant in the sun as they fell to the ground. (109–110)

This scene is significant because the approach is sentimental; that is to say, the author dwells on the pathos of the scene, and the tragedy of wounding and loss and war in general, and even shows us the regret and depression of the decent man who shot the Confederate officer's son—but the evil inherent in the situation has disappeared. It is pathetic that the young man was mortally wounded, but we do not hear about whether it was good or evil to have shot him. The basic issue (if the basic issue is a moral one) is covered by valid sentiment—but covered. Perhaps this is why Walker Percy says that a sentimental people is a cruel people, and why the Great Sentimental Age produced and/or permitted such a cruel war. Pain and grief are described in the novel, but killing is not discussed (except that Sara at one point lightly suggests that Willie might be changed to "Killie.") In this regard the *Captain of Company K* is inferior to, for example, Howells' "Editha," in which the prime issue is not death and suffering but killing.

War is interesting. There is a "joy of battle" (303) against the intense glare of which peaceful life appears hopelessly dull. Kirkland expresses this fact honestly, though he does not deal with the question of whether the contrast is so obvious because war is more real than peace or because our civilian conduct is weak and foolish. Perhaps the validity of Kirkland's observation says more about peace as we manage it than about war.

Kirkland's attitude displays human nature. It does not affirm the health of the human animal, but it does show us its consistency: feelings similar to Kirkland's are expressed in some recent Viet Nam fiction. We are now ready to regret the neglect of veterans which Kirkland also decries, and we are willing to praise the comradeship and character development one can find in the military. We can begin to understand why some soldiers re-enlisted for another tour in Southeast Asia, and we are even ready to use the words "honor" and "country."

Kirkland's novel will always be interesting, but it is especially illuminative now. At some times a country is in the frame of mind to honor those who waged and endured a war more than it is to honor those who opposed and protested it.

Note

[1] Joseph Kirkland, *The Captain of Company K*, Ridgewood, N.J.: The Gregg Press, 1968. Reprint of 1891 Dibble Publishing Company edition. (Page numbers given in parentheses.)

THE RARE BOOK DEPARTMENT OF THE UNIVERSITY OF WISCONSIN-MADISON: ORIGINS AND EARLY DEVELOPMENT, 1948-1960

Dennis Auburn Hill
University of Wisconsin, Memorial Library, Madison

Introduction

Although it was eventually to become a department with collections of national significance, in addition to providing direct and important services to the university community in meeting its teaching and research needs, at its inception the Rare Book Department (hereafter RBD) of the University of Wisconsin-Madison ran the risk of becoming and remaining a stepchild of the university library. Through the continuing definition and development of its functions the RBD became, during the period 1948-1960, an integral part of the University of Wisconsin community and developed a role extending to the wider city and state community.

At the outset two basic principles governed the RBD's development—the collections were increased for the most part in areas of strength, and these same collections were developed with the intention and expectation that they be used and answer to the research and teaching needs of the faculty and students of the university. The latter may seem an obvious point, yet it indeed needs to be made owing to the common belief that a rare book department consists of a collection of items preserved for their financial value or antiquarian interest alone.

Origins

The Rare Book Department was formed as a direct result of the acquisition of the library of Chester A. Thordarson by the University in 1946. The purchase price to the University was $300,000, a substantial sum for the time. Yet the library was considered well worth the price—it was probably worth a good deal more—and through the efforts of a number of persons lobbying for its purchase, the Board of Regents was convinced to vote its approval on January 19, 1946.[1] E. B. Fred, President of the University at the time, was to say in an interview in 1976 that the Thordarson Library "was the best investment the University ever made."[2]

Chester A. Thordarson was born in Iceland in 1867 and came to Milwaukee with his family in 1873. His father died shortly after the family's arrival in Milwaukee and his mother and her children went on to live in Deforest and Shawano, Wisconsin, moving to North Dakota in 1879. Thordarson, born Hjörtur Thórdarson, received his brief formal education in Chicago. He left school after completing the 7th grade at the age of 20 and continued his education through self-study. After working for a number of electrical companies in Chicago and St. Louis, he formed his own electrical manufacturing company in Chicago in 1895. The success of this self-educated and widely acclaimed genius was great and rapid. He was awarded more than 100 patents during his career and won gold medals at both the Louisiana Purchase exposition in St. Louis in 1904 and the International Panama-Pacific Exposition in San Francisco in 1915.

Thordarson acquired an interest in books and learning early and maintained this interest to an extraordinary degree throughout his life. He amassed a systematic collection of significant works in the development of early English science and technology in first and early editions which received wide attention. Fields well represented in the library include Agriculture, or Husbandry, Natural History, Medicine, Mathematics, Botany, Ornithology, Electricity and Magnetism, and Domestic Occupations. The collection of magnificent large color-plate books in Ornithology and Botany is remarkable. In addition, important works in English literature are well represented. The books were without exception very well preserved and Thordarson had many rebound in full or three-quarter leather by the well-known binder Rivière and Sons.[3]

The course of events leading to the acquisition of the Thordarson Library can be divided into two periods: interest on the part of the University while Thordarson was still alive; and lobbying efforts after his death to convince University administrators to support, and the Board of Regents to approve, its acquisition from his estate. There is little evidence concerning the first of these periods; and, although the actual initiation of the lobbying efforts also remains unclear, the course of these efforts can be described in some detail.

Thordarson had various associations with Wisconsin. His family lived here during their first years in this country. Later, Thordarson designed laboratory equipment for the faculty of the University, addressed classes on a number of occasions, and was awarded an honorary Master's degree in 1929. Finally, he owned and, after 1941 housed his library on, Rock Island, Wisconsin (now a State Park). His library had received some attention in the popular press as well as in the *Papers* of the Bibliographical Society; and as Thordarson himself indicated in a letter to Clarence Dykstra, President of the University, he had encountered active interest in his library from many parties.[4]

Beginning in 1942 it is possible to document the University's early interest in Thordarson's library. Gilbert H. Doane, Director of Libraries, prepared a draft of "Memoranda for an Agreement between Chester H. Thordarson and the Regents of the University of Wisconsin" in 1942.[5] This agreement proposed the donation by Thordarson of his library to the University. This draft agreement was then revised by A. W. Peterson, Comptroller, and submitted to President Dykstra.[6] A possible third version, "An Agreement Between Chester H. Thordarson and the Board of Regents," was submitted in November 1943.[7]

It is clear from all this that Dykstra was preparing to pursue the matter with Thordarson, but this agreement was never carried out. In a confidential memo to President Fred from Peterson, dated July 6, 1945, Peterson made reference to a concern of Trigg Thordarson (one of Thordarson's two sons), about a memorandum signed by Thordarson and Dykstra on November 12, 1943. This may have been the agreement last referred to above, but no memorandum of this date has been found over the signatures of these two men. In any case, Peterson assured Trigg Thordarson that the University would take no legal action.[8] Furthermore, Thordarson's letter to President Dykstra dated December 11, 1943 makes it clear that Thordarson had indeed not agreed to Dykstra's proposal as of that date.

In this letter, the only known statement by Thordarson on the subject of the disposition of his library, he writes in a somewhat rambling style about his library and its importance to his study of nature on Rock Island, the interest people have shown in it, and his "plan" for the library. This "plan" is of greatest interest here, but it unfortunately remains rather vague. Thordarson was clear about one thing, however, stating "I never use the word 'donation.' I couldn't because I never thought that way." His plan seems to have been to avoid the issue of "legal ownership" and to follow the plan of the Huntington Library in Pasadena, whereby an agreement with the state (according to Thordarson) provides "that the library is to be used as a semi-public institution and that they are exempted from taxation." Just what he meant by "they are exempted from taxation" is difficult to understand. Jens Christian Bay of the John Crerar Library was carrying on the correspondence with the Huntington Library for Thordarson. Thordarson intended to see Bay and "get from him a clear and definite summary of the plan and what has been done." Some light is shed on this near the end of his letter where he states "I still hope that I can find a way to establish a fund that would take care of the library for all time to come. This is my idea and I would not need any financial support from the University." From these statements we can infer that Thordarson's "plan" was to set up a fund to support the library, that the library be a semi-public institution, and that the fund not be subject to taxes.[9] Nothing came of this plan, yet interest did not die out, although an agreement was never reached with Thordarson, who died on February 6, 1945.

It is possible to identify several key figures in fostering the University's interest in the Thordarson Library as well as key steps leading to the University's final decision to acquire the library. President Fred and Professor William S. Marshall of the Zoology Department became interested at the outset. In a letter of May 15, 1945, Marshall informed Doane that "President Fred thinks there may be a chance of our getting the Thordarson Library, a few of us are trying to help him . . ."[10] He asks Doane for a description of the library and requests that he send Fred a letter. This he quickly did, as acknowledged in a letter to Doane from Marshall dated May 30, 1945, wherein he stated that Doane's and Professor Wagner's letters were "very good."[11]

A very important meeting took place at the Crerar Library in Chicago on November 15, 1945, at which Bay described to Doane, Ralph Hagedorn, Acquisitions Librarian, and A. W. Peterson, Director of Business and Finance, the unique importance of the Thordarson Library and its value as an investment.[12] It was at this meeting that Peterson's enthusiasm was restored and, as Doane reported to Bay on November 24, 1945, "the next morning we were able to win over the President. There remains the task of convincing the Board of Regents, but thanks to you, I now have two powerful allies in the president and the director of business and finance."[13]

Possibly the most important step toward convincing the Regents took place at a conference Doane had on November 27, 1945 with D. Clark Everest, President and General Manager of the Marathon Corporation of Wausau, Wisconsin, and Allen Abrams, Vice-President and Technical Adviser.[14] At this meeting Everest agreed to write to regents F. J. Sensenbrenner, Michael Cleary, and Walter Hodgkin. This he did, and Sensenbrenner, in response, reported that his letter "was read to the membership of the Board of Regents in executive session and I am hopeful with you that we can secure the library."[15] The Regents authorized the signing of an option agreement on January 19, 1946 and such an agreement was signed on January 21, 1946, providing for "a consideration of $270,000 for the purchase of the Thordarson Library and a broker's commission of not to exceed $30,000."[16] In a letter to Bay dated February 1, 1946, wherein he thanks Bay for his help in the transaction, Doane makes it fairly clear that Everest's influence was of consequential importance stating "Fortunately, one of our paper barons recognizes a book when he sees it and through him the President was able to convince some of the businessmen on the Board of Regents."[17] The Board of Regents exercised its option in December 1946 and the Thordarson Library came into the permanent possession of the University, although it had already been moved to Madison in August of that year.

Of the more than 11,000 volumes in the original Thordarson Library, fewer than half were to make up the foundation collection of the Rare Book Department, which came into being nearly two years after the final purchase of this important library. The other books, consisting mostly of reference works, secondary materials, collected editions of standard authors, and most of Thordarson's fine collection of Icelandic books, went into the general collection, while the Americana went to the State Historical Society Library. The volumes which made up the nucleus of the RBD formed the essence of the Thordarson Library and consisted of those books "which are genuinely rare; those which require special care (such as color plate books); and the important editions of scientific books which, although often not notably scarce at the present, should be preserved for future generations."[18]

Staff

From 1948 to 1960 there were three curators of rare books. Throughout this early period of the RBD the support staff in the department varied in number, length of service, and type of position. For the two years of the first curator's tenure and the first two years of the second curatorship, there was no assistance at all. Both curators referred to this situation in their annual reports pointing out that it was not possible to provide proper service so long as the department remained a "one-man" operation.[19]

Assistance first came in 1952 with the hiring of a student as a temporary library assistant. The first professional assistant began on April 2, 1954, nearly six years after the naming of the first curator. Over the years there were appointments of assistants in the department with varying titles, some of them clerical, others professional, and still others falling between these types, e.g. project assistant. The following list includes in chronological order of their appointment all the staff members who worked in the RBD from 1948-1960 together with their titles and inclusive dates of service:

- Ralph Hagedorn, Curator, 1948-1950
- Samuel Ives, Curator, 1950-1958
    - Carllyn Anderson, Temporary Library Assistant, July-Aug. 1952
    - Klara Cook, Project Associate, October 1952-June 1953
    - Donna Grooms, Student Assistant, Oct. 1952-Jan. 1953; Library Assistant, Feb. 1953-?
    - Aaron Polonsky, Assistant to Curator, April 1954-April 1956
    - Jeremiah O'Mara, Assistant to Curator, June 1956 (one week only)[20]
    - Edward Grant, Project Assistant, Aug. 1956-Feb. 1957
    - Garrett Droppers, [Project Assistant], Feb. 1957-Jan. 1958
    - Dorothy Handley, Assistant to Curator, Feb. 1958-
    - 2 part-time student assistants, Spring 1958
- Felix Pollak, Curator, Summer 1959-

The position "Assistant to the Curator" was a professional position. Ives, in making his recommendation for a full-time professional assistant in his first *Annual Report* (1950-1951), described the qualifications he had in mind. The assistant should be a "well trained cataloger, efficient, thoroughly reliable in all things, and with an appropriate background and enthusiasm for rare books." A full-time assistant was provided for in the 1952/53 budget, but none was appointed until April 1, 1954. Grant and Droppers, the two Project Assistants who filled in after O'Mara's unexpected resignation, until the hiring of a new Assistant to the Curator, were both graduate students in the History of Science Department of the University.

The curator's position originated when the Board of Regents created the position "Curator of the Thordarson Collection" for the 1947-49 biennium. This position was not filled, however, until September 1948 when Ralph Hagedorn was hired as curator. The title of the position was changed to "Curator of Rare Books" when the decision was made early in 1949 to establish a separate RBD with a major portion of the Thordarson

Library serving as its nucleus. Hagedorn, who had been Acquisitions Librarian, immediately went on a study trip to acquaint himself with rare books librarianship. From October to December 1948 Hagedorn studied at Harvard's Houghton Library and visited rare book libraries between Cambridge, Massachusetts, and Washington, D.C. During his tenure as curator he had to contend with the initial organization of the collections, while at the same time trying to provide services to the public. At this time the RBD occupied Rooms 324 and 325 of the State Historical Society Building, where it was to remain until the opening of the Memorial Library in 1953.

Due to the unorganized state of the department at the time, it was opened "without fanfare," Hagedorn recommending appropriate "advertising" once the collection was in good order. The duties of the curator were defined as follows: "75% cataloging materials and 25% searching for rare books now in the stacks, recommending purchases of rare books," and, 'in general, engaging in such work as will add to his professional equipment." Surprisingly enough, while this statement of duties implies other possible tasks, such as mounting exhibits, which Hagedorn did carry out, it leaves little room for servicing the collection for patrons. Hagedorn pointed this out in his *Annual Report* for 1949-50, adding that "the unsatisfactoriness of a one-man department is too apparent to need further discussion." In reading this report, one senses a general feeling of dissatisfaction. Although recommending purchases was considered one of his duties, *none* of the important reference works and rare books he recommended were purchased. Finally, he felt it necessary to state: "It is perhaps not unnecessary to point out that neither the article nor the address were prepared on library time." The article referred to appeared in the *Papers* of the Bibliographical Society of America and was entitled "Bibliotheca Thordarsonia: The Sequel"; the address was presented to the University's Language and Literature Club. Both these activities appear to be entirely appropriate and professional ones for a curator of rare books to perform and, in light of the extent to which the subsequent curator was involved in such activities, it may seem that Hagedorn had cause to be dissatisfied in his position.

Samuel A. Ives was appointed curator in 1950 and remained in that position until his sudden death on August 9, 1958. Ives was a classical scholar, with a knowledge of eight to ten languages in addition to Latin and Greek; an experienced rare book librarian; and a specialist in the history of science and the Bible.[21] Under his curatorship the department expanded services, developed effective relationships with the faculty, added greatly and significantly to the department, reorganized the collections, and refined procedures. Ives was active as an author of articles in scholarly journals, appeared on local television and radio programs, and initiated an important bibliographical project in the history of chemistry, medicine, and pharmacy.[22] Although he began as the only staff member in what was still a one-man and only partly-organized department, he was able to refer to what was to be his last full year as curator as "a banner year in the history of the RBD." As regards staff, the situation improved under Ives nearly to the point it was to reach at the end of the decade.

After Ives' death there was a hiatus of ca. 10 months in the occupancy of the curator's position. Handley, who carried on the day to day duties of the department referred to these months as a period of "treading water." During this same period members of other library departments did some work for the RBD. John Neu of the Order Department prepared a bibliography of the Burgess Collection (see *Collections Added* below) and Virginia Kay, also of the Order Department, organized the French Pamphlet Collection. Lloyd Griffin, the Humanities

Librarian, undertook the initial organization of the Sukov Collection.

The acquisition of the Little Magazine Collection of Dr. Marvin Sukov early in 1959 may have played no small role in the appointment of the next curator. Felix Pollak, who took over as Curator in the summer of 1959, was a poet and writer, who himself contributed to little magazines. After a career that included a doctorate of jurisprudence from the University of Vienna, and both bachelor's and master's degrees in library science, Pollak came to the Rare Book Department from Northwestern University, where he had been Curator of Special Collections. In addition to Latin and Greek, he knew German, French, and Italian. Although the staff of the department during Pollak's first year was as large as it had ever been, he, too, felt the need to request more staff in the form of permanent clerical help and/or an increased student assistant budget. Some help was again received from outside the department in 1959-60, as John Neu helped in the cataloging of the *Mazarinades* in the department.

In terms of staff the RBD thus evolved from a one-person department to one requiring a regular staff consisting of the curator, professional assistant to the curator, and student assistants performing the routine clerical duties in the department. This development was in part a response to that of the department in other areas, especially in collection development and public services.

Collection Development

In general a dual pattern in the acquisition of material for the RBD was followed during these years. Collections and individual works were purchased to build on the strength of the collection. For example, beginning with the Thordarson Collection's importance in the history of science, the Duveen, Boyle and Priestley Collections were added. Secondly, material was acquired outside of areas of present strength in response to faculty needs, major purchases not being made without faculty support or the expectation of such support. The Sukov Collection is an example of a major acquisition in a new area, but one which had received strong faculty support and which has been built on ever since. Acquisition by purchase specifically for the RBD was only one of several methods by which additions were made to the collections. Gifts, of both collections and individual titles, transfers from the general stacks, transfers from the State Historical Society Library, exchange books, and books acquired through normal channels and earmarked for the RBD all constituted means for increasing the department's holdings. Examples in each of the first four of these methods of acquisition illustrate the importance of multiple sources very well:

1. a) The gift from Norman Bassett of an O. Henry Collection of 20 volumes of first editions.
   b) The gift from Denis I. Duveen of manuscript notes of lectures in chemistry given by Joseph Black at the University of Edinburgh in 1776-77.
2. The transfer from the stacks of a volume of alchemical tracts once in the library of Isaac Newton and including marginal notes in Newton's hand.
3. The transfer from the State Historical Society Library of the exceedingly rare 47 volume lithographic facsimile of the quarto edition of the complete plays of Shakespeare.
4. Receipt on exchange from the University of Uppsala of Johannes Hesse's *Itinerarius* (Cologne, 1500).

General principles governing the material to be included in the RBD's collections had been set out in a document dated February 25, 1949 and supplemented by a note from Louis Kaplan, Associate Director, dated

March 25, 1949.[23] Now lost, this document must have contained chronological guidelines, since Hagedorn refers to selection of stack transfers "within date limits" in his *Annual Report* for 1948-49. Ives reported three years later that ordering by the curator was limited to rare books in the history of science and general bibliography.[24] Since this was still early in the department's history and before the expansion of fields of interest which was to come, it is possible that this policy changed later on. Books being recommended by the curator for transfer to the RBD either from the general stacks or by earlier transfer from the Historical Library underwent further review by Kaplan and Gerhard Naeseth, the Head of Technical Services.[25] In Pollak's first *Annual Report* (1959-60), he referred to what was the general policy governing RBD acquisitions, namely collecting "in strength" and reflecting faculty needs and interests.

Regarding this latter aspect of an acquisition policy for the RBD, Ives had solicited from 13 faculty members representing 9 departments names of titles that were rare and important in their fields, for the purpose of forming "a file of prime desiderata."[26]

This, however, was not the only instance of faculty-RBD contact which sheds light on the subject areas covered in the collections. At a meeting with several faculty members called by Louis Kaplan, the subject cataloging of rare books was discussed. The outcome of this meeting was a list of "Subject Headings for Rare Books" solicited from the faculty members present representing "the needs of people who would most use it."[27] This was intended to be a "subject guide" rather than a "subject catalogue." These headings were to be assigned by the RBD staff and a subject card file using these headings was eventually set up. While this is another example of faculty-RBD relations, it also provides a way of determining the strengths of the collection and interests of the faculty during this period. A printed list of these headings has not been located. A list reconstructed from the old subject-file in the department includes twenty-three headings:

Alchemy	Mathematics
Astronomy	Medicine
Biography	Music
Botany	Natural History
Botany-Herbals	Occult Science
Chemistry	Pharmacy
Cook Books	Philosophy
Emblem Books	Physics
Geography and Travel	Rhetoric
Geology and Mining	Sermons
Legal Works	Social Studies
Literary Works	

The following record of major collections added to the RBD during this period is based on information in the *Annual Reports* and articles in the *UW Library News,* the library's newsletter from 1956 to 1973. References to articles in *UW Library News* on the collections are given in parentheses at the end of each description.

Collections Added 1948-1960:

Thordarson Collection. 1949 (1946). *History of British Science, Color-Plate Books. Literature.* Acquired by purchase from the Thordarson estate for $300,000 in 1946. Originally 11,000 volumes; 4-5,000 volumes formed the nucleus of the Rare Book Department in 1949. (I:3, p. 4; XI-3, p. 1; see also Bay and Hagedorn)

Marshall (William S.) Collection. 1950-51. *English Literature and Travel.* Gift of the estate. Ca. 30 vols. of an original 700 from which the department could choose. (I:3, p. 3)

Brownell (George H.) Collection. 1950-51. *Mark Twain and Twainiana.* Gift of Brownell. Ca. 300 vols. and ephemera. (I:1, p. 2; II:9, p. 2; III:1, p. 7; XIII:7, p. 1)

Duveen (Denis I.) Collection. 1951. *Alchemy and Early Chemistry.* Acquired by purchase from H. P. Kraus for $50,000. 3452 vols., 2958 titles. One of the most extensive single collections of its kind. (II:1, p. 1; XII:3, p. 1; see also printed catalog *Bibliotheca Alchemica et Chemica,* London, 1949.)

Montauban Collection. 1952-53. *French Calvinism.* Acquired by the library in 1951. Of 982 books, pamphlets and manuscripts, 250 vols. selected for the RBD. (I:6, p. 1)

Russian Underground Collection. 1954-55. *Russian Revolutionary Movement, 1825-1925.* Acquired by purchase. 1,000-1,400 items. (VIII:6, p. 1)

Hoyer (Theodore) Collection. 1954-55. *Lutheran Theology, 16th-18th Centuries.* Gift of Theodore Hoyer to the library in 1918. Ca. 50 titles, (III:7, p. 1)

Slaughter (Moses S.) Collection. 1954-55. *Latin Classical Literature.* 48 titles.

Bassett (Norman) Collection. 1954-55. *Mark Twain and Twainiana.* Gift of Bassett. Ca. 70 vols. (See under Brownell Collect.)

Papyri Collection. 1957 (1920). *Egyptian Papyri, 3rd C. BC-7th C. AD.* Acquired in 1920 with funds given by a graduate student. 83 papyri. (II:8, p. 4; IX:10, p. 1; XII:7, p. 8)

Goldschmid (Edgar) Collection. 1957-58. Evolution of Anatomical Illustration. Acquired by purchase. 170 titles in 241 vols. Later transferred to the new Medical Library. (XII:9, p. 1)

Burgess Collection. 1957-58. *Thornton W. Burgess, Juvenile Author.* Gift of the estate of Roy Oppegard. 162 vols., 10 scrapbooks. (VI:1) p. 1)

Boyle Collection. 1958. *Robert Boyle, English Scientist.* Acquired by purchase. Originally collected by Hugh MacDonald Sinclair. 141 titles in 153 vols. Includes items not recorded in the standard bibliography of Boyle. (III:4, p. 1; X:4, p. 1)

Priestly Collection. 1958. *Joseph Priestley, English Scientist.* Acquired by purchase. Originally collected by Hugh MacDonald Sinclair. 134 titles in 147 vols. Includes items not in the standard bibliography of Priestley. (III:4, p. 1; X:5, p. 14)

French Pamphlet Collection. 1958. *Political Pamphlets, 1550-1650.* Acquired by purchase. Ca. 1,000 items.

O. Henry Collection. 1958. *O. Henry and Porteriana.* Gift of Norman Bassett. 20 vols. (III:5, p. 1)

Wallerstein (Ruth C.) Collection. 1958. *English Literature, 17th C. Imprints.* Gifts of her estate. More than 60 vols. of the original 1,400 given the library are in the RBD. (III:6, p. 1)

Mazarinade Collection. 1958. *Opposition to Cardinal Mazarin, 1648-1652.* Acquired by purchase in several small collections. Several hundred. (XIII:2, p. 1)

Sukov (Marvin A.) Collection. 1959. *Little Magazines, 1900-1960.* Acquired by purchase from Dr. Marvin A. Sukov. More than 700 titles and 10,000 issues. One of the most extensive collections of its kind. (IV: 3, p. 1; X:2, p. 6; XI:5, p. 1; XII:1, p. 16)

Chwaliobog (Witold) Collection. 1959-60. *European Theology, 17th and 18th Centuries.* Originally acquired as a permanent loan from the Kellogg Public Library of Green Bay in 1946. Ca. 1,000 vols.; partly in RBD. (IV:10, p. 1)

Beatty (Arthur) Collection. 1960. *Wordsworthiana.* Gift of Hamilton Beatty in honor of Prof. Arthur Beatty. Originally more than 1,000 vols.; the editions of Wordsworth and the Wordsworthiana housed in the RBD. (V:2, p. 4; see also printed exhibit catalog)

Notes

[1] Memorandum re: Thordarson Library [incl. "Excerpt from Minutes of Regents Meeting, January 19, 1946"] no date, University Archives, UW-Madison.

[2] E. B. Fred, *Edwin Broun Fred: an interview* conducted by Donna S. Taylor, Madison, Uni-

versity Archives Oral History Project, 1976, p. 87.

[3] The library has been described in articles in the *Papers* of the Bibliographical Society of America by Jens Christian Bay ([1930] *23*:1-17) and Ralph Hagedorn ([1950] *44*:1-26). Thordarson's biography appeared in Reykjavik in 1973 (Steingrimur Jonsson, *Hugvitsma durinn Hjörtur Thordarson.*)

[4] Chester Thordarson, Letter to President Clarence Dykstra, December 11, 1943, University Archives, UW-Madison.

[5] Gilbert H. Doane, Letter to Clarence A. Dykstra, April 18, 1942, Rare Book Department Files, UW-Madison.

[6] A. W. Peterson, Letter to President Clarence A. Dykstra, May 16, 1942, RBD Files, UW-Madison.

[7] Draft, unsigned, includes a pencilled note indicating it was submitted to President Dykstra, November 18, 1943, RBD Files, UW-Madison.

[8] A. W. Peterson, Confidential Report to President Fred re Thordarson Library, July 6, 1945, RBD Files, UW-Madison.

[9] Chester Thordarson, *op. cit.*

[10] William S. Marshall, Letter to Gilbert Doane, May 15, 1945, RBD Files, UW-Madison.

[11] ______, Letter to Gilbert Doane, May 30, 1945, RBD Files, UW-Madison.

[12] Confidential Memo re Thordarson Library, November 15, 1945, RBD Files, UW-Madison.

[13] Gilbert H. Doane, Letter to Jens Christian Bay, November 24, 1945, RBD Files, UW-Madison.

[14] Confidential Memo re Thordarson Library, November 27, 1945, ms., RBD Files, UW-Madison.

[15] F. J. Sensenbrenner, Letter to D. C. Everest, December 3, 1945, RBD Files, UW-Madison.

[16] Memorandum re: Thordarson Library, no date, University Archives.

[17] Gilbert H. Doane, Letter to Jens Christian Bay, February 1, 1946 RBD Files, UW-Madison.

[18] Ralph Hagedorn, "Bibliotheca Thordarsoniana: The Sequel," *Papers* of the Bibliographical Society of America, *44* (1950), p. 4 and 3, resp. For detailed description, see also Jens Christian Bay, *op. cit.*

[19] *Annual Report* of the Rare Book Department, UW-Madison, 1948-49, 1949-50 and 1950-51.—Most of the information for this section on staff has been taken from the Annual Reports for the appropriate years. Information from other sources only will be noted separately hereafter.

[20] Jeremiah O'Mara was forced to resign after only one week's service after having been stabbed on Bascom Hill on June 24, 1956. *UW. Library News 1*:2 (July/August 1956), p. 13.

[21] "Samuel A. Ives," *UW Library News* (Sept. 1958), p. 1-2.

[22] *Chemical, Medical and Pharmaceutical Books Printed before 1800: in the Collections of the University of Wisconsin Libraries*, edited by John Neu, compiled by Samuel Ives, Reese Jenkins, and John Neu, Madison, University of Wisconsin Press, 1965, p. vii.

[23] *Annual Report 1948-49,* RBD Files, UW-Madison.

[24] *Annual Report 1951-52.*

[25] *Annual Report 1953-54.*

[26] RBD Files, UW-Madison.

[27] *Annual Report 1954-55.*

THE WELFARE MUSE

Anthony Graybosch
Mount Senario College
Ladysmith, Wisconsin

John Steuart Curry was the first permanent artist in residence at University of Wisconsin—Madison. The post was attached to the School of Agriculture. This progressive institution believed in introducing the latest technology into farming as well as in giving cultural expression to the values of this emerging educated class.[1] Curry's family was an American version of landed gentry. They were spared the trauma of the Depression, which might help to explain the artist's own romantic digression from the period. Curry attained prominence as a member of the midwestern Regionalist movement with the more widely known Thomas H. Benton and Grant Wood. This paper is a study of the values expressed in Curry's work, within the context of New Deal art, and was suggested by recent exhibits of his work.

The word welfare in the title recalls the fact that most 1930's artists like the other unemployed of the era, had to take a poverty oath and be officially on the dole before becoming eligible for work assignments.

The muse was the Great Depression itself. The disastrous economic climate with its social suffering and a budding trade unionism movement proved to be a fertile source of artistic images, the so called American Scene. Sometimes it was handled directly, as in the case of the social realists, or indirectly in an equally derivative but retrospective flight from its immediacy as in the midwestern Regionalist work of John Steuart Curry.

The Economic Background

Because of its unprecedented scale of subsidized artistic productivity and the polemics over style, subject and message which I will introduce shortly, the Depression resulted in several revolutionary steps.

It brought about official recognition of art as a legitimate occupation worthy of "unemployment benefits." It resulted in the toppling of academic art's monopoly and opened the field to newer forms of expression in the art commissioned for government buildings.[2] And, the Depression introduced novel concepts such as 'Art on Wheels'—mobile art museums, and adult art education networks as well as other methods of disseminating art to the masses.

Government patronage of the arts had its genesis in the contact initiated in 1933 by artist George Biddle with President Roosevelt. Biddle pleaded on behalf of fellow artists for an opportunity for American artists to immortalize in permanent art form and make living monuments to the: "social revolution that our country and civilization are going through . . . and to the social ideals which you are struggling to achieve."[3] Biddle cited the Mexican muralists as the precedent that they would like to follow. Roosevelt replied that he did not want a lot of young enthusiasts painting Lenin's head on the Justice Building.[4] He steered Biddle to the Secretary of the Treasury Department, Morgenthau, who set up the internal Section of Painting and Sculpture in 1934.

In a milieu of cyclical repression and revolution, Mexican artists used murals as a form of social protest.[5] The art form was indigenous to the illiterate, agrarian people. The American murals of the 1930's lack this immediacy and the medium itself has been abandoned for all but decorative—architectural purposes.

The other major New Deal art program, and the major benefactor of the multitudes of artists, was the Works Progress Administration (WPA), more specifically the Federal Art Project (FAP), established in 1935. The purpose of mass patronage was to keep artists alive and creative during this difficult period by purchasing their work while practicing non-interference with the artistic process. Both forms of patronage wound down with the onset of World War II.

The Section referred to above had a definite stated program of cultivating native art and artists while acquiring suitable art, as long as it was American Scene. In their attempt to assist development of art in this country administrators proscribed potentially divisive subjects. One of these was Curry's *Freeing of the Slaves.* Curry described what happened: "because of the racial implications of the subject matter it was felt that Washington was not the appropriate place to erect this mural."[6] Censorship was felt by artists on the other side of the political-artistic spectrum as well. The social realist Ben Shawn had to erase from a mural a Walt Whitman inscription perceived as too secular.[7]

The whole patronage phenomenon was a conscious attempt by the government to encourage a taste for a particular style of American art and thus engage in a management of ideas through the marketing of a controlled public art.[8] This manipulation was implemented by the public endorsement of a chosen style and subject matter, prominent display in places such as post offices and the precaution that the art said the right thing including tacitly encouraging the re-painting of much of American history where necessary.

To illustrate this point we can note that Curry's *Justice Defeating Mob Violence,* 1937, stands in the Justice Department building in the space originally reserved for the *Freeing of the Slaves.* This mural depicts a white man being protected from a lynch mob, clearly a victim substitution. In the other Curry works on the theme of lynching, the victims are black. A companion piece in the Justice Building is *Westward Migrations,* 1936, which shows noble American pioneers pushing ahead with an absence of any native Americans in their way.

The concern to spur American economic recovery by buying American and bolstering "America's faith in itself" is not a sufficient explanation of why the emerging American art took its particular regional style. After all, the private art patrons and the government could have had no reservations about buying and promoting the non-representational native art which was evolving in parallel to the realism of the 1930's.

I am, of course suggesting an accomplice role for the Regionalists in the government policy. To the extent that Curry engaged in collaborating with the party line to the detriment of art itself or the endeavors of other artists, he is culpable. A post-mortem on the careers of Curry, Wood, and Benton reveals a cul-de-sac. They failed to influence the further development of American art or its international standing. This is ironic because they spearheaded the call to arms for the creation of a native American art in opposition to modern European trends, a convulsive reaction to the New York Armory Show in 1913.

Regionalist Ideology

The Regionalists attempted to nationalize an art which spoke to their idea of middle America. According to the group ideologue Benton "the intellectual aspects of art are not art."[9] The critic Thomas Craven wrote: "the function of art is communication and not technique."[10] Curry's own criticism of social realists was that they painted symbolic figures rather than real people engaged in real events.[11] The obvious retort one can make to Curry is that a painting is nothing if not a symbol.

Perhaps the figures of the social realists seemed symbolic to Curry precisely because they were not farmers. This is Curry's own self-characterization: "I do not feel that I portray the class struggle, but I do try to depict the American farmer's incessant struggle against the forces of nature."[12] Curry as an artist poses a strange contradiction. He is trying to give an agrarian underpinning to an industrial society. A farm is a farm, in Europe or America, the nostalgia of the western frontier aside. An art which denies the existence of 90% of America, is a type of violence and not a unique, new style of American art. There is no such thing as an American people. The gates of immigration are still open, and they were open then too.

From biographical materials one gathers that the Regionalists spent time in Europe, but got no first hand exposure to the modern movements, with the exception of Benton. Instead, they floated like ghosts through the museums in search of dead masters. They made no attempt to plug into the vitality that was there but treated it as a place full of cemeteries. Is it any wonder that 'resentiment' was their reaction when these Europeans began to influence and control the course of modern art?

Perhaps only the itinerant photographers that worked for the Department of Agriculture give a direct access to the raw, uninterpreted human mass of the Depression, because they found it harder to superimpose a veneer on the images they took in the field. While it is known that few social realists had proletarian roots and, therefore, their insight and accuracy of portrayal of the working class are somewhat suspect, they at least acknowledged that they lacked a universal, ready idiom.[13] As a result, their work evolved more individualistically than that of the Regionalists.[14]

In contrast, the Regionalists in effect if not in intent, produced an art for hard times, an art encouraging the lowering of expectations and defusing the impulse toward the revolutionary. Instead of wondering what this new American art would be and who would produce it and when, the Regionalists decided that they already had it. They treated America as already-made and engaged in an aesthetics of everyday life and banality, with official sanction. The artistic commitment of the Regionalist movement was an attempt to create a landed gentry.

It is ironic that Curry, basically a nature artist, Wood, whose Iowa landscapes are very private and introspective visions, and Benton, all got drafted into expressing the official American consciousness with only the tenuous bonds of surface 'realism' and midwestern themes to bind them. Of the three, perhaps only Benton rose to the task with his muscular man as machine compositions unifying the farm and the urban setting.[15]

The fallacy of the Regionalist ideology is the belief that realism and familiarity somehow preserve and present an intact world with its verities and homilies. Curry forgets that the simplest object can be removed from its context in the universe through art. His focusing on ordinary life, despite his motives, takes the farm out of its specific social context. Using his father as a subject may avoid symbolism and intellectualization for Curry, but not for his audience. He is a child denying that there is a world outside of Kansas. And Curry does not try hard enough to reintroduce reality even within this limited subject matter.

The major political connection to make between the subsidized art produced by the Regionalists and their sponsor, was that the "paid commercial message" dictated that the way to survive in the face of an overpowering force such as the Depression is through resignation and perseverance. You should hold on to your traditional values and find a way to graze off the land. Where the political order manages to present itself as the natural order, people transfer the attributes of nature to the political order

Fig. 1. John Steuart Curry, *The Road Mender's Camp* 1929.

itself, leading to totalitarianism and glorification of the common man and a rise of 'resentiment' in the face of difference.

Curry's Work

Now to come to Curry as the man in his work. I find much of his work somnabulistic in flavor, curiously static even when portraying catastrophes. His focus is the anticlimax. This is his individual trait. In the *Road Mender's Camp,* 1929, (Fig. 1) all is in its place, there is no discord, just people at rest after a hard day's work. The key here is that he chose not to show the work itself—turning instead to the card playing, children's games and the mother with babe in arms.

Consider his *Baptism in Kansas,* 1928. Its history includes the fact that the canvas started out as Signorelli nudes around a bathing pool and then the prop change took place to a wooden baptismal fount.[16] This suggests Curry was still in search of subject matter. There is circus imagery here which relates to his later opus of circus prints. It is a spectacle complete with center ring, a Ferris wheel suggested by the omnipresent weather vane, and an absorbed audience. There is a cohesion of the group, suggesting unity of purpose, but Curry gives us an unobstructed access to center stage on the left as if offering us an invitation to join in or perhaps an outlet to escape.

The hands of the two protagonists are highly symbolized. Curry consistently uses hands iconically, they express a lot in a very stylized manner. The birds overhead are emblematic of the spirit. For example, in

The Fugitive, 1933, there are butterflies symbolizing flight. The woman in white in *Baptism* is suggestive of a melting candle, she dissolves and is assimilated into the glimmering pool of white water. The preacher pushing her in is shut-eyed and forcibly concentrating, face and body turned slightly away from her with effort. Also, you can see the Curry technique of using the weather metaphor to represent human emotion. Here we have a sunny day, but the emotional pitch of the group is evoked by the tight sway of the human circle. We are inside a human tornado. This is the work that launched Curry nationally, having won him a competition. I am not suggesting a mercenary response in Curry, but his subsequent work does engage in further nostalgia and glorification of his own idyllic version of an atemporal America.

When I look at *The Tragic Prelude* (John Brown), 1938-39, and see the background wagon trail, I wonder whether we should see it as the frontier spirit or flight from reality? Brown is an imposing quixotic figure, with a Bible, a gun, and a brave daring stance. He is simultaneously defiant and vulnerable with torso extended wide, a figure of obvious historical impact. The Bible and the gun symbolize the inherent injustice and accommodation to hypocrisy America has to take in order to exploit the blacks. Had we taken the Bible literally, and Curry is very interested in the impact of religion, there would not have been a need for the gun and the bloodshed. In the mural there is an obliviousness to Brown except by the black faces gazing up at him. The emerging black imagery in Curry and others in the 30's served as the symbol of social and not merely racial oppression. They had a group exhibition on the subject of lynching called "An Art Commentary on Lynching" in 1933.

Interestingly enough, we can accuse Curry of whitewashing Brown. The problem, as I see it, is that John Brown is not finished yet, although dead. He is still, and was then, a dynamic figure. The black struggle is still going on. The government showed awareness by not permitting black subject matter into Washington. This mural of a less than favorite adopted son is in Topeka, Kansas. This placement, although geographically accurate, limits the national importance of its theme. How could John Brown be a hero in a country which feared him and is still racist and ambivalent about its heroes? Curry is trying to fence Brown in, to homogenize him so to speak by tucking him away into the pages of history.

The Tragic Prelude, although visually exciting, points out that Curry was a product of his society. We have to deny privileged access to one's own values to all, even artists. No one escapes the shadow of history. One finds other hints of criticism of the social order in Curry, but one wonders why they are only hints and why he found a superficial, token treatment of blacks more accessible than dealing with the American worker, or the dustbowl and migrant labor.

If you look at the black faces in the mural you see them cowering, terrified in the protective shadow of the good white man, and the abolitionist sentiment he represented. So a final objection is that the blacks have been dispossessed of even their anger and the potential for violence and revenge. There are no angry black people, just an angry John Brown.

Freeing of the Slaves, 1942, is the infamous mural banned from the Justice Building. It portrays blacks in the aftermath of *The Tragic Prelude.* The center figure of Brown has been replaced by the young black who has stepped off his tree-cross in *The Fugitive,* and is now leading his people in exultation. The union flag is center stage and you can almost hear the voices, the black chorus praising the Lord. An old man is still praying in the wagon, perhaps he does not realize yet that salvation is here. Unlike the flat terrain in the back of John Brown, these people are ascending from the darkness left behind. They emerge from a hollow, dark low horizon on the left and are teeming into the light center stage. In a similar mural, Diego Rivera's *Zapata,* Zapata's men are armed, the people and the liberators are one and the same. There is no dichotomy as in American history and imagination. The casualties at the Mexican revolutionaries' feet are the ones they have killed themselves.

The forces that caused the plight of blacks were human forces: racial prejudice, economics, religion and politics. In the flood theme of *The Mississipppi,* 1935, they are represented as impersonal, uncontrollable forces of nature, blacks caught in the turbulent waters of history. Again we encounter the weather metaphor for human existence. This removes the human element of guilt and the personal value of survival as well. The blacks are just 'lucky' to have survived the whole mess. And what follows is that it all just could not be helped. The victims are resigned in the painting and resorting to prayer. The political order is the natural order with its storms and its calm days so do not rock the boat. Things will get better in time.

Only the roof of a house is left where the whole black family remains intact, even the cat. They are set drifting into a new future, freshly baptized as Americans. Curry gives blacks turbulent waters while the whites immerse themselves in calm streams and pools. The supplicating hands of the male are pronounced, males are the more expressive gender in Curry's work.

The one nice quality about *The Mississippi* is its musical-aural quality. The tumultuous waters, soaked whistling trees, cat meowing, roof planks creaking and the howling wind, all combine to produce a wall of sound effect.

Wisconsin Landscape, 1939-39 (Fig. 2), is representative of the later landscape work and is a macrocosm to the microcosm seen in the close up of a *Kansas Cornfield*, 1933. It is unusual in that it is very dramatic in its high color and almost impressionistic brush quality. The chiaroscuro light strips crisscross the landscape into dynamic parcels. The raised perspective also magnifies the already present vastness of the subject. If the human houses and barns were not tightly delineated by the artist, one could forget the intrusion of man into this Eden. The drama of nature occurs without human intercession. Perhaps, while awed by the suggested beauty of it we are also supposed to feel

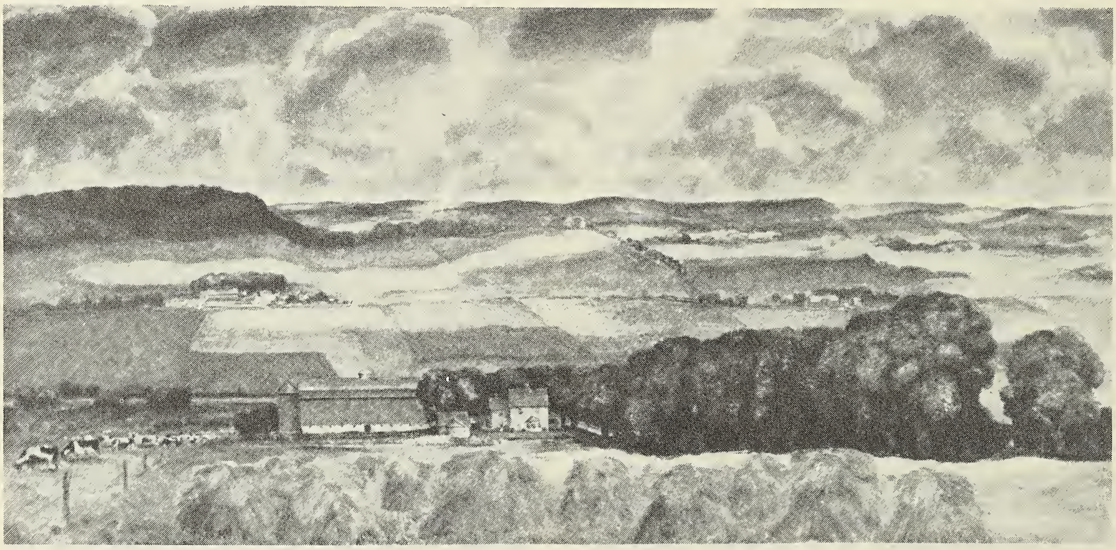

Fig. 2. John Steuart Curry, *Wisconsin Landscape* 1938-39.

fatalistically that everything would be fine in the absence of humanity.

Curry's nature images recall Nietzsche's indictment of society as being no shepherd and one herd. But this painting is certainly a more emotional engagement on Curry's part than the flat landscape backdrops he erects in the historical murals.

In closing this section, I would like to quote Arthur Dove, an abstractionist in the 1930's. "When a man paints the El (subway), a 1749 house or a miner's shack, he is likely to be called by his critics 'American.' These things may be in America, but it is what is in the artist that counts. What do we call American outside of painting? Inventiveness, restlessness, speed, change. . . . A painter may put all these qualities in a still life or an abstraction, and be going more native than another who sits quietly copying a skyscraper.[17] Only the term 'copying' betrays the indignation in this otherwise lucid pronouncement on the polemics of realism versus abstract art in America.

What Price Art?

The Section was oppressive in their funding of public art, attempting the creation of art for the masses. The older non-democratic societies had sponsored art for the elite only. The WPA was benevolent and non-intrusive into the creative process, but financially less rewarding than the Section. A question we might ask in retrospect is whether the public could have refused something the artist produced. Fortunately, we had the Section to insure that our dollars were well spent.

In post World War II America, there have been three ways for the artist to exist: in the commercial market, via subsidies through grants and awards, and teaching in the academe, while retaining the energy and impetus to produce. The days of private patronage seem to be over. One problem with public funding is that during periods of economic stress, art takes low priority and loses funds proportionately. Another problem is that centralized disbursement of funds and judging of beneficiaries, may lead to subsidizing mass culture art.[18] Also, government bureaucrats have a fondness for the concretism of conspicuous consumption evidenced in the erection of monumental museums and theater complexes.

A sad postscript to the New Deal was the destruction of a vast amount of art. Most of the destruction was not malicious and, before the dissolution of WPA, strenuous attempts were made to house and permanently allocate art works with any public institution that would have them. The WPA anticipated that the war shortages and the prospect of indefinite storage would imperil the works. This danger materialized when the majority of the work fell under the classification of surplus art.[19] There are stories of prints being recycled into pulp, paintings sold as 'used canvas,' and sculpture demolished because of its sheer size.

Of course, there are villians as well, such as the infamous Lt. Somervell who interpreted the order to liquidate the WPA as a mandate to destoy its artistic legacies as well. He destroyed several mural panels at Floyd Bennett Airport in 1940 as subversive material. But Somervell did not go after communist iconography alone. About 800 paintings and graphic works were incinerated. In the words of an artist active during the era: "for many artists several years of their serious professional work had simply evaporated."[20] The problem is compounded by the fact that the allocation cards have been lost thereby making the location of surviving lesser known work impossible to trace. Art had finally become public property.[21]

Notes

[1] Laurence E. Schmeckebier, *John Steuart Curry's Pageant of America*, (New York: American Artists Group, 1943), 82.

[2] Francis V. O'Connor, *Federal Support for the Visual Arts: The New Deal and Now* (Greenwich, Connecticut: New York Graphic Society, Ltd., 1969), 106.

[3] Ibid. 18.

[4] Ibid.

[5] Ralph E. Shikes, *The Indignant Eye* (Boston: Beacon Press, 1969), 374.

[6] Matthew Baigell, *The American Scene: American Painting in the 1930's* (New York: Praeger, 1974), 129.

[7] O'Connor, 24.

[8] Olin Dows, "The New Deal's Treasury Art Program: A Memoir," *The New Deal Art Projects, An Anthology of Memoirs*, edit. Francis V. O'Connor, (Washington, D.C.: Smithsonian Institution Press, 1972), 36.

[9] O'Connor, *Federal Support,* 63.

[10] Ibid. 23.

[11] Joseph S. Czestochowski, *John Steuart Curry and Grant Wood, A Portrait of Rural America* (Columbia, Missouri: University of Missouri Press, 1981), 40.

[12] Baigell, 128.

[13] Ibid. 174-175.

[14] Prior to the Depression America had no artistic tradition of social commentary and protest except political cartoons in the print media.

[15] Martin Greif, *Depression Modern* (New York: Universe Books, 1975), 34-36. Offers a quote by designer W. D. Teague, which applies to the Benton dynamics. "We are a primitive age, a dynamic people, and we respond only to the expressions of tension, of vigor, of energy."

[16] Oliver W. Larkin, *Art and Life in America* (New York: Holt, Rinehart, and Winston Inc., 1949), 414.

[17] O'Connor, *Federal Support,* 66.

[18] For an exhaustive exploration of these issues see Gifford Phillips, *The Arts in a Democratic Society* (Santa Barbara, California: The Center for the Study of Democratic Institutions, 1966).

[19] O'Connor, *Federal Support,* 102.

[20] Ibid. 103.

[21] Research funded in part by a Wisconsin Humanities Committee Mini-Grant.

SOME REFLECTIONS ON RIGHTS: HUMAN, NATURAL, MORAL, AND FUNDAMENTAL*

Marcus G. Singer
Department of Philosophy
University of Wisconsin, Madison

Recent years have seen an unprecedented flurry of interest in the philosophical analysis and elucidation of human rights. There are now two or three journals devoted to human rights—or at least to their discussion. The 1981 volume of *Nomos,* no. XXIII, is on the topic of Human Rights. There have been many books on the subject with, we may be sure, many more to come. It is a famous observation of Hegel's that The Owl of Minerva spreads its wings only with the coming of the dusk. We may hope that this observation, so profound on other matters, does not prove to be true of human rights as well. But there are regimes in the world that honor human rights more in the breach and the official rhetoric than in the observance, and others where they are honored in no way, not even in the official ideology. Even the present tendency of public opinion seems more concerned with freedom of enterprise than freedom of the person, with property rights, to lapse into some older terminology, than human rights. I think it was Anatole France who observed that a poor person has as much right as a rich one to dine at the Ritz, or to sleep on the banks of the Seine, or something to that effect, and a political regime in which that is emphasized is not one that has any special concern for human rights. Yet the notion is alive in the world, if not at the moment in Washington, and it behooves us to understand why and how.

The interest generated in recent years by appeals to human rights is not something temporary, unless human life itself is. That the appeal to human rights has met with such a response in the less developed parts of the world, as well as those enslaved by the present day imitators of Nero and Caligula, indicates that it is not something that can easily be papered over. On the world stage, the appeal to human rights has always had a revolutionary force, from the time it first arose in the 17th century, and though the force of the appeal has waxed and waned, it seems always ready to be revived when the occasion warrants.

The present period in human history may be one of those occasions. It is to be hoped that the present interest taken by philosophers in the concept does not result in its being appropriated as a topic to be endlessly analyzed and argued about and refined to the point where its appeal to governments and ordinary people is correspondingly diminished. Too much philosophical exploration of and debate about minutiae may tend to have this effect. Still, we need not worry overmuch about this. For it is not evident that all the philosophical talk about the existence of God has had any appreciable effect on the strength of religious belief. So it may be that all the philosophical talk about human rights will not damage the concept as a political, moral, rhetorical, and emotional tool. For of course it is such a tool. To be sure, on many occasions it has been misused. The idea, naturally, is to

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* This paper was presented at the Tenth Interamerican Congress of Philosophy, at The Florida State University, Tallahassee, Florida, 18-23 October 1981, devoted to the topic of Human Rights, in a Symposium on Human Rights and the Political Community, 19 October 1981. Abstracts of papers from the Congress, in English, French, or Spanish, can be found in *Human Rights: Abstracts of Papers from the Tenth Interamerican Congress of Philosophy* (Tallahassee, Florida: Department of Philosophy, The Florida State University, 1982).

clarify the concept, not to bury it; to elucidate it, not to appropriate it, and if philosophy performs its proper task aright, it will be strengthened, not diminished.

That is my object in this paper. I present no theory of rights—there are plenty of those available—only some observations and reflections and questions that seem illuminating and essential for any adequate general theory of rights to take account of.

1. A theory of rights must capture and explain the force of "rights-talk." It has rhetorical hence political and also moral force, which must be recognized. It is a vital weapon of social conflict, hence must be understood. It has a nearly universal appeal, hence must be mastered—not for purposes of propaganda, but for purposes of understanding and securing rights, when genuine.

For rights-talk is significant. The claim "A has a right to X" is different from "A wants X." If I say "I have a right to do X" that is different from saying "I want to do X." When we use such locutions ourselves we are conscious of meaning something different and something more and when we hear them used by others we are conscious of their meaning something different and something more. What the difference is, it is the task of a theory of rights to determine, but the fact is plain enough. The fact that one who asserts a right to something also wants that thing does not deny the point of difference; it only accentuates it. But I must recognize that when someone else asserts a right to something, what is being asserted is, quite apart from the validity of the claim, essentially different from merely asserting a desire to have it or demanding it, because I recognize that that is true of myself when I assert or claim a right. I am aware that I am not merely expressing a desire; that I don't merely *want* it. This is true even if I on occasion engage in deception, and assert a right to something that I only want and do not really believe I have a right to.

The argument here is something like Santayana's for the reality of truth. One awakes "to the being of truth," Santayana observes, through "the experience of other people lying. When I am falsely accused, or when I am represented as thinking what I do not think, I rebel against that contradiction to my evident self-knowledge; and as the other man asserts that the liar is myself, and a third person might very well entertain that hypothesis and decide against me, I learn that a report may fly in the face of the facts. . . ." [*Skepticism and Animal Faith* (1923), p. 266.]

Since I am aware that I mean something different when I assert a right to something than when I merely say I want it, I must recognize that there is a difference between them, even if I am unable to describe that difference in words. And a little experience of the world is sufficient to convince me that others also are aware of such a difference.

Further, there is a force in "You have no right to do that" that is not captured by its formal equivalent, "It is wrong of you to do that," or "You have a duty not to do that." What is the explanation of this?

To have a right is to have an authorization, an entitlement, and this is a certain sort of moral capacity. "You have no right" claims that you do not have that capacity. But why does it have this force?

2. Yet rights-talk is easily and often exaggerated, and is often used to cover up and suggest a sanction for mere claims or demands that have no other backing than self-assertion. In these circumstance, "I have a right to it" is only a highly emotive way of saying "I want it." Thus people claim a right to something they want *because* rights-talk is in general significant, powerful, effective. Too much of this darkens counsel, tends to corrupt moral discourse at its roots.

By an analogue of Gresham's Law, bad rights-talk will tend to drive good rights-talk out of circulation, or rather it will tend to corrupt and discredit it, as inflation corrupts and discredits a currency. This is why rights-talk, and rights-claims, need to be so carefully scrutinized, like the claims of advertisers and hucksters and propagandists.

Just as there is a distinction between a claim to know and genuinely knowing, there is a distinction between claiming to have a right and genuinely having one. Those who claim a right to everything they want are making a claim that would be self-contradictory if universalized. It follows that no one can have a right to everything he or she wants. The distinction between wanting something and having a right to it remains basic, and enables us to say that in a morally tolerable world people will, in general, have rights to have their basic wants satisfied and that these rights will be recognized. But since not everyone can have a right to everything she or he wants, *no one* can—and no one does.

3. In the United States especially there is a tendency to use rights-talk extravagantly, to exaggerate one's special wishes or wants into the claim that one has a right. This is only partly because of the American tradition of the tall tale and the happy exaggeration. The country was explicitly founded on the basis of rights and in the light of the philosophy of natural rights and the enlightenment, and the tendency to think in terms of rights as basic and self-certifying reasons is part of our heritage, which we acquire as we acquire our mother tongue. One result of this is that opposing sides in moral conflicts assert incompatible rights and as the conflict escalates assert them in louder and louder tones, so that many moral and value conflicts tend to turn into shouting matches, or worse. Some of these conflicts we get over; some we do not. But if the concept and the language of rights is to be of use in settling conflicts we must have a way of resolving conflicting claims of rights. It may seem self-evident—though it is probably not even true—that genuine rights themselves cannot be in conflict. But it does not matter, for a conflict of rights-claims cannot be settled merely by an appeal to rights. There must be a basis for determining which claims are genuine and which not.

4. Some consideration of the history of the concept may be of use. I do not know for certain when the expression "*human* rights" came into general use and currency, but the evidence indicates that it came into general use in the late 19th Century or early 20th, as part of the progressive movement. It was used in contrast with *property rights*, and it involved the implicit claim that human rights should take priority over the rights of property or corporations. Thus it was used by supporters of Woodrow Wilson's "new freedom" and in conjunction with Theodore Roosevelt's "square deal," and perhaps earlier. This is not its standard use now, but this is its pedigree. As the term is used now it traces from the 17th century notion of *natural* rights, which were regarded as the natural rights of man (as in Tom Paine's famous book). Mary Wollstonecraft's *Vindication of the Rights of Woman* received no noticeable vindication at the time it first appeared (1792, the year after Paine's), but it has been vindicated now for some time, so it is probably better to speak of the rights of human beings than of the rights of man. Hence "human rights" has a birthright. But it is, I think, a not altogether felicitous expression.

Why "human rights?" Presumably because they are the rights human beings have in virtue of being human, and they are no other special class of rights. The expression suggests, however, that they are a special kind of rights, along with such categories of rights as constitutional rights, civil rights, political rights, economic rights, legal rights. Of course they are not. And why are these rights of human beings, and not of other creatures or beings as well? I would prefer to speak of *moral* rights, but of course it is futile to argue against an established usage. Better to understand it.

But even though human rights are in a way a descendant of, and another expression for, natural rights, they are also a bit different. They are similar in that they claim to be universal, to have validity across cultural and political boundaries, to be the rights of human beings as human beings, in virtue of their common humanity (an assumption necessarily involved in the conception). But natural rights, as the concept was used for generations, were thought of as rights to certain kinds of freedoms and protections. What are now referred to as human rights tend to be thought of as, perhaps in addition, rights to certain kinds of services and benefits, such as health care and a living wage. Is this significant? I think it is not, that it is only a historical accident, the term "natural" having fallen out of favor and the term "human" not—at least not yet.

One rather amusing and at the same time pathetic aspect of this usage is the appearance of signs and manifestos saying, "We have human rights too!" This is usually proclaimed by some group that feels particularly oppressed, and of course sometimes such a group genuinely is oppressed. But this involves a confusion of categories. What is meant is "We are human beings and we have rights too." Unhappily, it is sometimes in this unhappy world necessary to point that out. But the expression "We have human rights too" suggests, as I said before, that human rights are a certain *kind* of rights, and of course they are not. They are the rights natural to human beings, if they are genuinely rights at all, in virtue of certain invariant and fundamental moral principles. Since their justification must lie in such principles I think it more perspicuous to think of them as *moral* rights.

And we should remember, in speaking of human rights, that we should not overlook human wrongs. Though it may not be only human beings that have rights, it is only human beings who can commit wrongs, just as it is human beings who are the source of evil, and it is only human beings who can violate human rights.

5. What is the basic human right, assuming that there is one? One often hears it said nowadays that the basic human right is the right to life, on the ground that being alive is essential to having any other rights. But the argument is fallacious. What is essential to having rights is not the *right* to life, but simply life. A right to life is, I have come to think, an ad hoc construction used to shore up certain contentious positions based on faulty logic and a misreading of history.

The idea that the right to life is basic is often traced back to the Declaration of Independence, in accordance with the characteristically American practice of tracing any contentious point of political philosophy back to some great document in the history of the country. Now it is true that the Declaration of Independence, as adopted, contains the phrase: "that all men are created equal, that they are endowed by their creator with certain unalienable rights, that among these are life, liberty, and the pursuit of happiness." But a little research suffices to show that what appears in the final version as a right to life was stated in Jefferson's original draft and early versions, and retained for more than a little time, as a right to "the *preservation* of life, and liberty, and the pursuit of happiness." [See Carl Becker, *The Declaration of Independence* (1922), Ch. 4.] A small change, you think? Well, I am not so sure it is so small. I think it was not a philosophical consideration that led to the dropping of "the preservation," but considerations of style and rhetoric and politics. For the purpose, superb. For philosophical and even moral purposes, perhaps not so happy.

Consider its antecedents. Hobbes's "right of nature . . . is the liberty each man hath, to use his own power, as he will himself, for the preservation of his own nature; that is to say, of his own life . . ." [*Leviathan* (1651), ch. 14, par. 1]. Locke, a more obvious influence on Jefferson, also had put it this way, though this is almost always overlooked in quick and rapid statements of what are taken to be Locke's basic principles. We find Locke, in the *Second Treatise of Government* (1690) speaking (sec. 11) of the "right of self-preservation" and also saying: "Natural reason . . . tells us that men, *being once born,* have a right to their preservation, and consequently to meat and drink and such other things as nature affords for their subsistence" (sec. 25, italics added). I do not know why Locke restricted himself to "men, *being once born.*" Perhaps Locke scholarship can tell us. I do know that that is what he says. And his famous trinity of rights, supposedly the model for Jefferson's statement in the Declaration, reads this way (sec. 87): "Man, being born with a title to perfect freedom and uncontrolled enjoyment of all the rights and privileges of the law of nature equally with any other man or number of men in the world, has by nature a power . . . to *preserve* his property—that is, his life, liberty, and estate . . ." Again, to *preserve* his life.

It appears, then, that the phrase "right to life" entered the language and our common culture only as a sort of shorthand and by accident.

It is in the context merely an aside and an example, and I do not wish to enter the lists here in the contemporary dispute about abortion, but it seems clear that those who oppose it in any and all cases must find some better argument for their position than a supposed right to life on the part of the fetus, as a right basic to all, say, human beings. For, as I suggested before, apart from the facts of history just reviewed, it is not the right to life that is basic as essential to enjoying or exercising any other rights, but rather life itself, and perhaps a bit more, such as competent life. Being alive, or being a being of a certain kind, is the condition of having rights.

In this connection one occasionally hears talk of a "right to be born," and I have heard that countered by an assertion of a "right not to be born." This is something perhaps congenial only to those brought up in a natural rights environment. But surely here we have an object for Bentham's contemptuous phrase, "nonsense on stilts." For if there is a right to be born, we must be able to specify whose right it is and under what conditions it is violated. If we can speak sensibly of a "right to be born"—which I doubt—then we can speak sensibly of "a right to be conceived," and a corresponding "right not to be conceived." And here we have started a game in which all rules are off. It is reported that when a student, terribly bothered by Descartes' demon, said to Professor Morris Cohen, "But Professor, tell me, do I exist?", Cohen replied by saying, "Who wants to know?"

One is also reminded of the old Jewish story, now famous, of the two men mournfully complaining of the woes and sorrows of existence. "Life is so terrible," one of them says finally, "it would have been better never to have been conceived." "True," said the other, "but who is so lucky?—not one in a million."

Whose right is it? Who's asking? Who wants to know?

Rights-talk has got to be more sensible than this if it is to pass rational muster. The alleged "right to life" does not. If it does, we shall have created also the right to be born and the right to be conceived and the right to be brought into existence. But who has such a right, and on what basis is it asserted? The multiplication of such alleged rights can only serve to discredit rights-talk altogether, which in turn will cover up the many and repeated violations of genuine human rights constantly occurring in the actual world in which we live.

6. A recent notice from an organization called "Greenpeace" asks "Do whales have a right to live?", and answers itself, "Yes, they *do* have a right to live."

I find myself wanting to agree with that, without any clear idea of why or what or how. For the peculiarity of assertions such as this, "Whales have a right to live," is that people who assert it are asserting it not of individual whales, but of the species, are asserting that the species has a right to survive. And when we talk of human beings having a right to life we of course are referring to each and every one, not the species of humans.

I wonder if the ease with which we find ourselves agreeing that whales, tigers, elephants, have a right to live is not generated by the ease with which we picked up and repeat the phrase "the right to life."

Do trees have a right to live? Do roses have a right to live? Do mosquitoes have a right to live? Do cockroaches have a right to live? Do bedbugs have a right to live? Do weeds have a right to live? Do these questions have answers?

Do minnows have a right to live? But freedom for the pike, as Tawney said, is death for the minnow. Do pike have a right to live? A right to freedom?

The piece from Greenpeace, after providing a horrendous description of the process by which whales are killed—slaughtered, actually—,observes that when the process of raping the whales' bodies of fat and muscle is finished, "the remains are dumped overboard to the sharks."

But if whales have a right to live, don't sharks have a right to live?

How can we tell?

7. We need to recognize that, even where it is not abused, rights-talk is not all-sufficient. It needs to be supplemented by a concern for and attention to consequences and alternatives, and also by a consideration of duties and obligations. For talk only about human rights, with no consideration of consequences and obligations, is egoistic talk, and can destroy the possibility of a moral community and a moral life. Under such circumstances it would lose all meaning, *including* emotive meaning, and could no longer be used, as it is now so often used, even for the deception of oneself and others.

If everyone were only to assert rights and never acknowledged duties, both rights and duties would lose all meaning and significance because there would be no moral community in terms of which alone they can have significance.

8. But are there basic or genuine human rights? Certainly there are, for there are moral rights. This follows from fundamental principles.

What would happen—how would it be—if no one had rights and if no one were recognized as having rights? It would be intolerable. No one could tolerate a situation in which no one was recognized as having rights and, as a consequence, no one's rights were recognized. A maxim of recognizing no one as having rights could not be willed to be universal law. All rational persons would rationally want others to recognize them as having rights, and consequently must recognize others as having rights. Though specific rights can vary from one to another, fundamental rights are necessarily reciprocal and identical. If *any* one has rights then so must *every*one similarly situated. The supposition that no one has rights thus cannot be sustained. And everyone is similarly situated in being a human being and thus a potential member of the moral community.

The supposition, indeed, that there is a community none of whose members has any rights is self-contradictory. An *organization* there might be with members having no rights—as there might be an organization of robots or automatons—but *community* there could not be. But without community there could be no duties or obligations either. Thus the idea of rights is, it seems to me, essential to moral thought. But principles establish them and it is by reference to principles that they are to be understood and weighed and, where appropriate and called for, limited.

9. Is there any one right that is basic or fundamental? I am not sure that there is, but if there is, I should say that it is the right to freedom of conscience, the right to think as one is led to think through the free and unfettered operation of one's own mind and distinctive personality. I say this because this right cannot be violated without destroying the individual, without destroying the individual's capacity to think, to feel, to be aware and conscious of oneself as an individual person and personality as distinct from a heteronomous automaton. And this is, so far as I can see, the only right of which this is true. This right has obvious affinities with, may even be identical to, the right to be oneself, but I do not discuss this here. It also links, in interesting ways, with other rights of great importance which, lacking the feature mentioned, cannot be regarded as rock-bottom.

10. The question is often raised, which is prior, rights or the community? Do human beings have rights outside of and prior to any community—as is implied by traditional contract theory and maintained today by egoistic libertarians—, or do human beings have rights only within and as a consequence of the existence of the community and of their being accorded by the community—as is maintained by collectivists and social function theorists? The question is, in my estimation, spurious. There is no need to determine which is prior, rights or the community, and no possibility of doing it. These are, I suggest, *polar* or *interdependent* notions. Neither concept can be understood or explained without the other.

There are at least two senses of polar terms that we have to note, one wider than and implied by the other. In one, (1) two terms *A* and *B* are *polar* if the meaning of one involves the meaning of the other. This is the wider sense, in which the relationship is conceptual only. In the other, the narrower stricter sense, (2) *A* and *B* are *polar* if it is impossible for there to be an instance of one without there existing an instance of the other. Clearly (2) implies (1), but not vice-versa.

Instances of terms that are polar in the stricter, existential sense are: buying and selling, north and south, cause and effect. Terms that are polar in the wider, conceptual sense, but not necessarily in the existential sense, include: supply and demand, means and ends, part and whole, peace and war, husband and wife, form and content, and, unfortunately, teaching and learning.

Now it seems clear enough that rights and duties are polar in one of these two senses. I do not stop to determine which. My suggestion here is that so are *right* and *community* polar, in at least the intensional, conceptual, sense: that is, the meaning of one involves the meaning of the other. Whether the *existence* of one entails the existence of the other I am not sure. But even the weaker polar relationship indicates that neither is basic, any more than one of the polar pairs north and south, right and left, husband and wife, buying and selling, must be basic.

The concept of polar notions can be extended to a wider range. Multiple conceptions can be polar—or better, interdependent or multi-polar—and there is illumination in extending the concept in this way. For it enables the polar relationship to be understood. The basis of the relationship between husband and wife is marriage, and there is similarly a basis for every polar relationship. The basis for the polar relationship between rights and duties is the ground or rationale or reason that determines that one person has a duty and another a right. And it is not at all implausible to hold that the notions of rights, duties, moral agents, and the moral community are in some such way as this interdependent.

11. This suggests another reason why, as I suggested before, the expression "moral rights" is preferable, on philosophical grounds, to the expression "human rights."

For they are, as I said, moral rights, rights which beings have in virtue of morality—fundamental moral principles.

Secondly, they are not just the rights of human beings, which is the suggestion conveyed by the expression "human rights." Animals can have moral rights, as they can be members—or can be treated as members—of the moral community. But how can nonhumans have human rights?

Thirdly, moral rights are polar to the moral community, which transcends all merely political and even cultural boundaries. Thus moral rights are not polar to the actual human community—if there is one—, or to any actual political community. What is polar to the political community are political rights, and in some political communities there may actually be none, except, perhaps, those held and exercised only by the rulers.

By the moral community I mean the community of all moral persons, persons of good will, those who recognize moral rights and duties, the "ethical commonwealth" originally conceived by the Stoics and so eloquently described by Kant in his later ethical works and in his concept of a kingdom of ends.

But of course the expression "human rights" is preferable rhetorically, politically, and practically.

12. None of this is to deny—it is rather to affirm—that human beings have certain fundamental rights, which ought to be, must be, need to be recognized. Any government that denies or violates such rights is to that extent bad, wrong, and illegitimate, and hence has to that extent no claim, no right, to respect or obedience or even to existence. But what this means in practice, and how it is to be applied and carried out into practice, is something else.

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WISCONSIN'S WAR AGAINST RUSSIA, 1918-1919

BENJAMIN D. RHODES
Department of History
University of Wisconsin-Whitewater

As they left America by troopship in the summer of 1918, the Wisconsin soldiers treated in this essay were under the impression that they were on their way to France to wage war against the forces of Kaiser Wilhelm II. At the last minute, however, both their destination and the enemy were changed. Their exact location was now a classified secret.[1] But, in letters to their relatives, the soldiers described many attractive aspects of the place. Geographically the country resembled northern Wisconsin.[2] Forests of pine, spruce, and aspen dominated the largely flat landscape which also featured numerous meadows filled with wild flowers and unusual mosses, as well as clear lakes and rivers. The woods teemed with deer, ducks, geese, woodhens, crows, immense rabbits, and flocks of white chickadees so plentiful that "when they flew it looked like a snowstorm."[3] In summer there were long hours of daylight and mild temperatures. During the months of intense cold the troops were housed in snug, well-heated dwellings which were frequently equipped with saunas. Even the long winter nights were made memorable by brilliant displays of northern lights. And the natives of the region were not too different from the people at home—hardworking, religious folk who loved a good joke and often drank too much.

At the same time there were drawbacks: bottomless swamps and clouds of mosquitoes in the summer. During the winter months homesickness and melancholia were induced by the short days and temperatures as low as −53 degrees Fahrenheit. The food ration, consisting primarily of black tea, hardtack, and canned willy (corned beef), also left much to be desired. Flies, fleas, cockroaches, bedbugs, and ticks were other sources of discomfort. "It's the filthiest place I've ever been in," wrote one Milwaukean. "The cooties keep us dancing every minute." Probably the most unattractive feature of the mission was the imminent danger of death from sickness, mines, booby traps, and rifle and artillery fire. Tragically for the ten Wisconsin soldiers who lost their lives, they were not engaged in practice maneuvers in the north woods, but were fighting a shooting war against the Bolsheviks more than 200 miles deep in the interior of North Russia.[4]

Wisconsin's connection with the affair originated in the distressing news which came out of Russia in the autumn of 1917. First, in November the Bolsheviks easily toppled the pro-Western Provisional Government. And within a few months, to the consternation of the Allies, the Bolsheviks betrayed the West by signing a separate peace with Germany and leaving the war. From the Allied viewpoint, especially that of the British War Cabinet, the Bolshevik action was intolerable, because it would permit the Germans to transfer their army to the Western Front and to gain control over Allied military supplies sent to Russia. The British proposed, therefore, to invade Russia through its northern ports of Murmansk and Archangel, take possession of the extensive military supplies there, and eventually reorganize the Eastern Front with the assistance of Russian volunteers.[5] President Woodrow Wilson, against his better judgment, reluctantly agreed to participate in the campaign. Supposedly the American troops were to be restricted to guarding military stores and to assisting the Czechoslovak Legion—an anti-Communist group of former war prisoners which was fighting its way across Siberia to Vladivostok.[6]

The 339th Infantry, the 4500-man unit which received the dubious honor of being selected to serve in North Russia, was primarily staffed by draftees from Michigan. In fact the regiment was commonly referred to as "Detroit's Own." To fill vacancies about 125 men from Wisconsin were transferred from Fort Sheridan, Illinois, to Camp Custer, Michigan, where the 339th Infantry underwent basic training. The University of Wisconsin was well represented among the junior officers and infantry assigned to the expedition. Students and recent graduates of the university connected with the affair included H. L. Babbitz, Carl H. Berger, Marcus Casey, Charles Collins, John A. Commons, Lawrence Gooding, Gordon Reese, W. B. Webster, and Malcolm Whyte; Berger and Casey were among the dead. The two American consuls at Archangel also had ties to Wisconsin. Consul Felix Cole, an articulate opponent of American intervention in Russia, spent his freshman year at the University of Wisconsin in 1904-1905, and his assistant, Consul Maurice Pierce, graduated from the university in 1912.[7] The largest Wisconsin contingent served not in the infantry, but in the 310th Engineers; about half the 788 members of this company were from Wisconsin. The other units involved in the affair, the 337th Field Hospital and the 337th Ambulance Company, were almost entirely staffed by soldiers from Michigan, except for a few Wisconsin physicians. According to an estimate by the Wisconsin War History Commission, approximately 500 of the 5710 soldiers sent to Archangel were from Wisconsin.[8]

Unquestionably the troops were inexperienced as their training had consisted of only a month at Camp Custer, followed by a second month spent in crossing the Atlantic. Arriving at Aldershot, England, they learned of their new destination and were outfitted by the British with winter equipment, including snowshoes, fur caps, long woolen coats, and the Shackleton boot, which proved warm, but slippery and vulnerable to dampness. Colonel George E. Stewart, the commander of the 339th Infantry, facetiously asked the British whether they intended to carry out the "Britishizing" process to its ultimate extent by issuing him five thousand monocles.[9] The soldiers' American rifles were replaced by Russian rifles (manufactured by Westinghouse), but the men had little confidence in them as the ammunition frequently jammed and they were said to be so inaccurate as to shoot around corners. Moreover, the bayonet was fixed immovably to the rifle and rapid fire was impossible. Each man had fired only ten rounds with the rifle on a range before the 339th departed from Newcastle on August 26, 1918.[10]

Three weeks previously the British had boldly seized the port of Archangel. On August 1 Major-General Frederick C. Poole and a naval flotilla equipped with two seaplanes overwhelmed Bolshevik defenses on nearby Mudyug Island. During the afternoon and evening the Bolsheviks fled southward toward Vologda by railroad and by boat toward Kotlas on the Dvina River. The next morning (August 2) a new socialist government, which had just seized power in a coup, invited Poole and his tiny force of fewer than 1500 onto Russian soil.[11] As the troops marched to the government buildings they were greeted with cheers, whistles, and the waving of handkerchiefs. However, Felix Cole, the 30-year-old American Consul at Archangel, detected an ominous note in the proceedings. Only the middle class and the peasants, the two groups which had suffered the most at the hands of the Bolsheviks' demonstrated approval. "The working class," Cole perceptively observed, "was patently absent."[12]

Even prior to the arrival of the 339th Infantry, Poole commenced his campaign to conquer North Russia. Within a few days allied forces were able to advance 40 versts (26 miles) to the south on the Archangel-Vologda Railroad before being stalled by burned bridges and rear guard sniping from engines. Preparations were hurried to chase the retreating Bolsheviks on the Dvina River as well, although Poole was temporarily delayed by an acute shortage of transport. A start was made at recruiting Russians into the "Slavo-British Legion"; however, only a few hundred enlisted, the majority of whom were either old and hungry or repatriated prisoners of war.[13] The amateurish nature of the enterprise shocked realistic observers such as the British representative in Moscow, Bruce Lockhart. "We had committed," the incredulous Lockhart noted in his memoirs, "the unbelievable folly of landing at Archangel with fewer than twelve hundred men."[14] Further folly was soon added when the intervention was expanded following the arrival of the bulk of the American forces on September 4, 1918.

Due to circumstances beyond their control about one-third of the Americans were in no condition to fight a war. Shortly after leaving Britain a virulent strain of "Spanish influenza" broke out on two of the three British transports. The illness frequently proved fatal even to young men in good health and it spread rapidly due to the close quarters on shipboard. By mistake practically no medical supplies had been placed on board the ships and the few medicines left over from training at Camp Custer were soon exhausted. "Congestion was so bad," recalled one soldier, "that men with a temperature of only 101° or 102° were not put into the hospital but lay in their hammocks or the decks."[15] Therefore, when the men arrived at Archangel the situation was serious, but only 25 seriously ill Americans could be accommodated by the British

Fig. 1. Funeral procession of Marcus T. Casey of New Richmond, Wisconsin, at Archangel, Russia, September 18, 1918. Photo no. 11-SC-28605 in the National Archives.

53rd Stationary Hospital. Under the direction of Major Jonas R. Longley of Fond du Lac, who was himself "nearly dead of the disease," an American hospital was established with supplies and nurses furnished by the American Red Cross and the Russian Red Cross. In September 378 Americans were afflicted by influenza and eventually 72 died of the disease or the resulting pneumonia. Lt. Marcus T. Casey of New Richmond, a law student at the University of Wisconsin, was the first of three Wisconsin soldiers to succumb to the disease. At Archangel Casey received an elaborate military funeral which was heavily attended by the well-to-do.[16] (Fig. 1) However, as had been the case when General Poole landed a month and a half before, the laboring classes were conspicuously absent.

For a time the local manufacturers of coffins were unable to keep up with the demand and the churches worked overtime conducting funerals for the American and Russian victims. One American medical officer observed that the Orthodox priests routinely used the same yellow robe to cover all corpses and that during the funeral chants each member of the congregation kissed the same spot on an icon held by the priest. "It is their belief," he noted, "that during a religious service it is impossible to contract disease."[17] The high death rate may also have been aggravated by the general lack of sanitation at Archangel. The sewer system consisted merely of ditches under the sidewalks which emptied into cesspools. "This is some city," reported Lt. Charles Ryan to Professor John R. Commons. "It can be smelled for quite a distance. Among his other crimes, Peter the Great was responsible for this place."[18] Under normal circumstances the cesspools were periodically emptied and their contents carted off to the swamps and tundra. But as Major Longley pointed out: "Due to the disorganization resultant from war conditions, the labor necessary to effect this had been lacking, the cess pits had overflowed, flush latrines had become plugged and human excreta was conspicuous and abundant both inside and outside of buildings . . . The situation was made worse by the Influenza Epidemic which started among the troops on the way to Russia."[19]

Under the supervision of the 310th Engineers—about half of whom were from Wisconsin—the odoriferous job of emptying and cleaning latrines and cess pits was begun. Bathhouses, incinerators, and a delousing station (the "cooty mill") were constructed. As a result, noted Longley, "before winter made outdoor work impossible, the situation had been greatly improved."[20] During a brief general strike, called to protest the temporary displacement of the socialist government by a coup, Company "C" of the engineers received somewhat more pleasant duties. Now they were detailed to operate the Archangel power plant, the waterworks, run a sawmill, and operate the local streetcar system. One problem with the latter occupation was that the Americans neither knew the language nor understood the value of the money presented by the passengers. Therefore, as one participant recalled, "No change was ever given. The motorman would go down the street hollering Michigan Avenue, Woodward Avenue and other streets in Detroit."[21]

In the meantime General Poole had sent about half the American troops southward by railroad toward Vologda. At first rapid progress was made as the Allies captured Oberskaya about seventy miles to the south. Soon surprisingly determined resistance was encountered, which led Poole to the mistaken conclusion that German officers were directing the defense. Another unexpected obstacle was the swampy terrain. As summed up by Poole: "The country consisting of practically nothing but forest and bog presents the most extraordinary difficulties. This renders any attempt at a turning movement both difficult and slow. For a detachment to have to wade waist deep in bog even on patrol work is an almost daily occurrence."[22] Between Archangel and Vologda (425 miles to the south) there were 262 bridges and, noted Poole, "as my forces stand at present I shall be held up at every bridge, each of which takes some days to repair."[23]

The hard physical work of replacing the wrecked bridges and track fell to the engineers. As a result, many of the Wisconsin men on the Railroad Front became more adept at construction work than at the use of weapons. Most of the bridges were short one-span structures supported by steel girders which rested on masonry abutments. In destroying the bridges the Bolsheviks customarily dynamited the girder span. Often the Americans found that it was possible, through the use of jacks, to lift the span back into place and support it with round timber and ties. Altogether the engineers estimated that they constructed 3000 feet of timber bridges. One of their most imaginative projects was the secret building of a 60-foot crib bridge in preparation for a fall offensive against the Bolshevik armored train, located just north of Plesetskaya at verst 455. As described by the officer in charge:

> This work was completed in two nights, and was entirely finished before the enemy knew that an advance was anticipated. Not a single spike or bolt was driven on the job. Railway spikes were driven into the ties behind our own lines, and ties carried up and placed. Finally the rails were forced in under the heads of the spikes, and were permanently fastened after the advance.[24]

Despite these preparations the offensive proved unsuccessful. A party of engineers had hoped to slip to the rear of verst 455, destroy the track and trap the Bolsheviks. But the engineers were unable to accomplish their mission due to the swampy ground. Therefore, when the Allies attacked at 6:40 a.m. on October 14 the Bolsheviks simply withdrew their armored train and troop train, destroyed another bridge and surrendered three versts (about two miles) of track.[25] Despite the setback, General Poole remained convinced that just a few more battalions would enable him to launch a successful winter offensive. "If we succeed in reaching Vologda, we may well open up line to Viatka," he predicted.[26]

In London the War Office was now having second thoughts about Poole's grandiose plans. At the same time the Wilson administration began to raise objections to Poole's use of American troops for offensive operations. As Secretary of State Robert Lansing instructed Ambassador David R. Francis, "all military effort in northern Russia [must] be given up except the guarding of the ports themselves and as much of the country round them as may develop threatening conditions."[27] Furthermore, when Poole made a short trip to London in mid-October, he found that not only had his plan for a winter campaign been rejected, but that he was being replaced by 38-year-old General Edmund Ironside. The change in leadership meant also a major shift in strategy as Ironside was instructed that his operations were to be "limited to the defensive and to the training of the Russians."[28] In other words, the offensive phase of the campaign had come to a premature end.

There remained an enormous amount of physical work for the engineers to perform in preparing a strong defensive position. First, the front line at verst 455 was strongly fortified with barbed wire entanglements (constructed from 40,000 rolls of wire found in Archangel), and these were supplemented by 316 shellproof blockhouses, 273 machine gun emplacements, and 167 infantry outposts. One of the most tedious and back breaking jobs was cutting lanes of fire through the dense timber. Further to the rear the engineers constructed barracks, and converted railroad box cars into sleeping quarters for the troops. Two hundred fifty-seven cars were double lined with six-inch-thick sawdust filled walls; bunks, stoves, and electric lights provided by an old airplane engine completed what were, by the standards of North Russia, deluxe accommodations. A Canadian aviator who toured the American train noted that it was "about as close to the Ritz as we are likely to get out here."[29]

Fewer engineers and therefore fewer Wisconsin men were involved in the second major phase of the expedition in which the British sought to advance along the Dvina river to Kotlas where a branch of the trans-Siberian railroad terminated. Among the Wisconsin officers assigned to this front were Captain Joel Moore, and Lieutenants Francis Cuff, Glen Weeks, and John Cudahy. Pursuing the retreating Bolsheviks by boat, the Americans at first made impressive progress against only light resistance. By the end of September the Allies had easily captured the cities of Toulgas on the Dvina and Shenkursk on the Vaga, the latter regarded as the most important city of the region after Archangel. "But," as John Cudahy observed in his memoir of the campaign, "before these forces had been halted, already the Vaga Expedition had gone too far, thrust out nearly one hundred miles from the Railway, and fifty miles further south than the Dvina River party, it presented inviting opportunity for enemy encirclement."[30] Another disquieting aspect of the situation, recalled Cudahy, was that Shenkursk was garrisoned by locally recruited Russians whose training, bravery, and loyalty were highly suspect. Actually, General Ironside was well aware of the overextended nature of the position he had inherited from Poole. However, for political reasons it was decided to hold the area through the winter, as it was felt an evacuation without a fight would deal a shattering blow to Russian morale (Fig. 2). Besides, reasoned Ironside, "I considered that my intelligence was good enough to give me sufficient warning to operate a successful evacuation to prevent our force from being shut in."[31]

The month of October in Shenkursk was relatively uneventful as the troops worked at

Fig. 2. Point of furthest advance by American forces in North Russia, 28 versts from Shenkunsk. The village of Pagosta in the distance was occupied by the Bolsheviks and the church towers were used as an observation post. Eleven days after this photo was taken, the Bolsheviks launched a surprise offensive which forced the Allies to abandon this point and Shenkunsk as well. Photo by Sgt. Grier M. Shotwell, Signal Corps, January 8, 1919. Photo no. 111-SC-152825 in the National Archives.

patrolling and, when it was not raining, building fortifications. One Wisconsin officer, Lt. Glen Weeks, noted in his diary that much of his time was occupied with writing letters and opening mail, having his teeth cleaned, and shooting three wild turkeys which were served with an excellent peach pie.[32] The signing of the Armistice on the Western Front on November 11, 1918 at first produced a mood of elation. But the arrival of cold weather, the closing of Archangel by ice, and the realization that there was no end in sight to the campaign, produced what Ironside called "a bad effect upon the weaker members of the command."[33] The widespread dissemination of Bolshevik propaganda and reports of demobilization in the West further contributed to sagging morale.

Demonstrating a familiarity with the terrain and ignoring the Arctic winter the Bolsheviks gradually took the offensive against the overextended Americans. On the very day the war ended on the Western Front the Bolsheviks subjected Toulgas to an intense artillery barrage. On this occasion, reported Ironside, the day was saved "by the exceedingly gallant behavior of the drivers of a Canadian battery; on the 11th November they turned out and annihilated a strong enemy force which had got round the rear of our forces and threatened them with capture."[34] Meanwhile the Vaga column experienced increased pressure. Lt. Weeks, now stationed at the most advanced American outpost of Ust Padenga (located eighteen miles from Shenkursk), recorded numerous instances of increased Bolshevik activity. On November 13 a four-man patrol fell into a trap from which only one escaped. The three victims were "mutilated sadly." Four days later "we caught two spies trying to find out our position, outpost strength, etc. Lt. [Frances W.] Cuff [of Rio, Wisconsin], Lt. [J. D.] Winslow [of the Canadian Field Artillery], and myself took one of them out in the woods and shot him." The next day in honor of the first sunny day in three weeks, the officers "went out and buried [the] spy."[35] On November 29 an American patrol of 60 men, seeking to locate the exact position of the Bolsheviks, ran into a strongly defended position in a forest clearing. An enemy force estimated at 400 men tried to surround the Americans who hastily retreated, being "severely handled in the process."[36] Fifteen Americans died including Lt. Cuff, who "was killed after he was almost out of the enemy territory."[37]

During the month of December, Bolshevik probing became more and more persistent and, in response, Ironside ordered increased Allied patrol activity to discover the enemy's strength. Learning that 200 Bolsheviks had occupied Kodema, located 20 miles east of Shenkursk, Col. C. Graham, the British commander at Shenkursk, ordered a similar sized force of Americans and Cossacks to recapture the place. Weeks, who participated in the operation, recorded that the column made its approach march at night in a snowstorm. Arriving at Kodema at 5:45 a.m. on December 7, the troops prepared to attack but abandoned the plan when "the pom pom [a small one-pound cannon] would not work,"[38] Lt. Henry Katz, who was assigned as regimental medical officer, observed that the machine guns froze also and therefore "we retired without firing a shot." A week later Katz was present as a second American attack on Kodema miscarried. Due to "some mistake in orders" the frostbitten Americans failed to advance in support of a hundred attacking Cossacks. "It was very cold and trip very hard on the men," he noted.[39] A completely different interpretation was recorded by Ironside. In his view the attacks "failed owing to the quality of the U.S. troops and the behaviour of one of their officers, and gave the enemy an idea of the value of our troops opposed to them."[40] Then a few weeks later the 280-man Caucasian Cossack Regiment, despite two months of training, also failed in an attack upon Kodema. "The enemy were noticed to be in greater numbers than had been expected," recorded Col. Graham, "and in addition to the committing of several tactical mistakes the Cossack Cavalry got out of hand and could not be rallied."[41] Weeks and his troops were sent out from Shenkursk to gather stragglers and re-establish order.[42] In Ironside's opinion the disastrous performance of the Cossacks further demonstrated to the Bolsheviks "the lack of value of our troops."[43]

The next few weeks were unusually uneventful. Weeks' diary entries mentioned concerts featuring "very good" singing by the Russian Y.M.C.A., a visit to the local jeweler, card playing, reconstruction of Shenkursk's fortifications, and extreme cold which reached −27 degrees. "Not much change in conditions in general," he recorded on January 17.[44] The next day General Ironside arrived for an inspection and was thus present at Shenkursk when the Bolsheviks launched a surprise New Year's offensive against Ust Padenga at 6:15 a.m. on January 19. As Ironside summarized the situation:

> The enemy attacked with great gallantry and considerable organization. The American troops at Ust Padenga and the Cossack Infantry made a gallant resistance, but were driven in by force of numbers. All the Troops, both Russian and American, did very well this day. Casualties were about 50 out of a number of about 450, and the shelling was heavy.
>
> Seeing that the enemy attacks were growing stronger and stronger and that casualties had increased, I ordered the evacuation of Shenkursk late on the 24th.[45]

Throughout the battle Weeks and his platoon protected the line of communication between Shenkursk and Ust Padenga. By the evening of January 23 the platoon was ordered to retreat to Shenkursk and Weeks for the first time realized that the situation was serious. An all-day bombardment of Shenkursk, which "set fire to part of our billets," was followed by a daring night retreat over an obscure winter road which the Bolsheviks had neglected to block. The main body of Americans departed at 1:30 a.m. on January 25 and Weeks, who was assigned to the rear guard, was one of the last two Americans to flee the city at 3:00 a.m. Fortunately the evacuation was not detected and after a retreat of 50 miles a new defensive line was successfully established. "The Bolo [slang for Bolsheviks] tried to knock us out," recorded Weeks, "but our line stuck."[46]

For two weeks the atmosphere remained tense as the Bolsheviks probed with patrols and lobbed artillery shells. However, by early February the military pressure subsided as Allied planes reported that the Bolsheviks had pulled back their troops and artillery. On February 7, for the first time since the start of the Shenkursk offensive, Weeks was able to change clothes and get a good night's sleep. Much of the lieutenant's time was now taken up with letter writing, playing dominoes and cards (black jack and "chase the ace" were the most popular games), and on February 23 his company played a game of baseball in the snow against the Canadian artillery men (losing by the score of 21 to 5).[47] Yet, from Ironside's perspective, the American troops conducted too little in the way of physical training and as a result the "American troops deteriorated rapidly even from the low value they already possessed, through the incompetence of their officers in this portion of their duties."[48]

In view of all the factors against them—enemy attacks, long hours of duty, the lack of reserves, bitter weather, and unappetizing food—it is hardly surprising that the 339th Infantry experienced a severe crisis of morale. As one injured soldier noted after his return to America in April, "A spirit of restlessness has been spreading over the whole regiment since the armistice. No one has been able to tell the men why they were fighting in Russia, and naturally their morale was not what it should have been."[49] Dr. Arthur Nugent, a Milwaukee medical officer, recalled that the Americans who fought Germany on the Western Front had no difficulty in understanding their mission. "But we were fighting a people against whom war had never been declared and we didn't know why we were fighting them."[50] None of the officers seem to have been able to offer the troops any coherent explanation as to why they were being asked to risk their lives. When Col. George Stewart, the highest ranking American officer in North Russia, addressed troops on the Dvina Front, he tactlessly remarked that the men should understand that his work at Archangel was just as difficult as theirs, if not more so. According to their commander, the men were "very disappointed by the talk he made to them as it did not explain what they were here for."[51]

Letters critical of the shaky morale of the troops began to filter through the heavy veil of official censorship. Most of the letters were smuggled out of Russia by wounded soldiers and then printed in the *Congressional Record* or released to the press by such critics of the venture as Senators Charles E. Townsend of Michigan, Robert LaFollette of Wisconsin, and Hiram Johnson of California. "This is the most God-forsaken country I have ever seen," wrote a Milwaukee mechanic.[52] "I'm full up on Russia, and ready to move now," wrote another Milwaukean.[53] Others complained of the distasteful British ration which neither dogs nor cows would touch. Captain Joel R. Moore of La Crosse wrote of an occasion when the menu featured "grass stew" and one soldier gave his portion to a Russian woman. "She tasted it," recorded Moore, "and then threw it on some hay before the cow. The cow refused to eat either the 'grass stew' or the hay."[54] Under the circumstances, the 339th Infantry felt forgotten and abandoned. The disillusioned soldiers exchanged bitter remarks such as, "It's hell to hang on, but it's death to stop," or "We are one outfit that hasn't had to worry about finding jobs after the war. We keep right on with what we are doing."[55] The letters he had received about conditions in North

Fig. 3. Verst 455 Railroad Front, February 17, 1919. "I" Company is lined up preparatory to the awarding of the French Croix de Guerre to eight soldiers for bravery. Captain Horatio G. Winslow of Madison is in front of the company. Six weeks later "I" company was inaccurately accused of having mutinied. Photo no. 111-SC-161083 in the National Archives.

Russia, proclaimed Senator Johnson, made "an American hang his head in shame."[56]

Still, most Americans had little if any awareness of the North Russian expedition until the press carried sensational accounts of a "mutiny" by American troops at Archangel. According to the reports and a subsequent press release by the War Department, members of "I" Company, while stationed at Archangel, refused on March 30 to pack their equipment and return to the front. It took a personal appeal from Col. Stewart to persuade the men to obey the order, and even then, the men insisted upon the release of a soldier who had been confined to the guard house for insubordination. The troops also asked such questions as "Why are we fighting in Russia?" and "Why are we being sent to the front now that war on the Western Front has ended?"[57] Captain Horatio Winslow of Madison, the commander of Company "I", was the recipient of much unwanted publicity (Fig. 3). One Wisconsin newspaper ungraciously suggested that Winslow had been subverted by insidious socialist and Bolshevik propaganda.[58]

All connected with the affair agreed that the term "mutiny" was a distortion of what was basically a trivial incident. One returning soldier recalled, "We kicked like hell, but we didn't mutiny"; another called it "a case of shattered nerves, not mutiny."[59] Major J. Brooks Nichols of Detroit regarded the incident as a misunderstanding and said, "I have heard more 'bunk' about this mutiny than could be written in a dozen books." Captain Winslow concurred stating, "There was no mutiny."[60] A thorough investigation by Brigadier General Wilds P. Richardson confirmed that the incident was "of not a very serious character." In his view, the non-commissioned officers could have handled the affair more forcefully, but he commended Col. Stewart for talking to the men and explaining to them the serious consequences of disobeying an order. Further action in the case "could not have served any good military purpose," concluded Richardson.[61] However, DeWitt Poole, the American Chargé at Archangel, regarded the incident as an object lesson and urged the State Department to announce a definite date for the withdrawal of the troops. To leave the 339th Infantry in Russia past the month of June was "quite out of the question."[62]

The widely publicized affair further impressed upon the Wilson administration the necessity of extricating itself from a situation which was not only untenable from a military point of view but from a political one as well. Senator Johnson shrewdly accused the Wilson administration of having submitted to a *de facto* league of nations by accepting British command over the American forces in North Russia. "Under the orders of foreign nations Americans wage war without declaration by the American Congress or the consent of the American people," he charged.[63] Wisconsin Governor E. L. Philipp demanded an immediate pull-out of the troops. "Our country is not at war with Russia and we should not keep an army in that country," he stated. "I am in favor of withdrawing our army at once."[64] In fact the Wilson administration had already taken steps to pull out unilaterally. A few weeks previously Brigadier General Wilds P. Richardson, an officer with Alaskan experience, had been appointed to command the American forces in Russia and to supervise their evacuation. When Richardson met the President at Paris in mid-March to discuss his assignment, Wilson was emphatic in criticizing the British use of the American forces and stated that he desired the withdrawal of all Americans "as soon as practicable after the opening of navigation."[65]

Fortunately for the demoralized American forces, the expected large scale Bolshevik spring offensive never materialized. The diary of Lt. Glen Weeks now dealt with such matters as melting snow, fishing, duck hunting, card playing, two fighting roosters falling into a well, and the court martialing of several of his men to determine where they had got their "gabby water." A woman presented Weeks with two dogs which were appropriately named Lenin and Trotsky. Retreating toward Archangel Weeks laconically recorded: "We burned the mill in the woods outside of Shuskega," and on May 2 he noted: "Beautiful day . . . Gunboats bombarded Kurgomen. Burned the two churches. We took a couple of prisoners; also arrested a family caught signalling to the Bolo gunboats. They had a dance at the Y. I wrote a couple of letters in the evening." By late May the main subject of the diarist's concern was how to defeat the Canadian artillery men at baseball. Unfortunately, in the last inning "our men went to pieces and the Canadians beat us." A rematch was aborted when the baseball refused to stay in one piece.[66]

Finally at 5:30 p.m. on Saturday, June 7, Weeks and his troops arrived by boat at Archangel and eight days later, dodging large ice flows in the White Sea, the transports *Menominee* and *Porto* evacuated all but a small rearguard of the American North Russian Expeditionary Force. During a brief stopover at Murmansk, a "dirty town of shack buildings," the troops experienced their last taste of combat. Unwisely the *Menominee* was docked opposite an incoming British troopship bringing large reinforcements to Archangel. What began as mere "ribald banter" between British sailors and American soldiers soon degenerated into an exchange of insults.[67] According to a British pilot who witnessed the affairs, it was the Americans (objecting to being called "bloody hobos") who began throwing lumps of coal. Before the pilot "could say 'Jack Robinson' buckets of coal were being handed up from below at an amazing speed." Numerous casualties were recorded on both sides, but it was the British, throwing bottles in addition to coal, who took the honors. "I saw one Yank take an enormous lump full in the face," recorded the British observer. Finally, one of the Americans "committed a dastardly act," by throwing an open jack knife which missed its target. Such cowardice, maintained pilot Ira Jones, explained the Americans' "unenviable war record in Russia."[68] The remainder of the trip was far less eventful. On June 26 the *Menominee* arrived at Brest, and five days later Lt. Weeks and members of the 339th Infantry sailed for America on the S.S. *President Grant.*[69]

For the time being the reinforced British troops remained in North Russia. By September, however, they too abandoned the cause as hopeless. For a few months the shaky "Provisional Government of the Northern Region" managed to stagger along while the Bolsheviks concentrated upon defeating White Russian forces in Siberia and the South. The defeat and execution of Admiral Kolchak in early 1920 meant the inevitable. On February 19 the Northern Provisional Government fled to Britain and two days later, without firing a shot, Bolshevik forces entered Archangel to the acclaim of the population.[70]

So far as the Wisconsin participants were concerned, the North Russian expedition was by then no more than ancient history. In mid-July the 339th Infantry arrived at Detroit and was given a tumultuous welcome which included a ticker tape parade and a Chamber of Commerce reception. Within a week the soldiers were discharged to return to their homes and the routine of civilian life, occasionally to reminisce about their experiences at reunions of the Detroit-based Polar Bear Association. Like the rest of the country, most of the Wisconsin soldiers wanted merely to forget the whole unpleasant experience as soon as possible. Many felt a sense of chagrin and rejection for having been associated with a "mutinous" regiment which fought an unpopular and unsuccessful war. "Whether willfully or unwillingly," wrote John Cudahy, "our country had engaged in an unprovoked intensive, inglorious, little armed conflict which had ended in disaster and disgrace." In his view the North Russian expedition "will always remain a depraved one with status of a free-booter's excursion."[71] Much of the soldiers' resentment was directed at the British and at General F. C. Poole in particular. As Capt. Robert P. Boyd of Eau Claire told the local Kiwanis Club, Poole thought the Russians would rally to do the fighting while the Allies guarded supplies. Instead, "the Russians stole the supplies and we did the fighting."[72] The soldiers' opinion of the enterprise was aptly summed up by a doughboy's ditty brought home by one Wisconsin engineer:

It's the land of the infernal Odor
The land of the National Smell
The average American soldier
would sooner be quartered in Hell.

It's back to the States for Yours Truly,
I'm not wishing anyone ill
But Russia can hang for all I care
And truly I reckon she will.

Yes it's back to the States for Yours Truly,
A sadder but wiser young chap
The Lord played a joke on Creation
When Russia was dumped on the map.[73]

Did nothing at all beneficial result from the experience? Several of the Wisconsin soldiers suggested that the nine months in Russia had turned them into something resembling superpatriots and had made them appreciate many things in America they had previously taken for granted. Writing to professor Carl Russell Fish, Lt. John A. Commons remarked that the war had "made damn good Americans out of our soldiers . . . And, if you should care for a very exciting 5 minutes at any time, just mention Bolshevik or I.W.W. to a member of the 339th."[74] Or, as expressed by Capt. Robert P. Boyd, all those lucky enough to come back from Russia alive were certain to be "better men and better citizens, to be more contented with less envy, willing to work and to clean up the backyard."[75] Certainly the Wisconsin soldiers had no reason to hang their heads. It was true, of course, that the 339th Infantry was not well prepared for its assignment (General Ironside said he had never seen any American regiment in France as "bad" as the 339th Infantry, and that the troops had received "absolutely no training and the officers are one and all of the lowest value imaginable").[76] But it was also true that the British commanders were utterly unrealistic in their expectations. In the opinion of General Richardson, the British seemed to think the Americans "were imbued with some quality of inherent ferocity and desire for blood which would cause them to do all the fighting willingly and eagerly, even though commanded by incompetent British officers." Based on his four months at Archangel, Richardson concluded that the American troops had ranked "well at the top of all of the troops in North Russia, both as to character and accomplishment."[77]

Transported by an historical accident from the pastoral life of Michigan and Wisconsin to the tragicomedy of the Archangel intervention, the soldiers of the 339th Infantry were deserving of the eulogistic sentiments expressed by Senator Hiram Johnson: "They served under conditions that were the most confusing and perplexing that an American army was ever asked to contend with, but they did their duty."[78]

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INCIDENT AT NORTHLINE

John Anthony Turcheneske, Jr.
River Falls, Wisconsin

Throughout the United States today there is renewed racial and religious intolerance which is surfacing in reaction to increasing world and national social, political and economic instability and polarization. This illiberality is especially manifested by the preachments of hatred and bigotry on the part of such extremist organizations as the American Nazi Party, particularly vigorous in Illinois, California, New York and Maryland; a resurgent Ku Klux Klan which is currently not confining its endeavors to the South, but is also assiduously laboring in such fields as New Mexico, Arizona and California; and the Posse Comitatus which is currently conducting underground law and order campaigns and operations in Wisconsin. In view of this occurrence, it is well to recall what can befall a community's social fabric when residents succumb to the fears generated by agents of bigotry who would exploit the nation's ills for their own distorted ends. Nearly fifty-five years ago inhabitants of Hudson, then a sleepy hamlet located on the St. Croix River in northwestern Wisconsin, were so afflicted.

As a case study Hudson is both interesting and important since, in certain respects, this community continues to bear the scars inflicted by the societal plague experienced throughout this period. At that time, the United States as a whole was beset by the Red Scare and the urge to return to the false security of isolationism. Thus, during the decade of the twenties, there reappeared on the national scene fanatics who were fully determined not only to make the United States safe for Americans, but also to reconstitute this country's social fabric in their own warped image.

In Hudson the fanatics were the Knights of the Ku Klux Klan. This organization spread its influence and invective throughout the northern and western sections of the United States. Such ideology was introduced to Wisconsin from the Klan's stronghold in Indiana by specially trained agitators. One of the areas in Wisconsin to be particularly troubled by the Klan's presence was St. Croix County.

Though the Klan entered Wisconsin in the early twenties, the hooded order did not commence its operations in western St. Croix County until June 1926. Hudson, the county seat, was one locale which was especially torn asunder by the Klan activities. It was not long before Hudson's Roman Catholic community, whose members were the particular targets of these individuals, felt the sting of Klan vituperation and innuendo. What follows is an account of Catholic reaction to Klan malignities and the results thereof.

During the second week of June, there were rumblings in Hudson that some kind of Catholic protest was to be registered against the Ku Klux Klan's Northline meetings. Northline, approximately three miles northeast of Hudson, was both a junction and way station on the old Omaha Railroad. Located about one mile east of this junction, the Klan tent was pitched on a rented plot of ground. On a clear salubrious evening the Catholics chose to make their stand. At approximately eight o'clock on June 14, the Knights of the Ku Klux Klan began to assemble for their meeting. Marching as a body, the protesting Catholic delegation soon arrived. Arguments ensued and, to the dismay of the Klansmen, the Catholics managed to gain access to the tent.

Father Peter Rice, Pastor of St. Patrick's Catholic Church in Hudson, arrived soon thereafter. He approached the stage with the purpose of proving false the Klan attacks on the Catholic Church. Rice failed in his attempt and general disruption ensued. Klan speakers soon fled the scene. Under what appeared to be suspicious circumstances, and as a final climax to the evening's proceedings, the Klan tent, with its appurtenances, burned to the ground. It was an incident which achieved instant notoriety and which resulted in acrimonious feelings for all involved.

As reported by the *St. Paul Dispatch,* the Klan tent was alleged to have been burned after the meeting ended in a near riot. Several hundred men were said to have protested against anti-Catholic statements made by Alfred Brown, a Klan speaker. One thousand persons had gathered to hear Brown. Rice was said to have gone to the platform protesting that the meetings, held at Northline for the past week, were anti-Catholic in nature. Still, the lecturer attempted to continue. Subsequently, the meetings ended with several encounters between opposing factions, though none was serious. It was at this point that the tent was burned.[1]

In its version of the incident, the *New Richmond News* noted that the Klan tent was destroyed by fire of an unknown origin "together with the piano, seats and everything." Prior to the fire a rather boisterous meeting was held. "There was no storm during the night, so the tent evidently was not struck by lightning."[2] According to the Spring Valley *Sun,* 1000 people were gathered to hear Alfred Brown. Brown was said to have challenged a Catholic priest to answer him. Rice appeared with several hundred supporters. After he proceeded to the platform, a row developed.[3]

Warrants were soon sworn out for the fourteen individuals suspected of being involved in the Klan tent burning. Charging the suspects with disturbing a public meeting, the warrants were issued on the complaint of J. H. Neff who was said to be the Ku Klux Klan organizer at the meetings. On Saturday, June 19, eleven of the defendants were arraigned before Judge Otto A. Arnquist at Hudson Court House. All concerned pleaded not guilty and were later released on a one hundred dollar bond, with their cases being adjourned until June 28.[4]

In an editorial entitled "He Who Casts the First Stone," the Spring Valley *Sun* stated that the burning of the tent was to be regretted particularly because of the effects the incident would produce. No one, explained this journal, believed that the Klan would fail to retaliate. It was now time for cooler heads to prevail lest serious consequences follow. Violence would beget violence. Hatreds created as a result of this affair would last a lifetime.[5]

At the preliminary hearing, on the morning of June 28, Judge Arnquist opened the proceedings. Describing the hearing's setting, the *St. Paul Dispatch* said the fourteen defendants were under an armed guard of ten deputy sheriffs. Five hundred persons jammed the court room one half hour before the hearing commenced. "Hudson is filled with automobiles of farmers and persons from neighboring cities and towns. They began arriving early today and were still coming at noon." Excitement was said to be at fever pitch. Not only was the court room filled to capacity, but hundreds were said to be milling also about the halls and the Court House grounds. There was jeering from the crowd when organizer Neff testified. Arnquist issued a severe rebuke. Later in the morning, he announced that due to wide interest in the proceedings he would permit "'wide latitude in the testimony in order that the truth about the Klan might be made known and to discourage and set right some of the rumors that have been circulated.'"[6]

According to the *St. Paul Pioneer Press,* five hundred persons braved the heat and jammed the court room to overflowing. "Two girls in the crowded court room fainted from heat in the forenoon session and several others succumbed to the heat in the afternoon." Hudson was said to be sharply divided on the matter. Due to a manifestation of partisanship during the hearing, St. Croix County Sheriff M. C. Emerson was ordered to clear the court room at the next display of such action.

"This order was issued after repeated cautionings and rebukes from the bench."

Further tension was added, said the *Pioneer Press,* when Ray C. Twining, an attorney from Milwaukee, arrived on the scene. His purpose in coming to Hudson was soon evident. It was Twining's intention to sue fifty Hudson businessmen for the sum of $2000 in damages in connection with the tent burning affair. This "intention to sue for damages was made in letters received by the businessmen a week ago, but was not taken seriously until late today when Twining arrived to gather evidence for his case."[7] Twining said he definitely planned to go on with the suit.

Any excitement that was evident during the first day of the hearing, said the *St. Paul Dispatch,* had disappeared by the second day of the hearings. Hudson had returned to an orderly condition.[8] Parallelling the *Dispatch*'s story in this regard, the *New Richmond News* noted that the interest in the proceedings appeared to have waned materially as the "morbid curiosity seekers concluded the day before that there wasn't going to be anything doing in their line." Reporters described the day as "sweltering" and "torrid" with the court room packed to the suffocating point. As to disorder in the court room, the *News* remarked that there was not foundation to the stories appearing in a certain St. Paul paper, items which were to be chalked up to the excitement and imagination of the young reporter. What fever pitch existed was due to the torrid temperatures and lack of ventilation. People were standing in the aisles, along the sides and in the rear, with others standing on chairs or perched on window sills, radiators and tables. Still others stood within the rail. The "court room was a sort of a Turkish bath on a large scale. People perspired gallons and gallons and everybody reduced very materially."

As to the matter of the armed guard, Sheriff Emerson said "'Why, there's absolutely nothing to the "ten deputies" story.'" There was on duty "'but one deputy and myself and nothing for us to do in the way of maintaining order. There was no disorder of any sort.'" Emerson never saw a "'crowd of that size more orderly despite the lack of chairs and despite the torrid heat.'" Whatever violence there was, said the *News,* "was confined entirely to the vigorous use of fans" and whatever could be converted into such.[9] Still, the *Hudson Star Observer* noted that "considerable partisanship was manifested and on two occasions Judge Arnquist threatened to have the court room cleared by Sheriff Emerson unless better order prevailed."[10]

During the course of these proceedings, the *New Richmond News* also noted the appearance of attorney Twining from Milwaukee. Twining told a *News* correspondent that he represented the state organization of the Ku Klux Klan and was keenly interested in the deliberations. A civil suit would be brought against fifty Hudson businessmen to recover damages for the Klan tent destruction. These businessmen had received a letter from Twining stating that he had been retained by A. McMaster, J. H. Neff, Ben Anderson and Arley Martin "to collect damages from you and others associated with you in the destruction of the tent, piano and other personal property burned and destroyed at the Klan meeting held at the Town of Hudson on June 14." Twining also had the names of sixty other individuals who were involved in this matter. "Unless settlement of the damages is made within one week or some satisfactory arrangements made for a settlement, suit will be commenced against you and the others for the amount of $2000."[11] Initially, they did not give the letter serious consideration. But with Twining's arrival "for the purpose of getting evidence in the matter affairs took a new turn, and the parties concluded that he means business."[12]

William T. Doar, a New Richmond attorney, represented the defendants when the preliminary hearing opened at Hudson Court House.[13] William R. Kirk, District Attorney for St. Croix County, was the prosecutor. J. H. Neff was the prosecution's chief witness. Neff, who swore out the original complaint, was the Klan organizer present at the tent affair.

Neff stated that he was the Grand Titan of the Fourth Province, Realm of Wisconsin, Knights of the Ku Klux Klan. Klan meetings had been held one week prior to the events of June 14. Advertisements for these meetings consisted of handbills distributed in that part of the state. He described the tent as being forty by one hundred twenty feet with plank seating and a platform twelve by twenty feet in size. Decorations consisted of American flags and bunting. There was also a player piano and Klan paraphernalia such as robes, signs and handbills.

That evening, the Klan meeting was scheduled to begin at eight thirty. At eight fifteen, said Neff, a large mob gathered at the gate and demanded to be admitted. Because the meeting was for Protestants only, the crowd was told that it could not enter. Also, since the grounds were rented, it would be illegal to do so. But the crowd advanced in a boisterous manner "stating that they were there to commit violence, stating to me that fact."

Neff said the crowd was excited, "and naturally they cursed me; they God-damned me, if that is admissable. I hate to say it, yet I must." He was "called other names; the tent was filled up to its full capacity of a howling, cursing—you couldn't hardly call it an audience—call it a mob." According to Neff, the Klansmen tried to defend themselves. Dr. Brown was taken to shelter. Neff said he then went to the platform and attempted to ameliorate the situation by a recitation of the Lord's Prayer and the singing of "America." This was met by jeers, cursing and general disturbance by the anti-Klan element. Neff explained that after telling the mob it was acting illegally, an attempt was made to explain the principles of the Klan; "but I was told that they did not want to hear anything about the Klan. They knew it all, but they wanted to know about those damn lies that had been told about the Roman Catholic Church." Neff, seeing that all was futile, said he was about to dismiss the meeting when Father Rice walked to the platform. Rice said he was representing several local priests and the Catholic people with the intention of protesting the meeting and driving the Klansmen out.[14]

Neff testified that he finally dismissed the meeting, but immediately saw several guns pointing at him. Neff then went to the back of the tent to the yells of "'kill him, lynch him, mob him; we want Pat Malone, where is he? Where is Dr. Brown? We want him; we want Neff!'" Neff said he managed to escape through the side of the tent to his car, after managing to hastily rebuke the crowd for its destruction. Then he and several of his associates drove to the Fillbach house where his wife and family were located. Neff said he remained at the house until he saw the tent in flames, at which point he drove to River Falls.[15]

Under questioning by attorney Doar, Neff maintained that he did not have an arrest record. Testifying that he had been connected with the Ku Klux Klan since 1922 when he joined the organization in Indiana, Neff said that he earned his living by working for them as an organizer. At first, Neff refused to divulge information about his wages and other interests in the Ku Klux Klan. Later, he stated that his income was four dollars per man enrolled, which funds came out of an initiation fee. As to whether his living depended on enrolling as many members as possible, Neff said that this was not the case since he was interested in building the Klan out of the best timber he could get, regardless of the commission he received. Still, it was his living.

Neff said that he had been connected with the entire province of the Ku Klux Klan for one year. Meetings had been conducted in the St. Croix Valley only during the two previous weeks and these had been at Northline. Prior to that, he had been in River Falls for a month. As the Grand Titan of Province Number Four, it was his job to supervise Klan activities in twenty-one counties, an area which included St. Croix County.

Pat Malone's affiliation with the Klan was only as a lecturer, as was Dr. Brown's. Only Protestants were admitted to the meetings because these were of a private, Protestant and invitational nature. Hence not all American citizens were permitted to attend.

Neff insisted that the uninvited crowd poured through the gate. As to Father Rice being recognized as a Catholic priest, the organizer stated that Rice introduced himself explaining that he was there on behalf of his colleagues and people. Neff said that he had no knowledge of an invitation being issued to a priest; that no charges were leveled against the priesthood; and that he never heard about any reflections being made against the Catholic Church, its priests, sisters and faithful, at least not at Northline. Neff admitted to hearing these accusations at River Falls. But the challenge to debate was issued to Father Fassbender by Pat Malone. Neff insisted that Father Rice was never challenged at Hudson.[16]

Father Peter Rice was the chief witness for the defense. Answering attorney Doar, Rice testified that he knew of the Klan meetings at Northline through the Klan placards he had seen displayed. In addition, he received anonymous letters from several places in the county, letters which had Pat Malone's picture on them. Contained in the letters were charges made against the morality of every Catholic priest in the county. These letters arrived after the first of the River Falls meetings.[17]

Rice testified that the substance of an earlier sermon was that "our Catholic people should protest, not by way of violence or physical force, but by pamphlets in writing and by requested permission to attend" Klan meetings. Klan members were to be asked whether "we could get a chance to refute their statements as to the moral character of the Catholic priesthood in general and the priests of the county in particular." As to the remarks made at the Catholic Guild meeting that Sunday afternoon, Rice told the ladies that they should defend the Sisters' and their honor by protesting in a dignified manner against individuals who saw fit to admit anti-Catholic lecturers within their home. Cathoic nuns were charged with being "the mistresses of Catholic priests." These statements were made at River Falls and at Northline, only with more inuendo.

Rice admitted attending the Klan meetings, but said that it was more a spur of the moment type of thing. Initially, he had no intention of doing so. If there were to be a debate, the priest expected that the confrontation would take place at Hudson. Rice went to the meeting at the request of Joe O'Connell and James McMahon. Also, the Klan had issued an invitation. "That was the sole reason I went, because I was a man and wouldn't back down where challenge was made." Rice said he went into the tent, quieted the people down, and asked Neff if he could say a. few words. Neff said "'certainly.'" He told Neff that "I had come out here in response to repeated challenges brought to me, conveyed to me, to refute or ask for proof of any charges against the morality of any Catholic priest in this county, any sister, or his housekeeper." Rice then told the people to keep quiet. Rice also told Neff that "I wanted proof given of any statement that any of the Klan members had to make against any Catholic priest in the county, to make it now." Neff, in a low tone, replied that none had been made.

Neff seemed to be a little excited at this juncture. Rice then said as a "Catholic priest I protest against being slandered or my brother priests being slandered. I did not say that they must be driven out." He had no intention to incite violence and denied any "literal expression that can be interpreted, legally, with intent toward physical force or disrupting their "meeting. After his speech Rice immediately went home.

As to the matter of the challenge, Rice testified that it was direct inasmuch as the placard issued at the River Falls meetings challenged Father Fassbender and other priests. It did not matter who authorized the placard as it was still the same organization.

Besides, "they would be alike in their dirty methods." With regard to the statements made at Northline, the Pastor said that he was informed "they were asking for the Catholic priest out there, people in Klan uniform." Several individuals yelled "'why don't you bring out your old priest.'" Rice said he ignored previous challenges. "But I thought I would back down before no man when he challenged my character." Kirk then asked whether Rice was directly attacked. Rice explained that a general attack was made against all Catholic priests in the county and the "fact that I was a priest in the county was a specific attack, because there are only five priests in the county."

Rice had no prior knowledge that there was to be a crowd of several hundred parishioners at Northline; although he had heard rumors that a Catholic crowd would be there. Even so, the purpose in going out was to defend the character of the Catholic priesthood and sisterhood. Rice also testified that he did not believe that his concern over the statements of the Ku Klux Klan would serve to influence his parishioners. He did not advocate physical violence and testified that "my Catholic people were instructed in church to avoid physical violence with anybody."

But he also told his parishioners "that when your Catholic priesthood is attacked and the honor of Catholic women and sisterhood, that you should answer back and ask for proof of the statements they were making." As to instructing the Ladies Guild to go down to Disney's, Rice said that "I did; pardon me, that is incomplete. On Sunday afternoon the 13th, I think," Rice suggested to the ladies that they visit these individuals and ask them "if it was their intent to insult their Catholic neighbors by keeping anti-Catholic lecturers in their home." He did not know that this was the Disney's only source of income. Rice did not want anyone put out. It was just to be a protest. As to whether harboring the Klan lecturers indicated the Disney's true feelings in the matter, Rice replied that "under the circumstances it would indicate at least sympathy." It was his belief that there existed no connection between the action of the Ladies Guild and the Klan tent burning. Under additional questioning, Rice said he did not rile up the Catholic men, but did impress upon them the necessity of upholding the honor of their women.

Kirk then asked Rice whether he gave advance notice that he would engage Klan leaders in debate. Rice explained that "I mentioned in a lecture given in the church to Catholics and non-Catholics earlier in the year, that I stood ready to meet at any place, any time, any anti-Catholic lecturer as long as" Rice was given a "fair show and fair hearing for debate. That was sometime in March, and I believe you were present in the Catholic church the same night Mr. Kirk, because I saw you."

Replying to defense attorney Doar's question relative to a printed challenge, Rice said that he had one in his possession which read as follows. "'As a rule I debate only with priests but due to the fact that Father Fassbender is too big a coward to meet me in open debate, I will be glad to meet your man Emil E. Holmes.'" As to the Pastor's feelings toward Hudson's Protestant community, Rice testified that "my experience generally is the Protestant people are as fine people as there is in America; I want no religious bigotry."[18] Thus was concluded the priest's testimony in the matter.

In his summation for the State, Kirk demanded that all defendants be bound over to the Circuit Court for trial. Rice was said to be morally responsible for the riot.[19] Doar, in a complete and total condemnation of the Klan, demanded that the cases be dismissed.[20] As County Judge, Arnquist was only empowered to determine whether the defendants should be turned over to the Circuit Court for trial.[21]

In arriving at his decision, Judge Arnquist issued a ringing denunciation of the Klan. Arnquist said it was "regrettable that any such organization should have come here. There is no question but that it tends to make bitterness, strife and violence." There "have been a number of such movements in the past, and many of them created violence." One could not "blame Father Rice for being indignant at the charges of immorality made against him and the Catholic priesthood in Klan meetings." As such, Rice could not be condemned for "going to the Klan tent when told, through bad judgement, that he was invited there to defend himself against them."

Furthermore, said Arnquist, the "doctrines for which the Klan stand are well known, and are antagonistic to those of the Catholic Church," Because of this, and the charges made against him, Rice "was naturally against the Klan." As such, Rice "said in his church that a protest should be made against the charges." He had "no violence in his mind, only protection of the Church and himself from the charges." From this, noted the Judge, the "District Attorney has deduced a moral responsibility of Father Rice for the riot." Yet there was "no legal responsibility attaching to him, and that is what we are examining here. Therefore, it is my duty to discharge Father Rice."[22] Tony Lombard and George Hennesy were also acquitted.[23] Eleven remaining defendants were bound over for the Fall Term of the Circuit Court.[24]

In the aftermath of the hearing, the *Hammond News* noted that a great deal of feeling was being created over the incident. Many different stories were said to be circulating. These had gotten to be so out of proportion that it was getting difficult to obtain any accurate information on the happenings.[25] Feeling, observed the *Baldwin Bulletin,* was running rather high in Hudson. Sheriff Emerson was said to be taking precautions to prevent any reprisals that might occur. After the hearing was concluded, Klan members and sympathizers gathered to discuss Arnquist's decision. Those who sympathized with the defendants did the same.[26]

Hudson, noted the *New Richmond News,* was indeed getting plenty of publicity. Most of it, however, was of an undesirable nature. This Klan rumpus managed to push the town right onto the front page. Said the *News* of the publicity: "It reminds one of what the manager of a 10-20-30 show once said to this writer: 'I don't care whether you write us up or write us down, but great Scott, don't ignore us any longer!'"[27] Still, the end to the Klan tent affair had yet to be written.

In October, the *Woodville Times* noted that the Klan riot case was scheduled for the Fall Term of the Circuit Court. Yet there was some talk that this case might not be called. District Attorney Kirk, though, insisted that, if at all possible, he would bring the matter to trial.[28] In a succeeding issue, the *Times* said that the Klan riot case was not to be tried that Fall after all. Indeed, it was exceedingly doubtful that the case would ever come to trial. This was particularly so because "with the present evidence," or lack thereof, "no conviction could be secured," and Kirk did "not want to make a fizzle of it."[29] Thus the case was put over to the March Term.

In November, the County Claims Commission was approached with a claim for $1967 for the loss of the Klan tent. This was said to be the biggest item before the Claims Commission.[30] Members of this body, composed of N. E. Fraher, J. W. Hanley and Elmer Afdahl, dissallowed the claim. As to the reason for its action, the Commission stated that it was a matter for the courts to handle.[31]

Even so, the Klan tent affair did not reach the Circuit Court for the Spring Term of 1927. In the interest of a peaceful settlement of the issue, Spencer Haven appeared before the St. Croix County Board which convened a special session on Saturday, May 7. Haven said that the Catholics had subscribed five hundred dollars to this end. Various Hudson businessmen contributed a total of four hundred dollars. It was Haven's belief that if the County were to contribute five hundred dollars, the case would be settled out of court.[32]

Acceding to this request, the County Board charged this claim to the next year's tax receipts.[33] One source noted that "the Klan will accept the $1400 in full for all damages and drop the suit, which was bothering a number of people quite badly."[34] The identity of the individuals who instigated the incident at Northline would remain a mystery. The Klan riot case was closed.

Finally, it is to be hoped that the lessons emanating from the social divisiveness, experienced not only by Hudson and other Wisconsin communities, but also similar localities throughout the land, have not been forgotten; and having remembered, citizens will not succumb to the irrational fear generated by such revitalized hate organizations.

Notes

[1] *St. Paul Dispatch* (St. Paul, Minnesota), June 15, 1926. In a postscript to the article, the *Dispatch* noted that Brown's remarks had been resented. Several days prior to the incident, a delegation of twenty-five Catholics went to the place where Brown was rooming with the demand that the landlady evict him. Brown volunteered to move to a different residence.

[2] *New Richmond News* (New Richmond, Wisconsin) June 16, 1926.

[3] Spring Valley *Sun* (Spring Valley, Wisconsin), June 17, 1926.

[4] *New Richmond News*, June 23, 1926.

[5] Spring Valley *Sun*, June 24, 1926.

[6] *St. Paul Dispatch*, June 28, 1926.

[7] *St. Paul Pioneer Press* (St. Paul, Minnesota), June 29, 1926. Twining was one of three signers of the Articles of Incorporation, Knights of the Ku Klux Klan, Realm of Wisconsin.

[8] *St. Paul Dispatch*, June 29, 1926.

[9] *New Richmond News*, June 30, 1926.

[10] *Hudson Star Observer* (Hudson, Wisconsin), July 1, 1926.

[11] *New Richmond News*, June 20, 1926.

[12] *New Richmond News*, June 30, 1926.

[13] The fourteen defendants were: Alex Lomnes, William Burton, Jr., Edward Christoph, Robert O'Rourke, Father Peter Rice, Gregg Busby, Henry Zorn, Mrs. Joe Miller, Tony Lombard, Henry Klein, George Hennessey, Harry Kinney, Eugene Ritchey and Tony Muchie.

[14] Testimony of J. H. Neff, State of Wisconsin *v.* Alex Lomnes, *et al*, June 28-29, 1926, File Number 9506, St. Croix County Court House, Hudson, Wisconsin (hereafter cited as Preliminary Hearing), pp. 1-4. Father Rice was present on behalf of Father Fassbender of River Falls and Father Shanaghy of Ellsworth.

[15] Testimony of J. H. Neff, Preliminary Hearing, p. 5. The Fillbach's were the people who rented part of their acreage to the Klan.

[16] Testimony of J. H. Neff, Preliminary Hearing, pp. 7-15. It should be noted that Pat Malone, whose headquarters was at Chetek, Wisconsin, was a circuit lecturer for the Klan in Wisconsin. Anti-Catholic and one hundred percent American in approach, Malone was a big drawing card at Klan gatherings. Interestingly enough, Malone was not a member of the Klan. Prior to working for the hooded order as a lecturer, Malone rode the anti-Catholic lecture circuit causing community dissension, disruption and acrimony in such diverse areas as Elm Creek, Nebraska and Oakland, California.

[17] Testimony of Father Peter Rice, Preliminary Hearing, p. 78. Of interest here is that Rod Chinook, owner of a River Falls printing shop, printed a large amount of the Klan's propaganda. This material was used for the River Falls and Northline campaigns.

[18] Testimony of Father Peter Rice, Preliminary Hearing, pp. 79-89. It should be noted that the Klan were mistaken in their belief that Holmes was a Catholic representative. Holmes, president of the World War Veterans Association, located in Minneapolis, Minnesota, debated on his own account with Pat Malone at River Falls in April 1926.

[19] *Baldwin Bulletin* (Baldwin, Wisconsin), July 2, 1926.

[20] *St. Paul Pioneer Press*, June 30, 1926.

[21] *St. Paul Dispatch*, June 29, 1926.

[22] *Baldwin Bulletin*, July 2, 1926.

[23] *New Richmond News*, June 30, 1926.

[24] *Hudson Star Observer*, July 1, 1926.

[25] *Hammond News* (Hammond, Wisconsin), July 1, 1926.

[26] *Baldwin Bulletin*, July 2, 1926.

[27] *New Richmond News*, June 30, 1926.

[28] *Woodville Times* (Woodville, Wisconsin), October 1, 1926.

[29] *Woodville Times*, October 8, 1926.

[30] *Baldwin Bulletin*, November 26, 1926.

[31] *New Richmond News*, November 26, 1926.

[32] *Hudson Star Observer*, May 12, 1927.

[33] St. Croix County Board Proceedings, Special Session, St. Croix County Court House, Hudson, Wisconsin, May 7, 1927, 055/1/2, Area Research Center, Chalmer-Davee Library, University of Wisconsin, River Falls, Wisconsin, VII, p. 66.

[34] *Woodville Times*, May 11, 1927.

THE CHANGING *COMPADRAZGO* IN THE UNITED STATES

SILVESTER J. BRITO
Department of English
University of Wyoming
Laramie

INTRODUCTION

This essay will examine the way in which the *compadrazgo* mechanism presently operates in the United States as compared to its older form in Old Mexico. We will discuss the *compadre* system in terms of its basic structure as well as its functional relationships to various aspects of culture, such as the family, the status system, and the role of the individual in culture.

The *compadrazgo* as it exists in the New World is a ritual phenomenon which designates a particular set of complex relationships which are set up between those individuals who participate in the ritual of a Roman Catholic Baptism. This term is also used to indicate those similar sets of relationships which are set up when discussing the *compadre* mechanism as it is applied to the Catholic rituals of confirmation and marriage. When applicable, we will borrow Mintz and Wolf's use of the term "horizontal" to designate the direction which the *compadre* mechanism takes when linking together members of the same social class, and also, the use of their term "vertical" to indicate the direction that this mechanism takes when linking members of different socio-economic and socio-cultural classes.

BASIC STRUCTURE AND TERMINOLOGY

In the main, this religiously based rite—*compadrazgo* (ritual kinship) involves three individuals or groups of individuals, depending on the type of Roman Catholic rite taking place. The basic participants in this ritual are: one, an initiate who is a child, as in the baptismal rite (although the initiate may be an adolescent and in rare cases, an adult); two, the biological parents of the initiate; three, the sponsors of the initiate. The *compadrazgo* or co-parenthood thus, generally involves three sets of relationships: The first set links the parents and the child; the second set links the child and his ceremonial sponsors; and the third set links the biological parents of the child to his ceremonial sponsors. The ceremonial sponsors of the child at baptism are known as *padrinos de bautismo* or *padrinos de pila* (godparents). The baptized child (godchild) is thus addressed as *ahijado* (male) or *ahijada* (female). The godchild addresses his sponsors as *madrina* or *nina* (female) and *padrino* or *nino* (male). The relationship between godparents (*padrinos*) and godchild (*ahijado* (a)) is known as the *padrinazgo.* The relationship between the child's sponsors (*padrinos*) and his real parents is known as the *compadrazgo* or co-parenthood. Both the child's sponsors and his parents generally address each other as *compadres,* and in the singular, *comadre* (female) and *compadre* (male). These terms are also used to indicate similar sets of relationships when discussing the *compadrazgo* as it is applied to the rituals of first communion, confirmation and marriage.

Field data for this paper were gathered from 1976 to the ethnographic present, May 1984. I selected these interviews out of twenty others dealing with Mexican-American (Chicano) culture and society; these are on ten, one hour tapes. I believe that they best represent the ongoing changes in the *compadrazgo* system among Mexican-Americans (Chicanos) in the United States. I have used the terms Mexican-American and Chicano relative to the way the people (respondents) see themselves.

Portions of this study were presented in a folklore conference (II Mesa Redonda De Folklore Y Ethnomusicologia) in Mexico City, Summer of 1983.

For a detailed discussion on the structure and function of the *compadrazgo* in Meso-America see: Paul 1942; Mintz and Wolf 1950; Foster 1953; Sayres 1956; Ravicz 1967; Nutini and White 1977; and in the United States, Spicer 1940.

Historical Development

Various writers have speculated on the background of the *compadrazgo's* New World development—debating whether its main influence came from Europe, the American Indian, or Criollo culture (Mintz and Wolf: 342). But in order to best understand the importance of the *compadrazgo's* changes in the Americas, more especially in the United States, it is necessary to understand its early development in Europe.

Although the basic form of the New World *compadrazgo* had its chief antecedents in Spain, the concept and practice of co-parenthood was also known across medieval Europe. In fact, in the early days of Christian persecution a system of requiring sponsors for new converts was established to avoid the admission of untrustworthy individuals into the cult (Mintz and Wolf: 343). Sponsors of new Christian converts came to be viewed as spiritual parents or godparents. Subsequently, the ritual practice of co-parenthood went through various stages of development in Spain and Europe.

Ritual co-parenthood received its primary established overt recognition when the Roman Catholic Church required that all infants be baptised. This ritual act was viewed as a spiritual rebirth, the sponsor being spiritually bound to the new member. The biblical scholar, Jeremeas contends, however, that infant baptism was in practice before the church made it mandatory in the Fourth Century (Gudeman: 228). During this historic period, required sponsorship for the godchild went through several major changes. At first, it was required that an outsider be the ritual sponsor, then it became a custom for the parents of the child to be his sponsor. This practice became so entrenched that by A.D. 408, Bishop Boniface believed that parents were required to sponsor their own children. Saint Augustine (A.D. 345-430), however, disagreed with this point of view. He called the Bishop's attention to the fact that because slaves, orphans and deserted children could not be sponsored by their parents, it was necessary to make exceptions to this custom, thus permitting non-parents to be the ritual sponsors of these familyless people (Gudeman: 228-229).

During the fifth century individuals revived the initial custom of having non-parents serve as the ritual sponsors for an infant's baptism. This custom grew out of the belief that a special spiritual relationship was established between the sponsor and the godchild. Furthermore, by choosing outside individuals to sponsor a child, people began making the clear distinction between the natural parents and the spiritual ones. The Roman Catholic Church in A.D. 813, recognized and reinforced this idea of a spiritual relationship; moreover, it issued an edict which forbade parents to be their children's ritual sponsors (Gudeman: 231; Mintz and Wolf: 344). In addition, from 900 to 1300 A.D., ritual co-parenthood relations became vertical between serfs and their lords (Mintz and Wolf: 364). Thus, mutual aid agreements between feudal lords and their vassals were strengthened through the *compadrazgo* system.

During the sixteenth century the Spanish essentially conquered the New World, and as a result established a *compadrazgo* system, similar to that of the feudal period, between the conqueror's and their Indian subjects. Each Spanish conqueror was obligated to have all the Indians under his jurisdiction Christianized. Therefore, to facilitate the conversion of the Indians, the Spanish rulers introduced their *compadrazgo* system.

Since little is known of the development of the *compadrazgo* in Old Mexico following the Spanish conquest it is appropriate to note the views of the following Middle American scholars. According to George

Foster (1953:24), the Indians were not only receptive to the Spanish *compadrazgo* because it was similar to their indigenous practices (i.e., the notions of spiritual rebirth and spiritual kinship were not contradictory to Indian beliefs), but they also developed it into a more complex system than that in Europe. Horstman and Kurtz, however, believe that the conquered Indian society readily accepted the Spaniard's introduction of the *compadrazgo* system because of their post-conquest condition, one permeated with grief and stress (Horstman and Kurtz: 361). The institution of ritual co-parenthood, then, was a vehicle which these native cultures could utilize in their efforts to regroup as a viable force under the dominance of their Spanish rulers. It can thus be hypothesized that it is this nationalistic impulse which the Mexican-Americans (Chicanos) have institutionalized in their practice of the *compadrazgo* in the United States. In other words, these acculturating Mexican-Americans have experienced conditions under the Anglo-Americans similar to those experienced by their ancestors under Spanish rule. It can be argued that the *compadrazgo* system serves the Mexican-Americans (Chicanos) as a viable adaptive mechanism for coping with stressful conditions in American society. It is also quite probable that the *compadrazgo,* as an institution, has persisted in Mexican-American (Chicano) culture because of its superior adaptive ability, especially in terms of the wide choices it offers this ethnic minority group in establishing interpersonal relationships. As a result of making strategic choices in their selection of *compadres,* these people are able to establish internal (horizontal) ties as well as vertical ties with fellow Mexican-Americans (Chicanos) who have achieved a higher socio-economic level in Anglo-American society. This practice, then, assists them to survive as an identifiable society. With the aid of the following studies as well as my field interviews, we can better understand how the Mexican-American (Chicanos) utilize the practice of the flexible *compadrazgo* system in their efforts to adjust to stressful conditions in Anglo-American society.

Compradrazgo and Adaptation in Twentieth Century U.S.A.

For comparative purposes it is appropriate to review both Madsen's and Rubel's descriptions of the *compadrazgo* among rural Mexican-Americans in South Texas as well as Carlos' and Thurston's data on the use of ritual co-parenthood by urban Mexican-Americans.

In South Texas the ceremonies for which ritual sponsors are selected are baptism, confirmation and marriage (Madsen: 49; Rubel: 80-83). Madsen states that it is also an accepted practice for the baptism godparents to serve as the confirmation godparents. In order of importance, godparents of baptism come first, then those for confirmation. By comparison, godparents of marriage rank last, and in a sense, are considered insignificant (Madsen: 49).

Mexican-Americans of South Texas seek *compadres* who have the following qualities: honorable, goodhearted and respected in the community. In keeping with this value system, it is considered bad taste to select godparents who are of a higher socio-economic status. Within this esoteric community, such a choice would suggest that the selecting party is interested in rising above the socio-economic status of his neighbors. More and more, it is becoming a common practice for these people to select *compadres* from their blood kin, such as uncles and aunts. These people believe that it is wise to select *compadres* who are biological relatives because they are less likely to leave the community and thus not fulfill their ritual obligations as godparents. Choosing *compadres* who are blood relatives not only strengthens the bonds of the family but it helps to preserve the group's identity in the face of increasing anglicization (Madson: 49).

Relationships between Mexican-American

compadres are dignified and formal. Therefore, it is only proper for these co-parents to address each other in the Spanish formal term, "usted," rather than with the informal pronoun, "tu." *Compadres* are never to joke or gossip about each other. Within this socio-religious system, it is expected that *compadres* will visit each other at regular intervals and cultivate close relationships. In times of great need, *compadres* may exercise their right to call upon each other for aid and advice (Madsen: 49; Rubel: 82-83). By comparison, Mexican-Americans in rural South Texas, have a complementary system of exchange which is similar to but not as formal as the system of exchange that characterizes the Tzintzuntzan *compadrazgo* in Old Mexico (See, Foster; 1967: 75-85).

According to Rubel, not only is formal behavior a custom between Mexican-American *compadres* in rural South Texas, but the incest taboo also applies to their ritual relationships, similar to those among the Tzintzuntzenos of Old Mexico. Rubel states that one of his informants told him that if a man fears that his friend may sleep with his wife, he makes him his *compadre* (Rubel: 80; Foster: 79). Nevertheless, the most important characteristics of co-paternity among rural Mexican-Americans of South Texas are its combined reciprocal ritualized obligations between *compadres* with additional privileges of mutual aid.

Some researchers, such as Carlos, claim that there is little difference between rural and urban use of the *compadrazgo* among Mexican-Americans (Carlos: 476). Moreover, Carlos and Thurston found that urban Mexican-Americans are very interested in maintaining the *compadrazgo* system (Carlos: 477; Thurston: 51). Thurston's study of a Los Angeles barrio shows that a significant percentage (75%) of young women from this area are in favor of perpetuating the *compadrazgo*. He, however, suggests that the *compadragzo* has been devalued among Mexican-Americans, especially among the young. Grebler, Moor and Guzman, support Thurston's point of view (Thurston: 46-52; Grebler, Moore and Guzman: 354-355). Manuel Carlos disagrees with these writers. He contends that the *compradrazgo* is valued by urban Mexican-Americans, pointing out that welfare programs, voluntary associations and pressures for acculturation have not significantly changed the Mexican-American's reliance on family ties or fictive kinship for mutual aid (Carlos: 477). What has been asserted to be a devaluation of the *compadrazgo* among Mexican-Americans is more of a change in the formality of structuring the *compadres'* interrelationships.

Thurston states that urban Mexican-Americans choose sponsors for baptism, first holy communion, confirmation and marriage. According to his study of a Los Angeles barrio in 1957, Mexican-Americans believed that, ideally, non-relatives should be selected as Godparents (Thurston: 46). He notes, however, as did Madsen in his study of the rural *compadrazgo,* that there is a growing tendency for urban Mexican-Americans to select blood relatives as *compadres.* They believe that blood kin are more reliable and less likely to leave the Los Angeles area; thus, more likely to live up to their obligations as godparents and responsible *compadres* (Thurston: 46; Madsen: 49). Furthermore, it is evident that some young urban Mexican-Americans either select *compadres* who have prestige in the community or from those associates who are fellow workers. In addition to Thurston's and Madsen's data, Carlos' more recent information reveals that urban Mexican-Americans prefer relatives or intimate friends as ritual godparents, that relatives are selected more frequently than friends (Carlos: 477-478).

Selective Geographical Interviews in the U.S.A.

The following interviews represent selective, socio-cultural views of the *compadrazgo* system as practiced by

Mexican-Americans (Chicanos) residing in cities and small towns in the United States. In the main, their comments reflect the various forms of stress they experienced while in the process of acculturating to middle class Anglo-American society. G.M.'s godparents are of blood kin; his *padrino* is his father's brother and his *madrina* is the wife of his father's brother. Both families immigrated from Old Mexico to the United States, first his godparent's family and then his family. G.M. said "my father and his brother are compadres, they think of each other as compadres and then as brothers." G.M. related that, unfortunately, there was little contact with his godparents because they, unlike his family who settled in Milwaukee, Wisconsin, never settled in one place for they were constantly part of the stream of Mexican-American migrant farm workers.

With regard to co-parenthood relationships, G.M. believes that it is very common for isolated immigrant families, such as his, who settled in the Milwaukee area, to confine the selection of godparents, especially of baptism, to members within the extended family. G.M. is the godfather of his brother's son, and another brother is godfather to G.M.'s daughter. These brothers, however, unlike the formal relationship between his father and godfather (his uncle), think of each other first as brothers and address each other by name, seldom addressing each other as *compadres.* G.M. stated "I guess it feels strange for my brothers and I, here in the United States, to address each other as compadres." It is safe to assume that this change of formal relationships is due to their exposure to the norms of Anglo-American society which does not have or understand the *compadrazgo* mechanism.

G.M. and his brothers (*compradres*) realize that their socio-cultural milieu is different from that of their cousins in Old Mexico. G.M. states "our relatives in Monterey (Nuevo Leon, Old Mexico) live among the people. When they become co-parents in a baptism or for confirmation or in a marriage, their relationships are very formal with the child and his parents. They (the godparents and child's parents) address each other as compadres and comadres. These compadres look upon each other with great respect and reverence." G.M. said that this formal attitude is present in the relationships between godparents and their godchildren. The godchildren refer to their godparents as *madrina* and *padrino,* and the godparents address their godchildren as either *ahijada* or *ahijado.* All the members of this Mexican *compadrazgo* employ such forms of address very seriously for they consider these ritual relationships as part of a sacred pact with God. By comparison, G.M. states "In the United States, within my own family the practice of the compadres is different than that of my (Mexican) cousins. Even though my wife is a Catholic, she is of an Anglo background. Among her people there isn't that concept of compadrazgo (ritual co-parenthood) but they do believe in having godparents for a child's baptism." Thus, when the time came to select co-parents for their daughter, they chose one from each side of the family; one Anglo-American, and one Mexican-American. G.M. said that the reason for this dual selection was to keep peace in the family. He said "it works." The manner of reference between parents and godparents is not formal, each addressing the other by first name.

The next interview was with a third generation Mexican-American (Chicano) who was from Brown, Texas but now resides in LaCrosse, Wisconsin. D.C. states "My relationship to my compadres (godparents of his children) is one of friendship, but it is not ritualistic. For Chicanos, I think, the ritual aspect of the compadre has died. They are not Mexicans like the people from Old Mexico; they are Chicanos who are born in the States. With my father and his compadres (second and third generation Mexican-Americans), they were more than friends, but it wasn't a formal relationship. With my grandfather, however, it was a different case. He used the term compadre in a ritualistic way, with great respect and reverence."

D.C. said that there was a great difference between his grandfather's idea and practice of the *compadrazgo* and that of his parents. Among godparents and parents (*compadres*) there was always great respect for each other. These ritual co-parents, especially of a baptised child, could trust and count on each other in times of need, i.e., *compadres* and *comadres* could always count on each other's help. D.C. stated "Favors were always fulfilled between Mexican godfathers; then a promise was a promise to your compadre."

D.C. said that within his grandfather's generation, both in Old Mexico as well as in the United States, it was always considered a great occasion when godparents came to the child's house for a visit, especially if they were his baptismal sponsors. When the men got together (*compadres*), it was a call for a great festive celebration. The women of the house (wife, mother, and sisters) were expected to cook a meal for their *comadres.* D.C. stated "I think there was a lot of tribal attitudes present in the old traditional compadrazgo, something which is not present or seen today in the United States." It was evident, from further conversation with D.C., that the *compadrazgo* tradition and practices among second and third generation Mexican-Americans have been diminished or repressed as a result of their efforts to cope with American society.

D.C. stated that his baptismal godparents had not been selected from blood relatives. "They were just people who my parents met at church. In those days there were few places where Mexicans could socialize; they were a segregated group in Brown, Texas (a small town outside of Dallas)." For his confirmation an uncle and aunt served as his sponsors (godparents).

D.C.'s parents remained in Brown, Texas, staying in the same low income, socio-economic strata as most of the Mexican-Americans of their age group. His godparents of baptism, however, like a few other Texas, Mexican-American families, either entered the stream of migrant labor or permanently moved from Texas. D.C. said that he left his father's community so that he could get an education and gain higher socio-economic status. Now, as a college-educated man who married an Anglo-American woman, D.C. feels that he is an assimilated Mexican-American. He stated "I could not compare my Chicano culture to that of my grandfather's. My compadres, the godparents of my children, are Mexican-Americans. We address each other as compadres but we are only friends, compadre friends. We are not compadres of blood relation, and we don't maintain the formal practices of the compadrazgo as my grandfather did. We are Chicanos who have developed a different culture."

Mrs. H.S., from Grand Junction, Colorado presents another view of the practice of the *compadrazgo* among Mexican-Americans. The *compadres* of her parents, the ones who baptized her, are her father's sister and her husband. Mrs. H.S. stated "I always think of my aunt as my madrina and her husband as my padrino." Her parents and godparents always address each other as *compadres.* She emphasized that in her tradition (of an Old Mexican background), *compadres* remain as such for the rest of their lives, regardless of their blood ties or even divorce. Furthermore, when uncles or aunts, in her *compadrazgo* system, become godparents or *compadres,* the blood cousins automatically become more than blood relation. These cousins become known to each other as "hermanas or hermanos de pila." She also stated "If your brother(s) or sister(s) become the godparents of your children, then the tradition is that you should address them as your compadres. But if your parents baptize your children, then, even though they are your compadres, one must never address them as such. One must always refer to them as father or mother."

After further conversation with Mrs. H.S., it was evident that members of her nuclear and extended family not only identify with Old Mexican society and culture but they maintain its particular form of the *compadrazgo system*. The reason they adhere to and support the practice of selecting their parents as godparents for their children is because it helps strengthen the son-in-law and mother-in-law relationship, as well as the father-in-law and daughter-in-law relationship. This esoteric group also believes that because they maintain this practice there is less possibility that any one of the in-laws, on either side of the family, will commit incest with a son-in-law or a daughter-in-law. It is considered more sinful and sacreligious to break this incest taboo than if one of the in-laws or one of the married couple had extra-marital relations outside of their extended family. This group's practice of the incest taboo is similar to that cited by Rubel in South Texas or Foster in Old Mexico.

The values and respect for the *compadrazgo* pact, especially between *compadres* of baptism, is further exemplified in the following belief and practice. Mr. H.S. stated "when two compadres get mad at each other and they can no longer stand their anger, finding it necessary to fight, they throw their hats into the air and ask God's permission to fight; then they fight." According to Mrs. H.S., this custom must be adhered to in order not to offend God and thus maintain their belief in the sacredness of the *compadrazgo*.

In an interview with E.V. from Laramie, Wyoming, it is evident that young Chicanos still believe in and maintain the *compadrazgo* mechanism. He stated "I feel very close to my godchild (male) and he always calls me his nino. They (his parents) say that that is all he talks about, is his nino. I believe that I would be responsible for his spiritual and even general upbringing, that is, if his parents should pass away or they were seriously injured and "unable to raise him." E.V. visits his godchild every opportunity he gets, and takes him a present on his birthday.

The baptismal co-sponsors for the above godchild are the parent's best friend (E.V.) and the initiate's aunt on his mother's side of the family. E.V. speaks to his co-parents in English and addresses them by their first names but they answer him in Spanish and address him as their *compadre*. E.V. says that when he gets married (within a year of the interview) he will ask his "favorite cousin" (a second cousin) to be his sponsor (*padrino,* the best man) and his fianceé is going to ask her first cousin to be her sponsor (*madrina,* the maid of honor). The ring bearer is going to be her aunt's son on her father's side of the family. E.V. intends to have his children sponsored at baptism either by one of his brothers or his wife's brothers and their wives. His rationale for this selection is mainly to keep the *compadrazgo* relationships within the family, thus, they can be counted on to raise his children if something should happen to him and his wife, especially, in case of the death of both of them. In addition, speaking for himself and on behalf of his future wife, E.V. believes that in order of rank, *compadres* of baptism are the most important because they have the greatest responsibility to the growing child. Selecting *compadres* from any particular socio-economic level was not important to him, what counted was the child's spiritual upbringing. The sponsors for confirmation and marriage are secondary to those of baptism, especially for marriage because by that time the individual is grown and has learned the important spiritual way of life as well as proper social behavior. E.V. believes that the selection of *compadres* from blood kin also strengthens the bonds of the extended family. Finally, based on further discussion with E.V., it is clear that his views of the *compadrazgo* system reflect those of his immediate and extended family and friends who migrated to Wyoming from north central New Mexico.

Our final view on the practice of the *compadrazgo* in the United States comes from Nancy Ortiz. In 1976 she interviewed five urban Chicanos from central California. Her data reveals that: first, in every case, parents selected the baptismal godparents; three were not blood kin. Second, they maintain a sense of obligation and respect for their godparents. Third, all of them believe that relatives make better godparents than outsiders, because they are more dependable and tend not to move away. Even when they leave the community, they keep in touch with the *compadres* and will travel a long distance to see their godchildren. Fourth, all five respondents stated that it was preferable to select godparents who are relatives, for not only are they viewed as very special, more than those outside of the immediate family, but they strengthen blood kinship bonds. This view is in agreement with those of Mrs. H.S. of Colorado and E.V. of Wyoming. Fifth, all of the five Chicanos agreed that they would come to the aid of their godparents if they were in trouble. Finally, all of Ortiz's respondents believed that godparents are responsible for the care of the spiritual and physical needs of their godchildren in the event that the parents can not. (Ortiz, 1976) Both of these points of view are similar to all of the above cited interviews and studies of the *compadrazgo* system among Mexican-Americans (Chicanos) in the United States.

Analysis and Conclusion

Based on the foregoing studies and interviews, it is evident that Mexican-Americans and Chicanos, from both rural and urban settings, have an understanding of the *compadrazgo* mechanism, thus maintaining and perpetuating its beliefs and practices. These people, however, have experienced great pressure in acculturating to middle class Anglo-American society. This process has affected changes in the *compadrazgo* system. When married couples are outside of their traditional community and away from the extended family, they tend to select godparents from among other Mexican-American (Chicanos). And once the individual moves away from the esoteric community and out of the influence of the extended family, he acquires ways of the dominant society through social and cultural contact. In other words, in seeking upward mobility in both social and economic stratifications, they tend to choose Mexican-American (Chicano) godparents who are friends and not blood kin. Another ramification related to seeking upward mobility by first, second, and third generation Mexican-Americans is that acquiring degrees in higher education and positions in professional fields leads to both friendships as well as intermarriage with Anglo-American people, most frequently marriage with Anglo-American women. In other words, due to cultural contact and the upward movement in socio-economic status, these Mexican-Americans (Chicanos) find there are very few of their own to associate with, especially to date or marry. To fulfill these needs they acquire both Anglo-American friends as well as spouse from among their college peers and working milieu. In a case of intermarriage, *compadres* are selected from both Mexican (Chicano) and Anglo-American Catholic families, even though the two have different concepts, beliefs and practices with regard to godparents or co-parenthood. Moreover, the *compadrazgo* mechanism, though it operates on a less formal level, helps strengthen family ties for members of the Mexican-American (Chicano) family who have acquired afinal relatives through marriage.

The differences between the Old Mexican peoples' use and the Mexican-Americans' (Chicanos') use of the *compadrazgo* system may be explained, in part, by the different socio-economic conditions they experience. Mexican-Americans and Chicanos, like the people of Tzintzuntzan, do not adhere strictly to the Roman Catholic church's rules regarding ritual co-parenthood. Some have the same individuals for godparents in two or more ceremonies. All of them extend the spiritual relationship to include the parents of the child and the sponsors as ritually related. In addition, the *compadrazgo* for Mexican-Americans and Chicanos may be seen as a more intimate relationship reserved for relatives and close friends. Moreover, the informality between urban Mexican-Americans and Chicanos and their *compadres* is related to their contact with Anglo-American society which practices less stress on formality, i.e., people who are close express their intimacy by addressing each other by their first name. It is thus not surprising that urban Mexican-Americans and Chicanos drop the formalities within the *compadrazgo* relationships. But it would be an error to view this informality as a devaluation of the *compadrazgo* mechanism. It is as revered by Mexican-Americans as it is by Foster's Tzintzuntzenos. Both cultures observe the incest taboos between sponsors and godchildren and between *compadres* and members of the extended family. As in the Old Mexican traditions, Mexican-Americans and Chicanos have adapted the *compadrazgo* system to fit their changing needs and life styles.

Finally, it would be unrealistic to state that a generally established pattern has evolved for either the horizontal or the vertical selection of *compadres* by members of the various groups of Mexican-Americans and Chicanos, especially within the last quarter of this century. The reason for this diversity of practice is that not only have a sizable number of Mexican-Americans and Chicanos entered middle class Anglo-American society, but more of these people are breaking out of the manual labor and blue collar worker's socio-economic class, and into the professional world with its more sophisticated socio-political class structure. In essence, by becoming skilled workers, and acquiring better educations contemporary Mexican-Ameicans and Chicanos are becoming more mobile. It is this phenomenon of upward mobility which has had a direct affect on the nature of the *compadrazgo* system in the United States. There is no doubt, however, that the *compadrazgo* is a viable institution which is part of an ongoing, progressive Mexican-American (Chicano) society and culture.

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Respondents

D.C., 1977, La Cross, Wisconsin, age 27 B.A. and M.A. in Counciling, third generation Chicano (Mexican-American).

E.V., 1984, Laramie, Wyoming, age 27, B.S. in Biology.

G.M., 1976, Milwaukee, Wisconsin, age 30 B.A. and M.A. in Counciling, naturalized citizen.

Mrs. H.S., 1979, Grand Junction, Colorado, age 59, high school education, housewife.

FROM ARC LIGHTS TO GIGAWATTS FOR WESTERN WISCONSIN

FREDERICK H. C. SCHULTZ
Department of Physics and Astronomy
University of Wisconsin-Eau Claire

One hundred ten years ago man had for light at night and in dark places only the flaring gas jet and the kerosene lamp. These were better than the tallow candles and whale oil lamps they had replaced but they were still dim, inconvenient and dangerous, and a new source of light was needed by an increasingly technological society.

The Chinese of a thousand years ago used magnetism for the compass and Benjamin Franklin was a leading expert on the phenomena of static electricity. In 1789 Volta invented the battery which would provide electric current for Davy's arc and incandescent lights, for Davenport's electric motor and for Morse's telegraph. In the 1830's Michael Faraday combined magnetism and electricity in building the all-important generator which would turn mechanical energy into electric energy in any quantity desired. These men were scientists who pursued their studies for the love of them. Their discoveries were used by more practical men to complete the industrial revolution and to change the way of life of the civilized world.

By the 1870's Brush had developed the series connected electric arc but its sputtering glaring light was suitable only for streets or large places. Edison who, after several successful inventions, was looking for new opportunities immediately saw the enormous possibilities in home and general electric lighting. By 1879 he had invented the high resistance low current incandescent light bulbs to be connected in parallel in a low voltage circuit. On September 4, 1882, his Pearl Street Station became the first central electric generating station in the world. On September 30, the Appleton, Wisconsin generating station was turned on as the second Edison central generating station and the first in the world to use hydropower as its primary source of energy. The Edison direct current circuits limited the size of systems and especially the distances between generators and loads. By 1886 George Westinghouse, and his engineers had worked out a system for generating, transmitting and using alternating current which enormously extended these limits. After his brilliant success in lighting the 1893 Chicago World's Fair and a bitter battle with Edison and his General Electric Company, in 1896 the two companies adopted a compromise of 110 volt, 60 cycles per second, alternating current for distribution systems.

Within a few years nearly every Wisconsin community of more than a few hundred residents had one or more supplies of electricity. These were often called Electric Light Companies or Electric Light and Traction Companies as the combination of electric lighting at night and electric streetcars and interurbans during the day seemed a good way to get full use from the central generating equipment. The primary sources of energy were water power where available, coal fired reciprocating steam engines and, in later years, steam turbines and ponderous oil burning diesels. Service was erratic, often intermittent, and was limited to city residents or even to parts of cities. As the years passed, the quality of the service rapidly improved and the areas were increased, but only the most far-sighted of those early entrepreneurs ever imagined great electrical networks with connection available to almost every building in Wisconsin.

This is not surprising because growth was characterized by confusion, uncertainty, and almost yearly corporate change. Three classes of men transplanted electric plants from the greenhouses of the inventors to the cities and villages where they could grow: Manufacturers and salesmen, city and village fathers who saw electric lights as a desirable civic improvement; and less often, men who saw central stations as a business with a great future. At least thirty years passed before the electrical generating business in Wisconsin could be called reasonably stable and financially successful. It is interesting to summarize some of the reasons why that time was so long.

First the whole field was new and there was little outside or previous experience to draw upon. The equipment salesmen and city fathers were often more interested in getting the generation and distribution of electricity started than in establishing a stable industry which could grow and expand appropriately with the passing of time. Others saw lighting and traction companies as a quick way to make money and this was almost never true. Second, the combination of lighting and traction which seemed so attractive did not work out well. Few of the street car and interurban lines were ever profitable and the lighting part of the enterprise, which might have done well by itself, was financially unable to support both. Eventually the traction companies were separated and nearly all had quietly discontinued business by the end of WW II. A third reason was that the whole technology was new. Companies which were well managed and well engineered for the time had also to be almost lucky to be able to select good equipment for their particular installations and even then would find, in a few months or years, that it had been made obsolete by rapid technical developments. Finally, there was a fourth factor which had at least as great effect as any of the others then and is just as important today. It was that there is a great increase of economy with size in an electric generation and distribution system. An electric company must be big enough to efficiently utilize its management, its engineering services, its installation and maintenance services, its accounting and financial functions, and especially its generation and distribution facilities. This was recognized by the more astute in the industry as soon as technology made growth, area expansion, and interconnection possible. When appropriate levels of these had been achieved by various companies, electrical generation and distribution became profitable and service could be improved and extended in an orderly manner.

By 1882 there were eight arc lighting systems in Wisconsin, and Eau Claire was the first city in the state to have competing hydroelectric arc lighting companies. The Eau Claire Brush Electric Company was an immediate financial success and in 1885 became the first in the state to earn and pay common stock dividends and continued to do so for the next five years. The competing company gave only irregular service and by 1888 had been absorbed by the Brush Company. By this time a horse-powered street railway was in operation and in 1890 the three companies were merged into the Eau Claire Street Railway, Light and Power Company. The company went into incandescent lighting, electrified the railway and began to fail financially almost from its inception. When it went into receivership in 1896, it was acquired by A. E. Appleyard who, after some manipulations, combined it with the Chippewa Falls Water Works and Lighting Company, which had built an interurban line to Eau Claire into a successful operation called the Chippewa Valley Electric Railway and Light Company. Then in 1905 Appleyard suddenly and somewhat mysteriously sold out to a group of purchasers headed by the Ingram, Knapp and Stout lumber families.

The new owners, like most, directed their efforts towards hydroelectric power development, but unlike most, they used good judgement in so doing. A lease for the 650 horsepower output of the Eau Claire Dells Dam provided the principal source of energy for the Chippewa Valley Company. The Knapp-Stout interests also owned the lighting plant in Menomonie and supplied it from the hydro plant at their lumber mill on the Red Cedar River. They planned to expand from these two bases until the potentials of both the Chippewa River and the Red Cedar were fully utilized but they were also fully aware of the vagaries of these rivers, developed relatively small hydro sites, one at a time, on the Red Cedar and built a market for the new power as they proceeded. They did this by acquiring the lighting companies in the surrounding small towns, by extending service to others which had none, and by selling power to other companies. In 1910, the lumbermen completed the 8,000 horsepower moden hydroelectric plant at Cedar Falls and by 1914 they were ready to begin the development of the Chippewa. Then they hesitated when they learned that a single site would cost at least as much as they had previously invested in the entire company.

While they hesitated, the American Public Utilities Company, a holding company owned by Charles B. Kelsy and Joseph Brewer, promoters and engineers, offered them $5,848,000 for the Chippewa Valley properties. This gave the lumbermen a net profit of over $3,000,000 and they accepted the offer. Kelsey-Brewer already owned the LaCrosse Gas and Electric Company. It immediately merged the two into the Wisconsin-Minnesota Light and Power Company. The Kelsy-Brewer organization was aggressive, energetic, skilled and ambitious. The time was auspicious and it immediately began intensive development of the existing electric properties while continuing rapid expansion by acquiring the small hydro plants and other distribution systems in the area. The company was an immediate financial success but healthy earnings from a relatively small utility was not Kelsy-Brewer's goal. The reason for modernizing and interconnecting the Wisconsin-Minnesota system was to facilitate Brewer's larger plan to develop hydroelectric power sites on the Chippewa River and ultimately to bid for control of all electric service in central Wisconsin. He was in a position to do this when WW I began.

The Wisconsin-Minnesota Light and Power Company controlled by the Ingram-Knapp-Stout group and, after 1914, by Kelsy-Brewer, recognized that a potential market is necessary for an economically successful large hydroelectric project. By 1915 the market seemed assured and the Wisconsin-Minnesota Company began planning for a hydroelectric project at Paint Creek on the Chippewa River, two and a half miles above Chippewa Falls, where a fifty-seven foot head could be obtained for a potential power of more than 30,000 kilowatts. This was to be, at the time, not only the largest hydroelectric project in Wisconsin, but the largest in the United States and the entire world. The cost of the Wissota project, as planned in the depressed year of 1915, was to be something over $2,000,000. The actual construction, carried out in the highly inflationary years of 1916-18, cost nearly $6,500,000.

The power from Wissota was far more than the Wisconsin-Minnesota system was expected to need for some years, so a large part of it was contracted to the rapidly growing Consumers Power Company (changed in 1917 to Northern States) owned by the Byllesly interests, which served the heavily populated Minneapolis-St. Paul area in Minnesota. The contract carried a stiff penalty clause for poor water conditions and in the years from 1919 to 1922 the Chippewa had a continuously smaller flow. As a result of this and the fixed expense of the securities issued for the much higher than planned construction costs, Wissota, instead of being an asset, rapidly placed it deeper and deeper in debt to the Northern States Power Company of Minnesota. In 1923 Kelsy-Brewer sold Wisconsin-Minnesota's common stock to Northern States Power Company.

Wisconsin law required that utilities operating in the state must be Wisconsin corporations. The Byllesly interest, therefore, incorporated the Wisconsin-Minnesota Company as the Northern States Power Company of Wisconsin, a wholly owned subsidiary of the Minnesota company and operated as an integral part of it. The company immediately became prosperous, developed the hydroelectric resources of the Chippewa and other streams in its regions, and was able to give excellent service at constantly decreasing rates to the industry, businesses and homes in its area.

Here again it is illustrated that the electric central station business had become one requiring great financial resources. A prosperous, though somewhat local company, did not have the financial ability or reserve to plan and complete a project which, though surely large for the time, would be small in comparison to those necessary for good economical operation in the years ahead.

Natural Monopolies

Railroads and telephones had each been in existence only a short time before the public and the government recognized that it would be neither practical or economical to have competing companies serving essentially the same area. From this came the practice of the franchised public utility. Some unit of government, such as a city, township, or state would give a company the exclusive right, or franchise, to provide its services in some area over which the unit of government had jurisdiction. In return, the company would have to pay a fee, and also agree to provide certain services, such as a telephone to any person or business requesting a connection, at a cost previously determined by an agreement beween the unit of government and the utility. These franchises were usually for brief fixed times and so had to be continuously renegotiated.

The first Edison and Brush electric generating stations, which could supply, at most, only a few hundred bulbs to customers in a small nearby area, had not seemed to fall into the category of public utilities. However, with the introduction of alternating current and its almost universal adoption after the 1893 World's Fair, it was soon obvious that one company might best serve a whole city, or perhaps even many cities, and that electric generating and distributing companies were public utilities. As such, by 1900 the electric companies were being regulated by municipal governments with the regulation being whatever was most politically advantageous at the moment. Utilities offered a product available from only one source at a predetermined price, and politicians recognized almost immediately that voters often responded favorably to attacks upon them. As stated by McDonald in *Let There be Light,* "Utilities employed several weapons, none of which guaranteed success, and they never gained by fighting politicians. Local politicians had countless weapons, one of which, control over enfranchisement of utilities, was all-powerful, and they never lost and often gained by fighting utilities." Franchises were always for limited times and the utilities were in a constant hassle to stay in business at any kind of a reasonable profit. Responsible leaders in the electric central station, and other similar industries, recognized and propagated the idea that state regulation was a natural corollary of the monopoly principle and that it was the only way that the industry could be made stable and profitable.

The Wisconsin Railroad Commission and its Successor The Wisconsin Public Service Commission

There arose at this time in Wisconsin a political movement, led by a most dynamic politician named Robert M. LaFollette, which called itself "Progressivism." The simplest description of it would be LaFollette versus special interests, with the utilities, particularly the railroads and big business in general, as the special interests. Actually LaFollette was careful never to clearly define or identify these special interests thus leaving it possible to cooperate with individual business interest groups whenever it was mutually advantageous to so do. In addition, LaFollette progressivism had three other elements which made its position on regulation similar to that of the utility men: (1) Consciously or unconsciously, it espoused increased centralization of government power in the hands of the state. (2) It advocated government by expert commissions. (3) It had a vested interest in vocalizing against utilities and the railroads in particular; the non-Progressive political organizations were closely connected with the city, and other political machines which were considered to be the servants of the special interests and, as such, were natural enemies of the Progressives. These same local governments and politicians would strongly resist any measure which would take away their useful and profitable power to franchise utilities. Thus there was formed an alliance between what would seem to be bitter enemies.

This alliance influenced the 1907 legislature to pass the statute which created the pioneer Wisconsin Railroad Commission. This statute together with important amendments in 1911 and 1913, and its resulting commission, became the model for similar commissions in more than forty other states. It was the first such commission to have real regulatory powers and to use these powers in an enlightened way. The essential features were a three-person commission, appointed for staggered six year terms, with one commissioner being appointed every odd-numbered year. State appropriations were made large enough to enable the commission to attract highly trained engineers, accountants, and other necessary professional help. The record and reputation of the commission indicate that the commissioners were able men who carried out the spirit of the law to the best of their ability.

The responsibilities of the commission were to police the financial activities of all utilities, establish standards of service, and fix rates. Rate-making can surely be classified as the most controversial and troublesome responsibility. The commission operated on the theory that utilities were entitled to receive sufficient income to pay all reasonable and necessary operating expenses and taxes, maintain equipment in a good state of repair, provide an adequate reserve for depreciation, and yield a reasonable rate of return on legitimate and necessary investment in the business. The last has been the most misunderstood and the most difficult to determine. The Wisconsin Commission correctly decided that it takes money to earn money and with no investment there would be no return. Therefore, it set a certain percent of profit for each utility. If the utility, by good management and good fortune, appreciably exceeded this, the commission would have to cut rates. Poor management and smaller profits were not a justification for a rate increase; so the allowable rate of return actually worked out as a profit maximum rather than a minimum as it is often popularly thought to be.

To police the financial activities of the utilities, the 1907 law and the revision of 1911, provided that the utilities must have Commission approval for every issue of securities. This power, combined with that added in 1931 to grant or withhold certificates of public convenience and necessity, gave the Commission complete working control over investments and construction. The Commission also used this power to keep the distribution of kinds of securities at the best balance for the protection of investors.

The Commission also issued indeterminate permits in place of the previous limited term franchises granted by local units of government. Thus, the utility could depend upon a perpetual monopoly so long as it operated in a manner beneficial to the public. Conversely, municipalities could, at any time, purchase all the property of a utility at a "fair price" which would be established by the Commission.

By 1911 the Commission was given control over all water power in the state. From that time on, the Commission's approval of plans and a prior permit was required for the construction and use of hydroelectric generating facilities.

The Wisconsin Commission developed a uniform system of accounting which all utilities were required to follow. This system was later adopted by the Federal Power Commission and by nearly all other state commissions.

In 1931 the Wisconsin Railroad Commission was reorganized and given the title, the Wisconsin Public Service Commission. It was also given more control over the internal workings of utilities and over the relationships between utilities and holding companies. Finally, provision was made to pass the costs of regulation directly on to the utilities themselves. The creation of the Wisconin Railroad Commission and its successor, the Wisconsin Public Service Commission has great significance to the public, to the utilities, and to government. It gives a middle ground between the extremes of sometimes irresponsible private business on one side and the possible waste and inefficiency of public ownership on the other. It has created conditions under which private enterprise would work both for the benefit of the owners and the general public. During its lifetime it has also served as a model for other states and for the federal government and has demonstrated how such a government agency could generally remain independent despite pressure by business, by politicians, and by various special interest groups.

Northern States
Power Company's Privileges

a. The exclusive right to sell its services in the area granted to it by the WPSC (Wisconsin Public Service Commission).
b. The right to charge its customers for services at the rates set by the WPSC.
c. The opportunity to issue various kinds of securities, raise capital, acquire facilities, pay dividends, retire indebtedness, and conduct its daily business according to rules prescribed for public utilities with special attention to securing prior permission for certain classes of transactions.
d. The right to make a reasonable profit on their investments for its stockholders and the holders of its securities.
e. As a public utility, the right to secure property and right-of-way necessary for the most efficient generation and distribution of its products such as electricity, to the public being served. This includes the right of condemnation where necessary property or right-of-way is concerned and no mutual agreement can be reached.
f. The right to have the WPSC issue or deny permits, act upon requests, make recommendations, etc., in reasonable times and in ways which will facilitate the efforts of the company to give the public the best possible service at the lowest possible cost.

Northern States
Power Company's Responsibilities

a. Northern States Power Company (NSP) must provide service to all potential customers who request it and who are so located in the franchise area that it is physically possible to deliver electricity and gas to them.
b. NSP must charge for its services at rates determined by the WPSC.
c. NSP must maintain its generating and distribution systems and have trained personnel to keep its regular service at high level.
d. NSP must have plans, equipment and personnel to promptly and efficiently cope with natural disasters and any other unexpected interruptions to service.
e. NSP must make plans for the near and more distant future so that adequate service will be available. Plans must be made and approved by the WPSC so that sites and right-of-way can be acquired, equipment planned and ordered and the system given the capability to carry the expected loads. It is much easier to delay or cut back on expansion than it is to hurry it up.
f. Plans must be made for shedding load,

or other actions, to preserve the integrity of the system in the event of an overload above the capacity of the generating units and purchased power available. All possible eventualities must be considered for action with a minimum of inconvenience and cost to the customers.

g. NSP must conform to all laws, rules and regulations, etc., of the WPSC, the State of Wisconsin, the Environmental Protection Agency, the Federal Power Commission, the Occupational Safety and Health Administration, and the Department of Energy, the Securities and Exchange Commission and possibly others.

h. Finally, while complying with all the above, the officers and managers of the company shall run it so efficiently and well that there will be a profit, and therefore dividends, for the stockholders and the holders of any other company securities.

Growth and the Need for Power and Generating Facilities

From 1923 to 1938 the operations of the Northern States Power Company of Minnesota and its wholly owned subsidiary, the Northern States Power Company of Wisconsin operated as an integral company and cannot be considered separately. From 1938 on the Wisconsin company continued operation as an integral division of the Minnesota company but was managed, financed, and regulated as a separate utility.

The financial adjustments and revision of 1938 established the working relationships for the Northern States Power Company of Minnesota and its subsidiary, the Northern States Power Company of Wisconsin, which have been continued since that time. Under it, the Northern States Power Company is a supplier of electrical service in an area of 40,000 square miles in Minnesota, North Dakota, South Dakota, and Wisconsin containing 950,000 electrical customers in 630 communities with approximately 3,000,000 residents in 1975. The NSP electrical system has nuclear, coal and oil-fired steam; hydroelectric; oil-fired turbine; and diesel-powered generating stations; bulk power substations and local distribution systems. It is interconnected with Dairyland Power Cooperative, Cooperative Power Association, some municipally owned systems with which it shares its area, and with all the big utilities on all sides of it to be a part of the Mid-Continent Area Power Pool (MAPP) to give a maximum of reliability of service at a minimum of cost to its customers. It is a member of the National Electric Reliability Council (NERC) through its participation in the Mid-Continent Area Reliability Coordination Agreement (MARCA), which report to the Federal Power Commission on the reliability and adequacy of the bulk power supply of the electric utility systems.

As a public utility, NSP is obligated to provide reasonable and adequate service to all its customers in the area. This means that NSP must be able to provide the maximum amount of energy each customer needs and that it must also be able to provide the total amount of power required by all its customers at any one time. The latter must be accomplished in spite of scheduled maintenance, generating plant failures, transmission line outages, and all other foreseen and unforeseen contingencies, in ways that will keep power outage to the smallest possible area and prevent spreading into a disastrous breakdown of the whole system. This, combined with a constantly increasing demand in most areas (see Table 1) increasing capital and equipment costs, increasing environmental restrictions and regulations, and increasing public resistance to construction and power lines in the latter 1960's made accurate record keeping and scientific analysis for prediction of future needs absolutely vital. A critical problem was upon what factors predictions for future demand could be based. Should curves be plotted for the total energy use and for the peak demand, and then extrapolated? Should certain normalizing factors be used on the data for these

TABLE 1. Maximum Demand and Total Energy Use

	PEAK DEMAND (MW)		*TOTAL ENERGY (GWH)*	
Year	*NSP System*	*NSP Wisconsin*	*NSP System*	*NSP Wisconsin*
1965	1975	260	10140	1489
1966	2177	297	11154	1593
1967	2311	352	11994	1725
1968	2697	324	13413	1923
1969	2893	385	14637	2046
1970	3109	411	15916	2273
1971	3278	420	16697	2337
1972	3674	438	18039	2535
1973	3836	451	18669	2606
1974	3954	471	18783	2662
1975	4206	496	19769	2738
1976	4325	528	20890	2890
1977	4488	572	21300	3110
1978	4629	601	22390	3320
1980	(winter) 4018 (summer) 4667	(winter) 670 (summer) 656	23708	3515
1981	(winter) 4110 (summer) 4681	(winter) 682 (summer) 620	23938	3596
1982	(winter) 4137 (summer) 5222	(winter) 676 (summer) 662	25312	3689
1983	(winter) 4640 (summer) 5389	(winter) 712 (summer) 685	27246	3895

The Lake Superior District Power Company was added to the System in the middle of 1982. In 1983 it had summer and winter peaks of 122 and 137 megawatts and a total use of 817 GWH. The 1983 winter peak was unrefined in February 1984; refining may lower or raise it slightly.

curves before plotting and extrapolating? Should other influences such as the gross area product, population changes, etc., also be worked into the predictions? Both MARCA and MAPP agreed that operation should be with a reserve capacity of 15% each of the individual utilities peak demand. This has historically resulted in adequate reliability for consumers. With electricity becoming more of a prime energy source, and particularly the best and most available source for winter heat in Wisconsin, this reserve capacity becomes more critical.

As of January 1, 1984, the total system of Northern States Power Company had a summer generating capability of 5929 MW and a winter of 6375. This would be with all generating stations available and operating which would be a happy, albeit unlikely, situation. This total included 1633 MW of nuclear with the rest supplied by coal fired steam turbines for base and intermediate loads and oil fired gas turbines and a small amount of diesel and hydro mostly used for peaking.

Also available by NSP Wisconsin were 747 MW made up of 188 MW of hydro used for baseload and peaking, with the rest nearly all the very expensive to run oil fired gas turbines used only when absolutely necessary. NSP also has a contract to buy energy from Manitoba Hydro and exchanges energy with all neighboring systems when mutually advantageous.

In 1983 the 1633 MW nuclear plants provided about 50% of the electrical energy supplied to NSP customers and it was the economical performance of these that made it possible for NSP to continue some of the lowest electrical rates in the nation.

What Table 1 Shows

a. The system as a whole has had a 172% increase in peak demand from 1965 to 1983. From 1973 to 1983 the increase was 40.5%. The addition of the Lake Superior District contributed 3.7% to the peak in 1983. For the Wisconsin part of the company the corresponding percentages were 174 and 57.8. Although not constant, there has been an increase in the peak demand on the whole system every year of the record. The identification of summer and winter peaks shows the effects of weather but has not changed the overall picture. With the minor variation due to the warm winter, cool summer year of 1982 the Wisconsin record is similar.

b. In total use the system increased 169% from 1965 to 1983 and 47% from 1973 to 1983. The Wisconsin figures are 162% and 49.5%. There has been an increase in total electrical energy use by the whole system and by Wisconsin in every year of the record.

c. Though not shown in the tables, in 1968, 68% of the electrical energy used in Western Wisconsin came from the baseload generating plants in Minnesota. The percentage was about the same in 1983. This poses no problems, except for the distance of transmission, as long as the Minnesota company has the generating capacity available.

Summary

The production and distribution of electrical energy in Western Wisconsin has grown to be a major public utility and a major and highly important industry which affects the life of everybody. The availability and cost of this electrical energy are an important concern of the residents and government. This concern has resulted in the Wisconsin Public Service Commission and an enlightened regulation which is a credit to Wisconsin and a model for other states.

The 1973 energy crisis with the resulting depression, increase in costs, public awareness, and conservation somewhat slowed the rate of increase of both peak demand and total use of electrical energy. However, both continued to increase and there is every reason to expect that this increase will continue as oil and gas become more scarce and expensive and people are forced to turn to electricity for their energy needs.

Acknowledgments

The author would like to give special credit to *Let There Be Light* by Forrest McDonald, published in 1957 by the American History Research Center, Inc., of Madison, Wisconsin, which provided most of the information on the beginning of the electrical industry in Wisconsin. Other information came from the documents and management of the Northern States Power Company-Wisconsin and the author expresses his thanks and appreciation to NSPW for making this history possible.

NATURAL HAZARD EXPOSURES, LOSSES AND MITIGATION COSTS IN THE UNITED STATES, 1970-2000

Arthur A. Atkisson
Public and Environmental Administration
University of Wisconsin-Green Bay

William J. Petak
Institute of Safety and Systems Management
University of Southern California

Daniel J. Alesch
Public and Environmental Administration
University of Wisconsin-Green Bay

This paper presents the major findings of a three-year study of the exposure of United States population and buildings to nine natural hazards: expansive soils, landslide, earthquake, tsunami, coastal storm surge, riverine flooding, hurricane, tornado, and severe wind.[1] The research utilized computerized probabilistic risk analysis methods to determine annual expected losses for each hazard. The losses were calculated on the basis of long-term exposure of geographic areas in the United States to the various hazards, including estimated magnitude or intensity expected for each area. The research includes an examination of the costs and benefits of a wide variety of possible policies to mitigate the effects of the nine natural hazards on life and property, utilizing a variety of discount rates.

The Incidence and Costs of Natural Hazards in the U.S.

Almost no portion of the planet's surface is free from the risks produced by hazardous natural events. Scattered around the planet are 516 active volcanoes from which eruptions occur approximately once each fifteen days. The global network of earthquake monitoring instruments currently records approximately 2000 tremors beneath the crust of the earth each day and, almost twice each day, earthquakes of a magnitude sufficient to damage buildings and other structures occur somewhere on the face of the planet. Quakes of sufficient strength to produce widespread damage and death occur fifteen to twenty times each year. Above the surface of the earth, 1800 orbiting thunder storms can be observed at any given time and lightening strikes the planet's outer skin at the rate of 100 times per second. In late summer, 50 or more hurricanes can be observed forming somewhere in the world and, during approximately the same season, from 600 to 1,000 tornadoes strike somewhere in the United States at a rate of four or more per day. Nearly one half billion members of the planet's total population now reside in riverine and coastal flood plains where they produce one third of the world's total products and, on any given day, some fraction of these plains are covered by flood waters.

Many natural events occur only infrequently, but when they do occur, they produce catastrophic results. Natural disasters of major proportions have occurred throughout the history of the United States. Twenty-one years before the adoption of the Declaration of Independence, earthquakes shattered Massachusetts. During the height of the War of 1812, the highest magnitude earthquake in the history of the United States left parts of Missouri and Arkansas permanently sunken. In the immediate post-Civil War years a devastating earthquake struck South Carolina, and, in

1871, a forest fire raged throughout northeastern Wisconsin causing the deaths of more than 1200 persons.

On a single day in 1889, flood waters claimed 2,209 lives in Johnstown, Pennsylvania. Eleven years later, the largest civil disaster in U.S. history occurred when a hurricane pushed the waters of a storm surge over Galveston, Texas, causing 6,000 deaths. Six years later, in 1906, an earthquake rocked San Francisco and, along with the fires produced by the event, caused the deaths of 500 to 700 persons and more than $374 million in property damage. In 1928, a dam collapsed in California, sending a wall of water over an unsuspecting population, sweeping 450 persons to their deaths. Only a few months later a Florida hurricane caused 1833 deaths.

More recently, the Palm Sunday tornadoes of 1965 claimed 271 lives in five states; hurricane Camille (1969) destroyed over $1.4 billion in property and claimed 256 lives; the South Dakota flash flood of 1972 killed 236 persons; the Alaska earthquake (1965) killed 131; and Agnes, the hurricane and tropical storm (1972), caused 118 deaths and property losses in excess of $3.1 billion. On a single day in 1974, separate tornadoes caused the deaths of 318 persons in several southern and midwestern states.

Although less dramatic, a variety of other natural hazards produced considerable damage to property during these same time periods, resulting in substantial annual economic losses. These hazards include expansive soils, land subsidence, landslides, erosion of river and shore banks, periodic droughts, and hail, ice, snow, and rain storms.

The economic losses due to the nine natural hazards considered in this research project are substantial. As shown in Table 1, "Annual Expected Losses from Nine Natural Hazards in 1970, Compared with Annual Value of Other Types of Losses and Events," the annual expected losses from these hazards exceeds all losses from traffic

TABLE 1. Annual Expected Losses from Nine Natural Hazards in 1970, Compared with Annual Value of Other Types of Losses and Events

Type of Loss or Event	*Value in 1970 (Millions of $)*
1. All Property Tax Collections by State and Local Governments	34,054
2. All Accidents	27,000
3. Expected Annual Natural Hazard Losses (2000 Exposure)	17,779
4. All Traffic Accidents	16,200
5. Total Economic Effects of Air Pollution	16,000
6. Health Insurance Premiums	11,546
7. Increase in Annual Expected Losses from Natural Hazards, 1970–2000	9,685
8. Pollution Control Costs (Air, Water, Solid Wastes)	9,300
9. Auto Liability Insurance Premiums	8,958
10. Expected Annual Natural Hazard Losses (1970 Exposure)	8,094
11. Losses from Accidents at Work	8,000
12. Losses from Air Pollution-Related Morbidity and Mortality	6,000
13. Air Pollution Effects on Value of Property	5,200
14. Air Pollution Effects on Materials and Vegetation	4,900
15. Expenditures by All State and Local Police Departments	4,494
16. All Crimes against Property	4,264
17. Investments in Water Pollution Control Facilities	3,100
18. Business Losses Due to Six Types of Criminal Activities	3,049
19. Building Losses Due to Fires	2,209

Source: Petak and Atkisson (1982)

accidents and is approximately half the amount of all property taxes collected by state and local governments.

Public Policy and Natural Hazards

Many public and private actions have been taken in our efforts to mitigate the effects of exposures to natural hazards. Population warning systems have been placed in operation, rivers have been dammed, deepened, and diked. Coastlines have been equipped with sea walls, storm cellars have been dug in back yards, buildings have been elevated above the level of expected flood heights, and a variety of means have been employed to strengthen structures and reduce their vulnerability to the forces exerted by winds, land movement, and other natural hazards.

Unfortunately, these efforts at mitigating losses due to exposure have produced less than satisfactory results. Construction of flood control facilities has seemed to prompt heavy migration into flood prone areas and has, thereby, escalated the real costs of flood exposures. Governmental provision of disaster relief, low cost loans, and subsidized insurance has seemed to encourage, rather than discourage, private risk-taking activity. A public unwillingness to acknowledge the threat of future loss-producing occurrences in high hazard areas and an accompanying faith that government will somehow protect them, has contributed to a continuing population movement into such high hazard areas as the hurricane and flood prone coastal areas along the Gulf Coast and the South Atlantic. Similar population movements have taken place in seismically active areas and along the shores of rivers and lake subject to periodic flooding. As a result, the United States now faces the probability that one or more major community catastrophes, each far greater in loss of life and property than any which have previously occurred in our history, may occur over the span of the next several decades.

At the same time we have ignored the high risks of natural hazard events, we also face the risk of over-reacting to the threats posed by natural hazards and the related risk of implementing public policies which may result in costs far in excess of the benefits they will yield.

Numerous types of building strengthening, area protection, site development, and other technologies are available for use by those who wish to reduce the risks associated with exposure to natural hazards. Mandatory application of these technologies can be forced through adoption of a wide variety of federal, state, and local public policies. Hazard mitigating amendments to building codes, subdivision standards, and land use regulations can be enacted. Hazard zones can be identified and sanctions employed to prohibit development in such areas. The risk of loss may be spread through use of insurance schemes. The impact of catastrophic events on exposed populations may be reduced through community safety plans, disaster relief, and recovery measures financed by non-impacted parties.

What mix of these measures to employ, when, where, at what cost, and to whom, has become a major public policy question. To assist in resolving this question, the authors have conducted an interrelated set of policy studies of this subject[2] and have anchored these studies on findings from a computer-based study of U.S. population and building exposures to nine natural hazards over the period 1970–2000.[3] The computer models used in the study were based on risk analysis procedures developed to predict annual expected losses arising from the periodic occurrences of these hazards and were supplemented by procedures which permit examination of the relationship between the costs and benefits associated with applying a variety of loss-mitigating measures in the U.S. natural hazard zones.[4]

Annual Expected Losses and Exposed Populations

Application of risk assessment models resulted in estimates of nationally aggregated annual expected natural hazards losses

TABLE 2. Expected Annual Losses from Natural Hazard Exposures in the United States By Type of Hazard and Type of Loss, 1970 and 2000

Expected Annual Losses

Hazard	*Building Damage* (Millions of 1970$)*		*Number of Deaths*		*Housing Units Lost*		*Person Years of Homelessness*		*Person Years of Unemployment*	
	1970	*2000*	*1970*	*2000*	*1970*	*2000*	*1970*	*2000*	*1970*	*2000*
1. Earthquakes	781.1	1,553.7	273	400	20,485	22,858	736	648	413.5	634.9
2. Expansive Soils	798.1	997.1	—	—	—	—	—	—	—	—
3. Hurricane	1,056.0	3,528.3	62	153	31,885	52,237	34,505	48,271	21,004	58,223.7
4. Landslides	370.3	871.2	—	—	—	—	—	—	—	—
5. Riverine Flooding	2,758.3	3,175.33	190	159	—	—	—	—	—	—
6. Severe Wind	18.0	53.4	5	11	547	748	852	1,014	373.1	850.9
7. Storm Surge	641.2	2,342.9	37	103	24,521	43,757	7,290	10,330	369.7	1,018.3
8. Tornado	1,656.0	5,219.1	392	920	36,212	52,119	86,122	107,630	57,541.6	146,568.5
9. Tsunami	15.0	40.4	20	44	234	335	345	389	97.5	195.9
Totals	8,094.0	17,779.4	979	1,790	113,884	172,084	129,850	168,302	79,799.1	207,492.2

* Includes Contents, Income, and Supplier Loss.

for 1970 and 2000. These data are summarized in Table 2. The study revealed that natural hazard exposures in the year 1970 produced annual expected dollar losses totalling approximately $8 billion and nearly 1,000 annual expected deaths. Approximately 71 per cent of the expected dollar losses for 1970 resulted from building damage, approximately 24 per cent from damage to building contents, and the balance from expected losses sustained by workers and increased costs of transporting goods due to delays and reroutings. The study showed that annual expected natural hazard losses (in 1970 dollars) would rise to approximately $17.8 billion in the year 2000 and that building contents losses will rise to approximately 40 per cent of that total. Annual expected deaths from natural hazard exposures were predicted to increase to 1790 in 2000. Expected annual national losses from exposure to all nine hazards produced per capita losses of $39.76 in 1970 and $69.41 in 2000 (1970 dollars).

Mitigation Technologies and Costs

Seventeen potential loss-reducing strategies were examined in detail, representing five different major approaches to managing natural hazard risks. The five include hazard avoidance, area structure protection, building strengthening, site preparation, and building removal. The seventeen potential strategies are listed in Table 3. Each mitigation strategy is related to the hazards for which it is potentially applicable.

As a result of technology and cost analyses, it became clear that the high levels of hazard exposure the study predicted for the future need not occur; they can be prevented or lessened through use of several types of technologies and through implementation of a variety of public policies. The analysis revealed that building damage losses alone could be reduced by approximately 42 per cent from those projected for the year 2000. However, the study also revealed that no loss-reducing strategy is completely free

TABLE 3. Hazard-Mitigating Technologies, by Type and Applicability to Nine Natural Hazards

Technology by class and title	Hazard to which applicable								
	Riverine flooding	*Storm surge*	*Tsunami*	*Hurricane*	*Tornado*	*Severe Wind*	*Earthquake*	*Landslide*	*Expansive Soil*
1.0 Hazard Avoidance Strategies and Technologies									
1.1 Zero growth on fifty-year flood plains after 1980		●	●						
1.2 Zero growth on 100-year flood plains after 1980		●	●						
1.3 Zero growth on fifty-year riverine flood plains in specified additional numbers of flood-prone cities each year, to 2000	●								
1.4 Zero growth in counties exhibiting high Tornado Strike Risk (greater than 10^{-4} tornado strikes per year per square mile).					●				
2.0 Area Structural Protection Strategies									
2.1 Structural protection (dams, levees, etc.) of cities with riverine flood problems.	●								
2.2 Construction of sea-walls to protect four additional counties per year from 100-year storm surge heights. Construct in order of decreasing damages in affected counties.		●							
3.0 Building Strengthening Strategies									
3.1 Require tie-downs on all mobile homes.				●	●	●			
3.2 Increase designed wind resistance capability of new buildings to level equalling 1.5 x the level specific in the Uniform Building Code (1.5 x UBC)				●	●	●			
3.3 Increase designed wind resistance capability of new buildings to level equalling 3.0 x the level specified in the Uniform Building Code (3.0 x UBC).				●	●	●			
3.4 Increase strength of new buildings to level required in UBC Earthquake Zone #3. (UBC 3).							●		
3.5 Floodproof 2% annually of all structures in fifty-year riverine flood plains to provide zero damage to height of four feet.	●								
3.6 Floodproof 2% annually, of all structures in 100-year riverine flood plains to provide zero damage to height of four feet.	●								
3.7 After 1980, floodproof all new buildings in storm surge areas to height of four feet.		●							
3.8 Modify and retrofit existing buildings in high seismic risk areas to meet seismic safety standards.							●		
4.0 Site Preparation Strategies									
4.1 Require soils testing and improved site grading standards in landslide-prone areas.								●	
4.2 Require soils testing and pre-construction moisture control and/or soil stabilization on construction sites.									●
5.0 Building Removal Strategies									
5.1 Purchase and/or condemn and accelerate removal of high vulnerability structures in high hazard areas.	●	●	●				●	●	

Source: Petak and Atkisson (1982).

from economic or social cost and that overzealous use of some strategies might actually increase total national hazard exposure costs when these costs are defined to include both the losses resulting from hazard exposures and the costs of implementing the mitigations used to reduce such losses.

Examination of the annual amortized costs of implementing each alternative loss-reducing strategy resulted in the finding that many strategies are not cost-effective; their annual principle repayment and annual interest requirements exceed the projected value of their loss-reducing potential. The data generated by this study suggest clearly that imprudent and overzealous application of risk-reducing mitigations could actually increase net annual expected natural hazard costs in 2000 from 38.4 to 90.0 per cent above the levels that would be experienced if current policies remain unaltered.

Not all costs and benefits associated with implementation of mitigation strategies were included in the study. For example, the study did not include estimates of hazard-induced loss of public infrastructure. Perhaps more importantly, the study did not place an economic value on the reduction in human mortality that might result from application of more rigorous hazard management strategies. The authors do not attempt to place economic values on human life; they prefer to analyze the cost required to avert deaths. Such costs are often more meaningful to policy makers.

The procedures used to estimate losses were based on assumed, but empirically-supported, relationships between the magnitude of dollar loss associated with hazardous occurrences and the loss of life associated with such occurrences. This method resulted in annual expected life loss estimates which were substantially greater for 1970 than the annual average life loss from natural hazards actually reported for any of the decades in the current century. Moreover, both hazard-induced death rates and the absolute annual average number of deaths has been declining rather steadily throughout the century. Thus, even though the estimates of life loss were probabilistically derived and therefore reflect the intermittent and large losses of life which may be expected from major catastrophes, the annual expected estimates of life loss may overstate the consequences of natural hazard exposures. Past mitigations, including installation of warning systems, may be working effectively. On the other hand, since the estimates are probabilistic, and since the events are intermittent and characterized by massive losses, we may simply have been fortunate so far this century.

Even if the expected hazard-induced mortality predicted in the study were to occur, the annual expected estimates of life loss reported in the study are not as impressive as the mortality from other causes in our society. Examination of evidence suggests that the cost per death averted in natural hazard risk reduction programs can well be escalated to levels substantially in excess of those associated with other death and injury reducing programs which currently may be under-funded. Although this inference is not intended to suggest that life loss reduction should not be an objective of natural hazard management programs, neither does it seem appropriate to overstate the benefits and to understate the costs associated with such programs.

Notes

[1] The studies which resulted in this report were supported, in part, by National Science Foundation Grant Number ERP-09998, and by National Science Foundation Purchase order 78-SP-0620. In a substantially expanded form, the data reported here are also included in William J. Petak and Arthur A. Atkisson, *Natural Hazard Risk Assessment and Public Policy*, New York: Springer-Verlag, Inc., 1982.

[2] See, for example: (1) William J. Petak, Arthur A. Atkisson, Paul H. Gleye. *Natural Hazards: A Public Policy Assessment*. Redondo Beach, California, J. H. Wiggins Company, 1978 NTIS #PB297361/AS A23; (2) Arthur A. Atkisson, William J. Petak, Daniel J.

Alesch, et al, *Natural Hazards and Public Policy: Recommendations for Public Policies to Mitigate the Effects of Natural Hazard Exposures in the United States,* Green Bay, Wisconsin: University of Wisconsin-Green Bay Papers in Public Policy and Administration, 78-2 (December 1978); (3) Arthur A. Atkisson and William J. Petak, *Seismic Safety Policies and Practices in U.S. Metropolitan Areas.* (A Report to the Federal Emergency Management Agency), Redondo Beach, California: J. H. Wiggins Company, January 1981.

[3] William J. Petak, Arthur A. Atkisson, Paul Gleye, op. cit.

[4] J. Hirschberg, P. Gordon, and W. J. Petak. *Natural Hazards: Socioeconomic Impact Assessment Model.* Redondo Beach, California: J. H. Wiggins Company, 1978. NTIS # PB294681/AS A10.

MEDIA OF EXCHANGE

EDWARD E. POPP
Port Washington, Wisconsin

The term "medium of exchange" is applied to any thing, object, or document given and taken in the process of exchanging goods or services. The phrase "medium of exchange" describes the function of the thing. The thing that people agree to give and take to facilitate the exchanging of their goods and services is, by its function, a medium of exchange.

In the United States today an informed business or professional man will say our media of exchange consists of the following:

1. Federal Reserve notes
2. United States token coins
3. A few United States notes
4. Checks written against demand deposits in commercial banks.

An economist is very likely to say these four items make up our purchasing media.

A banker would say these four items make up our money supply.

So the phrases, *media of exchange, purchasing media,* and *money supply,* all mean the same things: the things we give and take in the process of exchanging our goods and services.

Goods and services can be exchanged either directly or indirectly. When the exchanges are made directly without any medium to facilitate the exchange, such exchanges are called direct bartering. When the exchanges are made indirectly, i.e., by the use of a medium to facilitate the exchanges, such exchanges are called indirect bartering or buying and selling.

The items that serve as media of exchange in direct bartering are items with exchange value in themselves, such as: full bodied gold and silver coins, salt, grain, nails, soap, tobacco, beaver skins, etc. The items given and taken have about equal exchange value. Neither the item given nor the item taken gives evidence that it is a claim for any other goods or services. They do not have to be redeemed for anything.

However, governmental bodies, private corporations, and individuals may declare that they will accept such items as payments due them. Any item the government will receive as a payment will be received by almost everyone as a payment. That is why people will choose to use it as a medium of exchange.

The items that serve as media of exchange in indirect bartering, i.e., buying and selling, are documents, bills, certificates, and tokens which give evidence that they are a claim for some goods or services or that they will be received as a payment due the issuer.

If a governmental body will receive these items as payments due it, everyone else will receive them as payments also. The people will then choose to use such items as media of exchange. That is, the people will choose to use such items as media of exchange, if they are issued in denominations and in a form convenient for making payments. If they are not issued in denominations and in a form convenient for making payments, people will not choose to use them as media of exchange.

For example, at the present time the U.S. government will issue to the people in exchange for Federal Reserve notes or in exchange for demand deposits of bank credit all the present U.S. coins the people want. The coins are legal tender for the payment of all debts to governmental bodies, private corporations, and individuals. They are brought into circulation without incurring interest-bearing debts. But people choose to use them only for small payments. They could be used for large payments, but they are not used for large payments because they are not issued in denominations and in a form that is convenient for making large payments.

We should note from what has been said, that of all the items we mentioned, none were issued for the *sole* purpose of serving as a medium of exchange. Grain, salt, nails, tobacco, and beaver skins were produced for some other use. People chose to use them as media of exchange because they were acceptable and useful for some need of the people.

When our first full-bodied gold and silver coins were made, they were not issued by the U.S. government to serve as payments for the expenditures of the government. The people brought gold and silver to the U.S. Mint. The mint made the metal into standard coins as a service to the people.

After the metal was made into coins, the coins were given to the persons who brought the metal to the mint. The coins belonged to them. They could use the coins for any purpose they wished. The coins were not government owned coins.

When the U.S. government agreed to accept the coins as payments due it (by declaring them to be legal tender at or above the market value of the metal in the coins), everyone else also accepted them as payments. Thus the people chose to use them as media of exchange.

Note well, the U.S. government officials did not tax the people to buy the gold and silver to make the full-bodied coins. The officials said in effect, "All who want gold and silver coins, bring the metal to us. We will make it into standard coins for you. And we will receive such coins for all payments due the U.S. government at or above the market value of the metal in the coins."

These were not the exact words of the government officials, but the effects that took place were as if those words were said.

As we see it, any government in the world can do that. Such action will not be any burden on the taxpayers. But that alone will not give the people debt-free purchasing media.

We stated that the items that serve as media of exchange in the process of buying and selling (indirect bartering) consists of documents—certificates and tokens—which give evidence that they are a claim for some goods or services or that they will be received as a payment due the issuer.

Who Can Issue Such Documents?

Any governmental body that levies taxes can issue such documents. It can issue tax credit certificates in denominations convenient for small and large payments. It can pay them out for its needed goods and services. It can levy a tax in a dollar amount equal to the dollar amount of the certificates paid out. It can receive them for all payments due it. It must redeem them when they are presented as the payment for the taxes levied for the expenditure for which they were issued as a payment. Any certificate or token that a governmental body will receive as a payment the people will choose to use as a medium of exchange.

Private corporations can also issue and pay out certificates of credit in exchange for goods and services. If they are issued in convenient denominations for making large and small payments, they too can serve to a limited extent as media of exchange.

But the main point we wish to bring out here is to show what items the U.S. government can issue to serve as media of exchange.

Many times we read or hear the statement that the government should issue our money. By the word "money" is meant the items to serve as media of exchange. So let us examine the power the U.S. Constitution gives Congress regarding the issuing of items to serve as media of exchange.

Article 1, Section 8, Clause 1, reads, "The Congress shall have Power to lay and collect taxes . . ." It is this section of the Constitution that gives Congress the power to decide what items it will receive as payment for the taxes levied. This is the section of the Constitution that gives Congress the power to issue the tax credit certificates that will be received as the payment for the taxes levied. If the government issues them in denominations convenient for making large and small payments, the people will use them as media of exchange.

Article 1, Section 8, Clause 5, reads, "The Congress shall have Power to coin money." The word money at that time meant coins and only coins to the writers of the U.S. Constitution.

So Congress can issue only two things that the people could use as media of exchange, tax credit certificates and coins.

Tax credit certificates can be issued in good faith only if the Congress levies a tax in a dollar amount equal to the dollar amount of the certificates issued.

Full-bodied gold and silver coins can be issued in good faith only in the amount that can be made from the gold and silver brought to the mint by the people who want the metal made into coins. They will pay them into circulation.

Token coins and certificates in lieu of coins can be issued in good faith only in the amount the people are willing to buy in exchange for their other currency or bank credit already in circulation.

Note, all the above coins and certificates are either paid or sold into circulation. The Constitution does not give Congress the power to loan into circulation any coins, certificates, or credit to serve as media of exchange.

So if, and when, the people ask Congress to supply them with media of exchange, they must tell Congress the specific items they have in mind and they must tell Congress how those items are to be brought into circulation. Remember, they must be brought into circulation without anyone incurring an interest-bearing debt.

Face Value of the Currency

Let us explain on which items of the currency the face value should be written. We have previously stated that full-bodied gold and silver coins have exchange value in themselves. They are commodities. They are not documents giving evidence of a claim for anything. Their exchange value may change from day to day.

No one, not even a governmental body can with honesty and justice put a set or a fixed market exchange value on a commodity that is being bought and sold all over the world and have it remain fixed over a period of time.

The writers of the U.S. Constitution were fully aware of that fact. That is why they did not authorize the Congress to put a fixed value on the full-bodied gold and silver coins. They gave the Congress the power to regulate—to adjust—the value of the yet to be minted U.S. gold and silver coins in the same manner as was being done with foreign gold and silver coins.

The value of the foreign gold and silver coins was being regulated or adjusted to the market value of their metal content at the time the coins were used as payments.

Therefore, we conclude that full-bodied gold and silver coins should not have a fixed value stamped on them. They, however, should have stamped on them the weight of the pure metal in the coins.

Gold and Silver Coins are Commodities

Full-bodied gold and silver coins are commodities used in direct bartering. In direct bartering the exchange value of the items bartered is established at the time the transaction takes place. So the proper time to establish the exchange value of full bodied coins is at the time they are exchanged for other goods or for services or used as a payment.

From what we have said, we can see that foreign full-bodied gold and silver coins can serve as media of exchange just as well as the domestic gold and silver full-bodied coins.

In the United States, at the present time, there are many full bodied gold and silver U.S. and foreign coins. All that is necessary to bring them into circulation to serve as currency is for the U.S. Congress to announce that all U.S. and foreign full-bodied gold and silver coins will be received by the

U.S. government for all payments due the government at the market value of their metal content at the time they are offered as the payment.

The Congress should also announce that the government will pay out these same coins for its needed expenditures at the market value of the metal in the coins at the time the coins are paid out. This is the way the foreign gold and silver coins served as currency in the early days of our country.

This is the way they would have continued to serve as currency, if the U.S. government had not placed a fixed exchange value on the U.S. gold and silver coins and then later refused to receive and pay out foreign gold and silver coins.

There is another way to bring the U.S. and foreign gold and silver coins into circulation to serve as currency. That is, for one or more of the individual states to declare by law that it will receive U.S. and foreign gold and silver coins for all payments due the state at the market value of the metal in the coins at the time the coins are received as payment. And also that the state will pay out these same coins for its needed expenditures at the market value of the metal in the coins at the time the coins are paid out.

While we know that it is not necessary to use gold and silver coins as currency, we have to illustrate how they can be used successfully.

We have shown that if full-bodied gold and silver coins are to be successfully used as currency, a fixed exchange value cannot be placed on the coins. But that is not true for all other types or purchasing media.

All token coins, certificates, notes, and bills used as currency must have a fixed exchange value placed on them because they are documents. They give evidence. They give evidence of the value of the payment or article for which they will be received or redeemed. For example, the U.S. Congress has declared that all token coins are legal tender for the payment of all debts, public and private. The face value of the token coins is the amount of the payment for which the coin will be received by the government and others. The amount of the payment must be written on the coin.

The Federal Reserve notes also are documents. They also given evidence of the legal tender law passed by Congress. Part of the law is written on the notes.

Gold certificates, silver certificates, tax credit certificates, certificates in lieu of coins, and certificates of credit are all documents. They give specific evidence of the amount of the claim or the payment for which they will be received.

They are like postage stamps. Postage stamps give evidence of the amount of the payment that was made for postal services. That amount is printed on the face of the stamps.

So it is necessary that the token coins, notes, and certificates have their exchange value stamped or printed on them.

BOTANISTS AND NATURALISTS AT DEVIL'S LAKE STATE PARK, WISCONSIN

KENNETH I. LANGE
Devil's Lake State Park
Wisconsin Department of Natural Resources

A traveler north-bound on Interstate Highway 90-94 in south-central Wisconsin notices a range of hills high and massive against the skyline for some time before the Baraboo-Devil's Lake exit. This is the Baraboo Range, an anomalous outcrop of pre-Cambrian, metamorphic rock amid otherwise younger, sedimentary rock. Generally called the Baraboo Hills or Baraboo Bluffs, this outcrop, actually a syncline, consists of an elliptical ring of quartzite rock extending for a west-east distance of 25 miles and enclosing the canoe-shaped Baraboo valley, with a north-south distance averaging 5 miles. Devil's Lake and Devil's Lake State Park are located in the southern half of the quartzite ring, three miles south of Baraboo, in Sauk County. Greatest relief is attained at Devils's Lake, where three 500 foot bluffs with talus slopes (west, east and south) flank a spring-fed body of water approximately 360 acres in area (Fig. 1).

The Baraboo Range is rich in geologic history and features, and has been visited by geologists since 1848 and school classes since

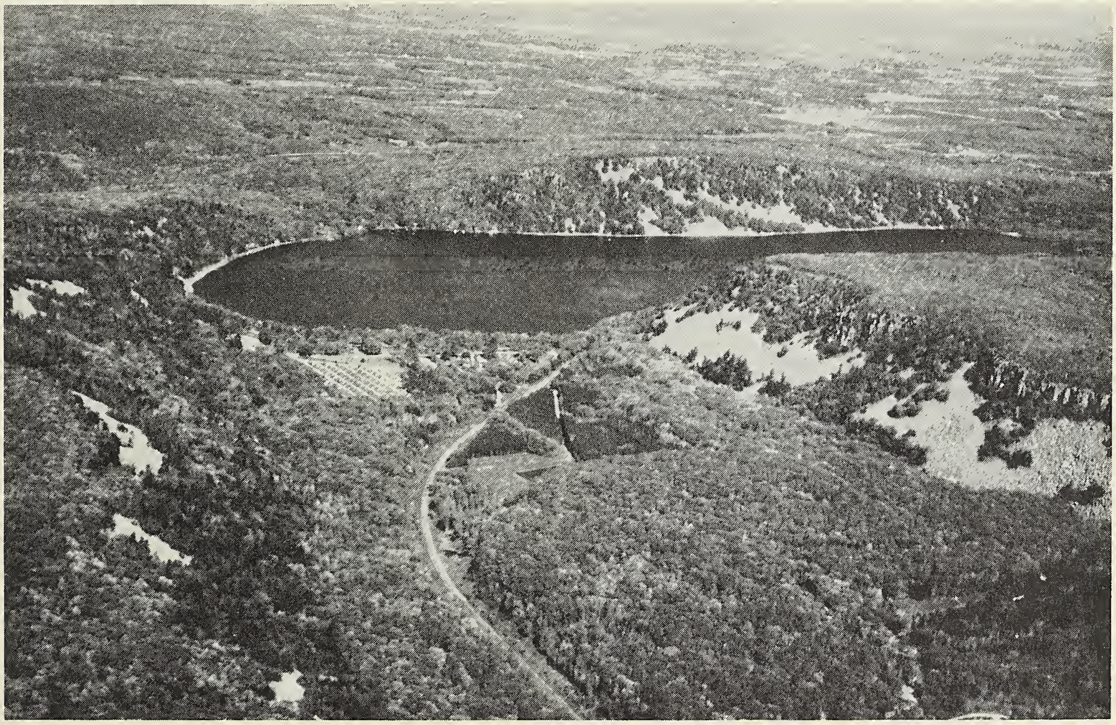

Fig. 1. Devil's Lake and the surrounding country as seen from an airplane. The west bluff is in the upper part of the picture, the east bluff is to your right, and the south bluff to your left. Notice the railroad track through the middle of the lower half of the picture, the talus slopes, and the prairie strip along the upper edge of the south end of the east bluff.

the late 1800s. Black (1968) and Dalziel and Dott (1970) detail the geology of the area, and Lange and Tuttle (1975) and Lange and Berndt (1980) discuss park history, including educational use.

The land cover in 7400 acre Devil's Lake State Park is primarily red oak woods with red maple understory, but because of the relief and varying exposure it also includes sugar maple woods, stands of yellow birch, white pine groves, boreal fern gardens on north-facing talus slopes, thickets of red elder and mountain maple and pockets of northern herbaceous plants at the bases of the bluffs (such as in the linear depression at the base of the east bluff called "Alaskan Grotto"), marshy areas, and dry prairie relicts on top of the bluffs. Mossman and Lange (1982) discuss pre- and post-settlement vegetation of the Baraboo Hills, including Devil's Lake State Park.

With such a varied land cover, one would expect a rich flora. The vascular plant list for the park now stands at 798 species, approximately 40% of the total vascular flora of Wisconsin. An addition 233 species occur in the Baraboo Hills only outside of the park (Lange, unpublished ms; *Crataegus* spp. are not distinguished).

Fig. 2. Wisconsin's pioneering naturalist, Increase Allen Lapham. From the collections of the State Historical Society of Wisconsin.

Devil's Lake has consequently been a magnet for botanists and naturalists, as well as geologists. In the early years they came by wagon, then, beginning in 1873 when the main passenger line of the Chicago and Northwestern was completed, also by train.

Wisconsin's pioneering naturalist, Increase Allen Lapham (1811-75), seems to have been the first botanist to have explored Devil's Lake, doing so in 1849 with several companions: "A large body of broken fragments have accumulated along the edge of the water rendering it very difficult to walk along shore: yet two of our party made a circuit of the lake, jumping from rock to rock as best they could" (Lapham, 1849). On Lapham's 1850 map of Wisconsin, Devil's Lake is called "Lake of the Hills," a local name he heard on the 1849 trip.

Lapham (Fig. 2) was the true naturalist: he had to explore and understand. As a youngster in Palmyra, New York, he was once sent to fetch the family cow: in his diary, he recorded a variety of natural happenings, but "didn't find the cow" (Milwaukee *Free Press,* 8 March 1911). As an adult he apologized to a brother for not writing sooner: ". . . my head has been so full of topography, geography, etc., etc., that it would not contain the material for a letter besides" (Milwaukee *Sentinel,* 16 October 1895, Part 2, page 12). In the last entry in his notebook, dated the day before he died, Lapham referred to a plant that he had never found before (Hawks, 1960, p. 277).

When asked his speciality, Lapham replied, "I am studying Wisconsin" (Sherman, 1876, p. 51). Lapham was a generalist, not a specialist, yet despite his diversity of interests and lack of formal education, he associated scientifically with his contemporaries in a variety of fields and was accorded universal respect by his peers

(Hawks, 1960, p. 279; Sherman, 1876, pp. 50-51). To Asa Gray of Harvard, for example, Lapham was thoroughly reliable, a "modest, retiring, industrious, excellent man" (Sherman, 1876, p. 21). Lapham and Gray met several times, for example in 1847 when Lapham traveled east where in Boston he had supper at Gray's with John Carey and William Oakes, and "didn't we four great Bostonians have fine times" (Hawks, 1960, p. 136).

Lapham wrote at one time or another to literally dozens of botanists, American and foreign, some of whom are now unknown, although others continue to be familiar names. He also had a national reputation as a "good exchanger," that is, someone who exchanged plant specimens generously and promptly (Hawks, 1960, pp. 149-150, 155).

Speaking as a botanist, Lapham preferred "spring and summer all year." By 1841 he had a "very handsome collection of dried plants, numbering something over 2,000 species," and was adding to it by exchanges (Milwaukee *Sentinel, loc. cit.*). Asa Gray by 1840, for example, had received plants from a total of 78 Americans of whom Lapham was his only contributor from Wisconsin Territory (Dupree, 1959, p. 96). These were the years when John Torrey and Gray were working on their *Flora of North America* (now in its 8th edition as *Gray's Manual of Botany*). Lapham sent plant specimens to Torrey and procured subscriptions for the *Flora* (Rodgers, 1965, p. 125).

In 1849 Lapham offered the University of Wisconsin his collection of plants if the University would preserve them properly, but he was refused (Noland, 1950, p. 83). Lapham also corresponded with the Wisconsin Natural History Association about his scientific collections, but here too the negotiations collapsed (Schorger, 1947, p. 174). The year after he died, Lapham's extensive scientific collections, including a 24,000 specimen herbarium of approximately 8000 species, was purchased for $10,000 by the State for the University (Arthur, 1881, p. 52; Bryan, 1950, p. 13). Lapham's plant collection was the beginning of today's University of Wisconsin Herbarium, as the other University botanical collections of the time were consumed by the 1884 Science Hall fire (Davis, 1925). Recently a series of lichens collected by Lapham has emerged from the past, but this has a different history (Thomson, 1973).

Sixteen years after his death, Lapham received special recognition as the most distinguished past citizen of the State of Wisconsin in a contest judged by the State Agricultural Society (Winchell, 1894, p. 1), a fitting epitaph to a remarkable individual.

Another exceptional naturalist, Thure Ludwig Theodore Kumlien (1819-88), was the first person to actually collect plants at Devil's Lake, insofar as extant herbarium specimens attest. The Milwaukee Public Museum has Kumlien specimens collected at Devil's Lake in 1860, and he very likely was here at other times also. "Camping trips" by Kumlien to Devil's Lake (for "preglacier flowers") are mentioned in her biography of her grandfather by Main (1944, pp. 333-334).

Kumlien, the oldest of fourteen children, was born in Sweden. Young Thure showed an early interest in natural history and was entrusted to a private tutor, later graduating from the University of Upsala where he studied under the renowned botanist, Elias Fries. Coming to America in 1843, he settled near Lake Koshkonong in southeastern Wisconsin because he had concluded from studying maps that this region would be rich ornithologically.

Kumlien hoped to make a living by selling natural history specimens to museums, American and foreign, and he wanted to travel (Kumlien, 1859). He did collect intensively around Lake Koshkonong and on a few trips but his income from these endeavors typically was meagre, so despite a background ill-prepared for farming he continued to work his land, albeit in a desultory way.

Like Lapham, he was the complete naturalist, being familiar with the fauna of his chosen homeland and its plant life, vascular and non-vascular. Kumlien authored only one paper under his name, a two-page note on the disappearance of wildflowers in the Lake Koshkonong area (Kumlien, 1876). Owing to his diffidence, he was well known to very few scientists, although they typically had heard of him and Lake Koshkonong.

In the latter years of his life, Kumlien taught at the nearby Albion Academy, collected birds for several schools, and was taxidermist and conservator at the Milwaukee Public Museum when he died (Greene, 1888; Lawson, 1921; Schorger, 1946).

A visit to the site of the original Kumlien homestead, a log cabin, reveals lilac bushes, several kinds of planted trees, a ground cover of periwinkle and lily of the valley, and a depression where the building stood. The Kumliens moved from the cabin into a frame house in 1874. Among her grandfather's papers in a trunk in the cabin, Main (1944, p. 337) found some lines written in pencil on an envelope by Kumlien after his wife had died: "We now have fine weather again and when I have time to spare I spend it in the old house . . . It reminds me . . . of old times and as much as says to me, 'Look at me now, we are old friends though of late you seem to not have cared so much about me as you used to. But I tell you that there is a great deal of similarity between us two. We both belong to the past, our present isn't much and our future prospects still less, my timbers are partly gone up, so are yours—age is upon me—so with you. With a little tender care I may last and be good for something yet a little while—so may you. I wasn't cut out for pretensions and show in the world, nor were you. Circumstances put me in a kind of out of the way place not very conspicuous to the public, yet many are they who have visited me. So with you. At the same moment we both lost our best friend, one who did more for us both than anyone else ever did. I have after all, been a comfort to some—perhaps you have too. I have served the purpose for which I was made. Have you?'"

One of Kumlien's children, Aaron Ludwig (1853-1902), was also a well rounded naturalist (Schorger, 1945). He taught in southern Wisconsin at Albion Academy and Milton College where one of his students was Arlow Burdette Stout (1876-1957). Stout was born in Ohio and grew up on a farm near the Kumliens, where he spent countless hours afield and attended a one-room country school. In 1903 he rescued a number of Thure Kumlien plants, including a Devil's Lake sedge (*Carex leptalea*), which had been left in the garret of the old log cabin. These undated specimens, apparently 37 in all, are now at the University of Wisconsin (University Herbarium, Collectors' Files).

Stout graduated from the State Normal School at Whitewater, then taught science at Baraboo High School from 1903-07, spending weekends and parts of his vacations in field work, mainly in the Baraboo area. The University of Wisconsin has specimens, mostly pondweeds (*Potamogeton* spp.), collected by Stout at Devil's Lake in 1904, 1905, and 1906.

Stout's early interests included ornithology and archeology. As a young man, Stout mounted birds and collected bird skins and eggs, and in the summer of 1904 invited a Baraboo High School student, Alexander Wetmore, to spend several weeks with him at Lake Koshkonong. Soon after this, Wetmore left Wisconsin to eventually become Secretary of the Smithsonian Institution and an internationally known ornithologist. Stout's archeological field work in the Baraboo area resulted in a 60-page paper on the archeology of eastern Sauk County which appeared in the *Wisconsin Archeologist*.

Stout was an instructor in botany at the University of Wisconsin when he accepted the position of Director of Laboratories at the New York Botanical Garden in 1911, a position he held until his retirement in 1947. He is best known for his studies on the sterility and fertility of seed plants, especially the day lily (Robbins, 1958; Stout, 1939).

In 1882 "Miss Remington" collected the only known specimen of twin-flower (*Linnaea borealis*) from the Baraboo Hills; the locality is "Baraboo." The locality has intrigued me more than the identity of "Miss Remington" (the collector might have been May Belle or Maud Estelle Remington, graduates of the University of Wisconsin in 1881—Sauk County *Democrat,* 25 June 1881). Science classes from Baraboo High School have been coming to Devil's Lake for field trips since the 1800s, for example the botany class to Pine Hollow (Pine Glen Scientific Area) in 1898 (Baraboo *Republic,* 11 May 1898). Possibly the plant was found in this locality, a steep, wooded gorge in the park, but deliberate search by the author for twin-flower in Pine Hollow has been unsuccessful.

Devil's Lake was becoming a popular place to search for plants by the late 1800s and early 1900s. C. H. Sylvester did so in 1886, collecting both on the bluffs and in the lake, and William Finger was here in 1903; the herbaria of Sylvester and Finger are at the Milwaukee Public Museum. Will Sayer Moffat (born in 1847) was an M.D. and active student of the flora of the Chicago region for many years; he collected at Devil's Lake in 1895 (specimens at the University of Wisconsin).

Levi M. Umbach (1853-1918), a science instructor at North-western College (now North Central College) in Naperville, Illinois,

Fig. 3. An "excursion" of University of Wisconsin students on the west bluff overlooking Devil's Lake in the 1890s, Lellen Sterling Cheney (marked with an x) the instructor. From the University of Wisconsin Herbarium, Collectors' Files.

was an avid plant collector who compiled a herbarium of some 45,000 plants. The Umbach Herbarium was purchased by the University of Wisconsin in 1927 (Williams, 1929, p. 1). Umbach visited Devil's Lake every year from 1895 through 1900 and among his Devil's Lake specimens are the only collection of a dryland sedge (*Bulbostylis capillaris*) and the first collection of an uncommon gerardia (*Agalinis gattingeri*). H. S. Pepoon's *Flora of the Chicago Region* is dedicated to Umbach, "best of friends and most enthusiastic of plant collectors."

Several University of Wisconsin faculty members visited Devil's Lake around the turn of the century, specifically, Lellen Sterling Cheney (1858-1938), Rodney Howard True (1866-1940), and Edward Kremers (1865-1941).

Cheney was the pioneer of systematic botany in Wisconsin. He was in charge of the University Herbarium from 1891-1903 and undertook botanical surveys of the Lake Superior shore and the Upper Wisconsin River valley. Transportation was by canoe or some other type of boat in a Wisconsin more primeval than any of us can ever know. Mosses were his main interest; in fact, he was preparing a catalogue of Wisconsin mosses at the time of his death (Cheney, 1938; Conklin, 1941, p. 6), but he also added many vascular plants to the University Herbarium. His vascular plant collections from Devil's Lake (1891-1900) include such species as rock fern (*Polypodium vulgare*), twisted-stalk (*Streptopus roseus*), mountain maple (*Acer spicatum*), red elder (*Sambucus racemosa* subsp. *pubens*), and bladdernut (*Staphylea trifolia*). Cheney taught a number of courses and in at least one of them "excursions" (Fig. 3) were offered (Anon., 1900, pp. 125-126).

True was from Baraboo, a son of John M. True who at one time was a state senator (Baraboo *Republic,* 28 July 1892; Baraboo *Weekly News,* 22 April 1926). He and Cheney often took field trips together, e.g. to Wisconsin Dells (Lange, 1981, 1982) and Devil's Lake (Fig. 4). True's collections from Devil's Lake (1889-93) include green dragon (*Arisaema dracontium*), a wetland arum that no longer can be found here; the scarce Hooker's orchid (*Platanthera hookeri*); and a southern bush-clover (*Lespedeza virginica*), known in Wisconsin only from a few localities in the Baraboo Hills and a rhyolite outcrop approximately 30 miles northeast of Baraboo. True concluded his

Fig. 4. Lellen Sterling Cheney (left) and Rodney Howard True (right) at Devil's Lake, with part of a plant press between them. A handwritten note on the back of the original picture reads: "Devil's Lake May 13. 1897 Annual Long Excursion with Pharmacy classes." This picture and Fig. 3 were a 1966 gift to the University of Wisconsin Department of Botany by Monona L. Cheney, a daughter of L. S. Cheney. From the University of Wisconsin Herbarium, Collectors' Files.

academic career at the University of Pennsylvania where he was instrumental in initiating an updated state flora (Fogg, 1982, p. 20).

Kremers was in the Pharmaceutical Department of the University and his herbarium of economic plants included some from Devil's Lake. In 1892 he expanded the 2-year course in pharmacy to 4 in pharmaceutical chemistry, the first of its kind in the United States ([Smith] 1941; Urdang, 1945).

John Ronald Heddle, a Nebraskan, is the next botanist to appear on the Devil's Lake scene. He received his Bachelor's degree in botany from the University of Wisconsin in 1910, and both the University and the Milwaukee Public Museum have Heddle specimens from Devil's Lake (1907-17), including a quillwort (*Isoetes macrospora*) and several species of Juneberries (*Amelanchier*). Heddle in more recent years was living in Racine, Wisconsin, where apparently he died in the 1970's (Mary C. Bell, Valley County Genealogical Society, Ord, Nebraska, *in litt.*).

At the time that Heddle was collecting at Devil's Lake, a committee of local citizens was agitating for a Devil's Lake State Park. On a spring day in 1907, for example, state legislators and guests had a picnic and luncheon at the lake: they listened to speeches, heard the Baraboo Marine Band, and many of them climbed the bluffs where residents pointed out choice views and rare plants (*Baraboo Weekly News,* 8 May 1907). The park was established in 1911.

In the same year that the park was becoming reality, a man was retiring as a medical doctor at age 59 and embarking on a new career—Curator of the University of Wisconsin Herbarium, a position he would hold until his death. This was John Jefferson Davis (1852-1937), who had already been collecting plants as a young man (Wadmond, 1956, p. 77). His first botanical interest was in collecting and naming seed plants he observed on his medical travels in the country, but his training as a physician led to curiosity about diseases and finally to the fungi producing the diseases (Jones, 1972). Davis (Fig. 5) brought his plant collection with him to Madison and supervised the herbarium's growth for the next quarter-century, during which time he became acknowledged as an authority on parasitic fungi. The University of Wisconsin has vascular plants, e.g. squawroot (*Conopholis americana*), collected by Davis at Devil's Lake from 1913-29.

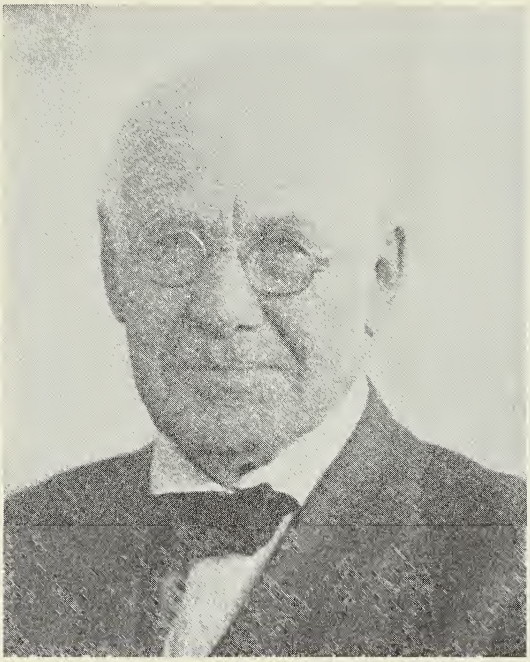

Fig. 5. John Jefferson Davis, Curator of the University of Wisconsin Herbarium, 1911-37. From the U.W. Herbarium.

Rollin Henry Denniston (1874-1957) was another University of Wisconsin figure who collected in the park, e.g. arrow-leaved violet (*Viola lanceolata*) in 1930. Denniston was an instructor in pharmaceutical botany and botany.

Albert M. Fuller (1899-1981) of the Milwaukee Public Museum was at Devil's Lake State Park on 28 July 1930, looking for ladies'-tresses orchids (*Spiranthes*), "but saw no plants" (Fuller, 1930). In the following January he was writing Norman

Fig. 6. Norman Carter Fassett, Curator of the University of Wisconsin Herbarium, 1937-54. From Taxon 4:51, 1955.

Carter Fassett at the University of Wisconsin for the ladies'-tresses orchid that "Umbach collected at Devil's Lake, Wisconsin August 23, 1900" (Fuller, 1931). Fuller's *Orchids of Wisconsin,* a Milwaukee Public Museum bulletin, was published in 1933.

Fuller joined the Milwaukee Public Museum staff in 1923, following his graduation from the University of Wisconsin, and was the Museum's Curator of Botany from 1933 until his retirement in 1964. Some of his field work on orchids was done in the Baileys Harbor area of Door County, Wisconsin, and he was much involved in the establishment of the Ridges Sanctuary there (Traven, 1981). His concern for the preservation of natural areas is evidenced by the nine years he served as Chairman of the Scientific Areas Preservation Council of Wisconsin.

Emil P. Kruschke (1907-76) was another Milwaukee Public Museum figure of these years. He was Assistant Curator of Botany from 1938-64, and Curator from 1964-74 when he retired. Kruschke specialized in the taxonomy of hawthorns (*Crataegus*), and advised poison control centers, the city health department and the police on poisonous plants. Like Fuller, he served on the Scientific Areas Preservation Council of Wisconsin (Pease, 1974; Anon., 1976). In 1933 he was at Devil's Lake State Park where he collected such plants as pale corydalis (*Corydalis sempervirens*).

As a result of correspondence in 1934 between Fuller and N. C. Fassett (Fuller, 1934), Richard W. Pohl, now Distinguished Professor and Curator of the Herbarium at Iowa State University, decided to work on the angiosperm order, Rhamnales. He attended Marquette University from 1935-39, when he was also a volunteer at the Milwaukee Public Museum. Pohl, a grass specialist, first learned to identify grasses when he worked one summer as a Civilian Conservation Corps enrollee at Interstate State Park in northwestern Wisconsin and made a few field trips to Devil's Lake State Park (Pohl, *in litt.*). The Milwaukee Public Museum has a panic-grass (*Dichanthelium xanthophysum*) collected by Pohl at Devil's Lake State Park in 1937.

Norman Carter Fassett (1900-54) followed Davis as Curator of the University of Wisconsin Herbarium. Fassett (Fig. 6) was born in Massachusetts and attended Harvard University where he studied estuarine plants for his Ph.D. under Merritt Lyndon Fernald (Peattie, 1954). Aquatic plants became an abiding interest, as he surveyed aquatic vegetation first in Wisconsin and later in Central America, and wrote *A Manual of Aquatic Plants.* His other books are *Spring Flora of Wisconsin, Leguminous Plants of Wisconsin, Grasses of Wisconsin, Ferns and Fern Allies of Wisconsin* (one of four authors) and *Hayfever Plants of the Middlewest* (one of three authors); his bibliography (Bruch and Iltis, 1966) also includes approximately 100 papers. Fassett became a leader of taxonomic thought in North America and at the time of his death was President of the

American Association of Plant Taxonomists, an organization of which he was a founder (Thomson, 1955).

Fassett was also a major figure in the conservation movement in Wisconsin (Anderson and Tryon, 1955). He sparked field botany and ecological work at the University, was active in the establishment of the Arboretum, served as the first chairman of the committee for preserving natural areas, and very likely introduced many botanical ideas to Aldo Leopold (Bean, *et. al.,* 1954; Thomson, 1955).

Fassett came to Wisconsin in 1925 as an instructor in botany. Within a year he was adding specimens to the University Herbarium from a number of places, including Devil's Lake State Park, e.g. a sedge (*Carex artitecta*) new to the park and still known in Wisconsin only from here, and Selkirk's violet (*Viola selkirkii*). The following year (1927) he found another northern violet (*Viola septentrionalis*) in the park. Fassett personally collected some 28,000 specimens for the University Herbarium, which grew several-fold during his years at Wisconsin.

Under Fassett's guidance, James Hall Zimmerman (Fig. 7) in the summer of 1946 conducted a botanical survey of the park, which included mapping vegetation, locating rare species, and recommending sensitive areas (Zimmerman, 1947). Zimmerman received a small stipend from the Wisconsin Department of Natural Resources for this project. He reported the first park records for a number of species, including a quillwort (*Isoetes echinospora*), a sedge (*Carex prasina*), two grasses (*Aristida dichotoma,* known in Wisconsin only from the park where apparently it is disjunct from central Illinois, and *Poa nemoralis*), and certain dicots; he also collected here in succeeding years. His compilation of ferns and seed plants (Zimmerman, 1962) has been the foundation of the park's current vascular species list.

Zimmerman has many fond memories of that summer. He rode the train back and forth from Madison, his home, staying in an upstairs room above the park's garage. On his first day the park superintendent drove him to the top of the east bluff and Zimmerman then proceeded to follow Fassett's advice—collect everything you don't know and also everything you think you know. By the time he staggered back with a stuffed vasculum and put the plants in a press, it was early the next morning. Thirty-five years later, Zimmerman (*in litt.*) recalled that sunny June day: "I remember seeing the Peregrine Falcons stoop from their eyrie, how the bluff looked, and many of the plants . . ."

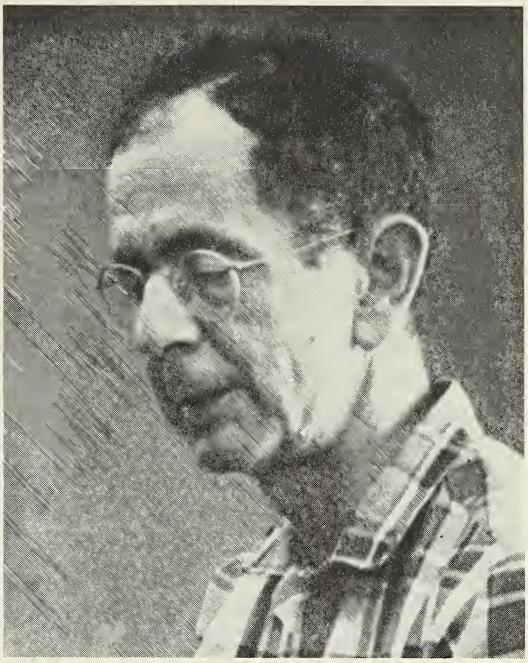

Fig. 7. James Hall Zimmerman, naturalist and consulting ecologist. Photo courtesy of J. H. Zimmerman.

Zimmerman is an instructor in the University of Wisconsin's Department of Landscape Architecture and a consulting ecologist. His current projects include sedges (*Carex*) of Wisconsin and an ecology book.

For more than half a century up to 100 or more University of Wisconsin students came to Devil's Lake State Park for a one-day field trip in the spring as a review for the final exam in the second semester botany course. At first they came by train, but later by bus. The tradition was started by George Smith Bryan (1879-1958) of Charleston, South Carolina, who taught the course until his retirement in 1949, and was continued by Herbert M. Clarke (1909-81) of Indiana until his retirement in 1974.

Bryan, with his duck hunter's cap, was a colorful story teller with a southern accent. Former students now in their senior years continue to recall him with fondness, and this is also true of Clarke who always tried to reach each student. These leaders strove to make the field trip a true sharing experience. The class broke into groups at the park. Both faculty and teaching assistants guided in earlier years when the group was larger, but in later years with smaller groups only Clarke and one or two assistants guided. They started at the south end of the lake, along the railroad tracks, and headed for Koshawago Springs near the southwestern corner of the lake. Here they always stopped for coffee. For lunch each student brought something to share, rather than an individual meal. The instructor, Bryan or Clarke, fried small pig sausages and bacon in a 12-inch skillet. After lunch they sometimes climbed a bluff. Since the course was a survey of all plants, the students were shown examples of all major plant groups; by the springs, for example, they looked for red algae (Clarke, pers. comm.).

Botanists and other scientists continue to visit the park. Thomas G. Hartley, now in Australia with the Division of Plant Industry in Canberra, studied the flora of the driftless area for his Ph.D thesis (Hartley, 1962, 1966) and his collecting stations included Devil's Lake State Park (Hartley, 1962, pp. 126, 127). Robert C. Koeppen, now with the U.S. Forest Service in Washington, D.C., collected in the park for his report on the mints of Wisconsin. William E. Tans, then with the Wisconsin Department of Natural Resources' Scientific Areas Preservation Council, added a plant to the park's list when in 1968 he discovered the three birds orchid (*Triphora trianthophora*). Michael Nee and Robert K. Peet in 1969 found ebony spleenwort (*Asplenium platyneuron*), a new species for the park; Nee is a Botany Curator at the New York Botanical Garden, and Peet is in the Department of Botany at the University of North Carolina at Chapel Hill. Theodore S. Cochrane, a Curator at the University of Wisconsin Herbarium, collected marsh plants along the lake shore in 1975 with J. H. Zimmerman on a sedge class field trip. William S. Alverson, then with the Scientific Areas Preservation Council, made a 1981 collection of the sedge (*Carex artitecta*) known in Wisconsin only from the park. Sylvia A. Edlund studied the ecology of pale corydalis in the park (Edlund, 1970), and F. Christopher Baker surveyed littoral macrophytes in the lake (Baker, 1975). Hans Ris, a geneticist in the University of Wisconsin Zoology Department specializing in chromosomal studies, collected quillworts in Devil's Lake. W. Carl Taylor, a pteridologist at the Milwaukee Public Museum, has also collected quillworts in the lake and in 1978, with Neil T. Luebke, Assistant Curator of Vascular Plants at the Museum, found Christmas fern (*Polystichum acrostichoides*), a first record for the park. In recent years still other botanists, e.g. Philip B. Whitford and Forest Stearns of the University of Wisconsin- Milwaukee, have led field trips for school classes in the park.

Four scientific areas have been designated in the park. One of these, the Red Oak Scientific Area, was recommended by Wisconsin's pioneering ecologist, John T. Curtis (1913-61). Gary Birch, then with the Scientific Areas Preservation Council, compiled a quantitative data sheet of this scientific area in 1976, using the point quarter method of Grant Cottam and Curtis.

Another scientific area in the park is Parfrey's Glen, a narrow, rocky gorge four miles east of Devil's Lake. Its beauty and unusual plants have long attracted botanists. Among them, as determined by vascular plant collections in the University of Wisconsin Herbarium, have been Samuel Christensen (S.C.) Wadmond of Racine, Wisconsin; Edgar T. Wherry (1885-1982) and Arthur N. Leeds (1870-1939) for the Academy of Natural Sciences of Philadelphia; Douglas W. Dunlop, now Prof. Emeritus of U.W.-Milwaukee and one of the authors of *Ferns and Fern Allies of Wisconsin*; Frederick J. Hermann, now in Fort Collins, Colorado, a moss specialist; Henry C. Greene (1904-67), who succeeded Davis as the University of Wisconsin's authority on parasitic fungi; John W. Thomson, of the University of Wisconsin-Madison Department of Botany, a lichen specialist; Hugh H. Iltis, Curator of the University of Wisconsin Herbarium since Fassett's death; Donald Ugent, Curator of the Southern Illinois University Herbarium; and Marsha Waterway, who studied clubmosses (*Lycopodium*).

The most extensive survey of the cryptogams of the park has been the study of the boulder fields of the Devil's Lake bluffs by Patricia Armstrong (1968); she found 35 species of mosses and 43 species of lichens, including a new state record, the boreal lichen, *Parmelia substygia* (Armstrong, 1970). Armstrong is an educator at the Morton Arboretum in Lisle, Illinois. Irving Halsey Black (1941) compared the mosses and liverworts on sandstone and quartzite in the Baraboo Hills, including Devil's Lake State Park; bryophytes in the park have also been investigated in recent years by Richard I. Evans, Frank D. Bowers, James A. McCleary, and (lichens also) Marietta S. Cole.

The author of this paper has been the park naturalist at Devils Lake since 1966, and has recommended scientific areas, initiated prairie restoration projects, compiled vascular plant lists for a number of park areas, added a number of species to the park's vascular plant list, including such uncommon natives as bush-clover (*Lespedeza violacea*) and purple milkweed (*Asclepias purpurascens*), and rediscovered others, notably maidenhair-spleenwort (*Asplenium trichomanes*) in 1978, which Fassett had first found in the park in 1926. An herbarium of vascular plants, mostly from the park and the Baraboo Hills, is located in the Nature Center.

Acknowledgments

Many thanks to the curatorial staffs at the herbaria of the University of Wisconsin-Madison, especially Theodore S. Cochrane, and the Milwaukee Public Museum, especially Neil T. Luebke, for all their patience with my many inquiries. James H. Zimmerman kindly shared his memories of his field work in the park, and Herbert M. Clarke, on a pleasant afternoon shortly before his death, shared his reminiscences of the botany field trips in the park. Michael J. Mossman, John W. Thomson, and Glenn Sonnedecker referred me to sources that I would otherwise have missed.

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HISTORY OF THE UNIVERSITY OF WISCONSIN ARBORETUM PRAIRIES

Thomas J. Blewett *and* Grant Cottam
Department of Botany
University of Wisconsin—Madison

The University of Wisconsin Arboretum was started with a grand and almost impossible idea—to recreate in 1200 acres the vegetation of an area extending beyond Wisconsin's borders. It was not to be merely a collection of trees and flowers in formal beds and with carefully manicured lawns. It was to be a collection of biotic communities. Aldo Leopold first gave voice to this idea at the dedication ceremonies for the Arboretum in 1934. He said the Arboretum should be a "sample of what Dane county looked like when our ancestors arrived here." (Sachse, 1965). That basic idea was subsequently enlarged to include the vegetation of the entire state, and later to include such exotic communities as Ohio valley hardwoods, and a Rocky Mountain forest complex. The initiators of this plan were undoubtedly unaware of the magnitude of the task they had set for themselves. A biotic community is an exceedingly complex thing, with thousands of different kinds of plants and animals, most of them too small to see with the naked eye but all of them influencing each other in some way. At the time of the beginning of the Arboretum, ecology at Wisconsin was in its infancy, and the knowledge of the complex communities that were to be created was grossly inadequate. Nevertheless, the basic philosophy stated by Leopold in 1934 continues today as the guiding principle on which the development of the Arboretum is based.

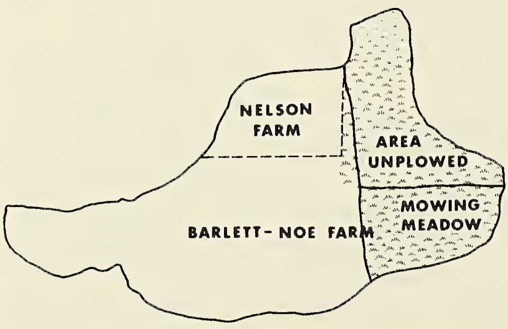

Fig. 1. Land ownership at the time of acquisition in 1932 (Curtis 1951).

Curtis Prairie

According to the original Government Land Survey records of 1835, the presettlement landscape of the Arboretum was dominated by oak openings and marsh. Large bur and white oaks were scattered over the uplands at a density of 15 to 20 trees per acre, and the ground cover was prairie grasses, prairie forbs, some shrubs and scattered oak brush or "grubs" which were mostly black oaks (Curtis 1951).

The area was first settled in 1836 and by 1860 the land had passed through eleven owners. The Bartlett family farmed the land from 1863 until about 1920 when cultivation was abandoned. Apparently, the land was regularly plowed and planted with corn, oats and pasture in rotation. This cropping seems to have been restricted largely to the western two-thirds (i.e. west of the dividing fire lane) of Curtis Prairie, while the wetter eastern third was probably not plowed. The northern half of the unplowed section, was undisturbed (or perhaps lightly grazed in dry years), while the southern half was a mowing meadow (Figure 1) (Curtis 1951).

After remaining fallow for about six years the land was leased in 1926 or 1927 to a veterinarian named West, who pastured 35 to 40 horses on the present Curtis Prairie, including the previously "undisturbed" area and the mowing meadow, until 1932. The Bartlett farm was part of the Bartlett-Noe estate purchased by the University of Wisconsin regents for an Arboretum in 1933. A small part of the Curtis Prairie was acquired in 1932 as part of the Nelson farm (Figure 1). At the time of purchase the fields were dominated by quackgrass (*Agropyron repens*), which gave way to bluegrass species (*Poa pratensis* and *P. compressa*) within a few years.

The Prairie Experiment

The restoration of the prairies benefited greatly from the presence at the Arboretum of a Civilian Conservation Corps (CCC) camp. This camp of about 200 young men was active from 1934 to 1941 and was responsible for many of the physical structures on the arboretum and most of the early plantings. The camp was run by the army, but planning and direction of the work was the responsibility of the National Park Service, and during this period the Arboretum was officially designated a park. The Park Service hired Dr. Theodore Sperry to direct the prairie plantings. Sperry worked under the technical direction of Aldo Leopold and William Longenecker. The availability of a large labor force and trucks and other machinery enabled the prairie restoration work to be accomplished much more rapidly than would have otherwise been possible. Indeed, the methods used would have been impossible without this assistance of the CCC.

Norman Fassett is credited with being the first to have the idea for creating a prairie in the Arboretum (Thomson and Cottam 1978). In 1935 Fassett assigned two students, John Thomson and Roger Reeve, to study through a series of experiments the feasibility of prairie re-establishment on old pasture in the Arboretum.

When Fassett and Thomson began their experimental work (Reeve was apparently less involved), little was known about planting procedures for developing a characteristic complement of prairie plants in old field or meadows. The experiments were conducted mostly in upland plots near the present Leopold pines though a few plots were located in the lowlands of the prairie. At the time the experiment was initiated, the upland plots were in old pasture dominated by bluegrass, quackgrass, mullein and thistle while the lowland plots had been in corn.

The soil was prepared in three ways: 1) the ground surface was scalped (everything was removed), 2) the soil was plowed, or 3) the bluegrass sod was burned. Superimposed on the three types of soil preparation were three types of planting methods: 1) the introduction of prairie sods, 2) planting of seed, and 3) placement of prairie hay collected from area remnant prairies. In addition some small shrubs were transplanted (Thomson 1937, Thomson and Cottam 1978).

Planting materials were collected in the fall of 1935. Hay and sods were collected in a low prairie near Mazomanie, on a dry hillslope and a wet meadow between Sauk City and Mazomanie, on a dry hillslope 4½ miles west of Middleton, on the sand plains near Arena and on the sand plains northwest of Spring Green. To acquire western prairie species Dr. Fassett assisted with the collection of shrubs and seeds on the bluffs of the Mississippi River at Hager, and additional seeds were collected on the Mississippi River terraces near Lake Pepin and north of Portage (Thomson 1937).

A series of experimental plots which were usually 30′ × 30′ were established in the fall of 1937. On these quadrats different combinations of soil preparation and plant introductions were tried. Thomson summarized the experimental methods of 1937 and by then it was apparent that the best survival of plantings was with the 1935-1936 sodding technique.

The first major effort at developing a prairie was made under the direction of Dr. Theodore Sperry. A total of 42 species were planted in large pure blocks (Figure 2) by the use of seeds, seedlings and sod transplants.

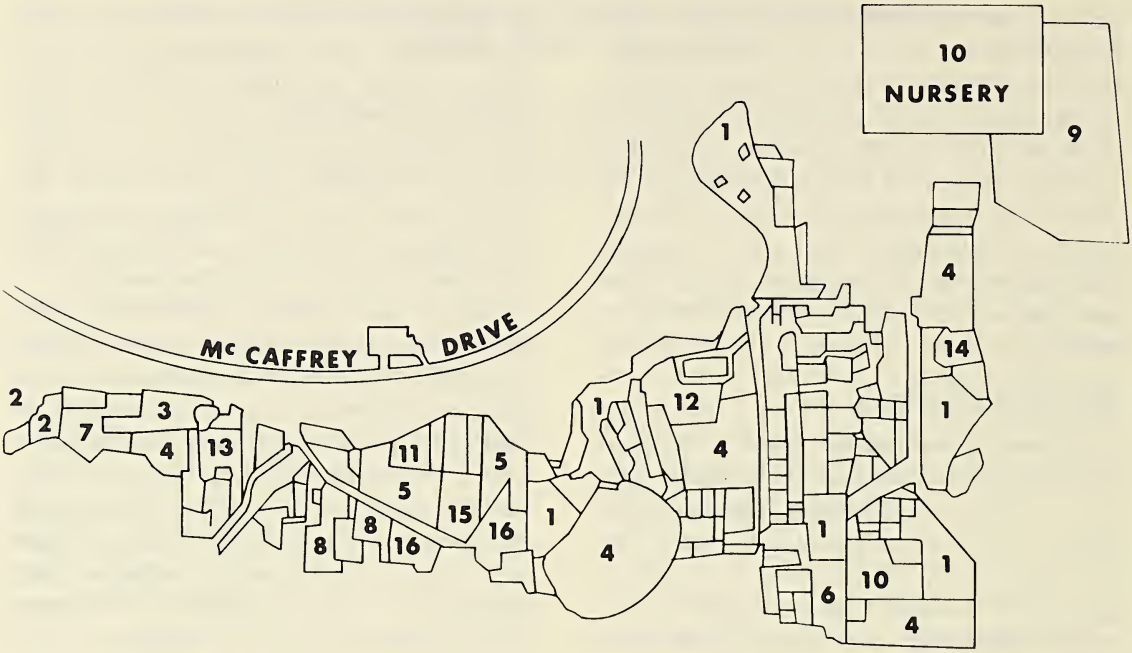

Fig. 2. Examples of Sperry's block planting of species (Arboretum file map).

1. Andropogon gerardi
2. Andropogon scoparius
3. Baptisia leucantha
4. control area
5. Koeleria cristata
6. Lepachys pinnata
7. Liatris scariosa
8. Liatris spicata
9. natural revegetation
10. nursery
11. Petalostemum purpureum
12. Solidago rigida
13. Sorghastrum nutans
14. Spartina pectinata
15. Stipa spartea
16. Tradescantia reflexa

The seeds and sods were collected from prairie remnants near the Wisconsin River (e.g. Thomson above) and seedlings were raised in nursery plots maintained within the area being restored to prairie. There is no precise estimate available of the number of plants involved in the Sperry plantings because Sperry's notes on the plantings (on file at the Arboretum) often indicate only the number of clumps, tons or truck loads. For example, over 40 tons of big bluestem (*Andropogon gerardi*) sods were transplated (Curtis 1951).

A large map detailing the planting locations of all 42 species between 1936 and 1940 was left by Sperry and is now on file in the Arboretum. In 1950 the Arboretum Botanist, David Archbald, ranked the success rate for each of the planting methods for all species (appended to Curtis 1951). The success was evaluated by plot without regard to the number of individuals planted in each plot. The success of each of the three planting methods (seeds, seedlings and sods) was very similar, but the sod technique appeared to have a slight edge. In Curtis' view the expense of the sod technique out-weighed its slight advantage over the other planting methods.

Under adversely dry conditions the sods may have the best advantage, but, as Curtis (1952) later noted, for large scale efforts such as the Arboretum projects "there is a need for inexpensive methods because of the large number of individuals" required to establish the prairie landscape. This led

Curtis to recommend broadcast seeding after spring burns as the most economical method for large scale efforts. This method, of course, is very much dependent on good weather and viable seed.

Additional planting experiments were initiated by Dr. John Catenhusen in 1942 on a 10′ × 30′ plot that was subdivided into three 10′ by 10′ blocks. These efforts consisted of direct seeding on desodded and untreated ground. In the first block only big bluestem and Indian grass (*Sorghastrum nutans*) were planted, in the second block the grasses were planted in mixture with forbs and in the third block only forbs were planted. Catenhusen left for military service and his plantings suffered the misfortunes of poor climatic conditions (McCabe 1980). Following Catenhusen, Robert McCabe was appointed Arboretum Biologist and he repeated the Catenhusen experiment on new soil adjacent to the original plot in the spring of 1943 (Figure 3). McCabe's plantings were successful and the pure grass block was eventually invaded by forbs resulting in a mixture that persists today. The mixed block did not change much except as new species entered by natural propagation. The forbs block, however, remained almost pure forbs for many years and is still identifiable today. The beneficial value of desodding was affirmed as part of the Robocker experiments (Curtis 1951, Robocker et al. 1953), but this method cannot be used without destroying already established vegetation such as the Sperry plantings.

Fig. 3. Locations of some experiments: 1—Fassett and Thomson, 2—Catenhusen and McCabe, 3—Curtis and Cottam, 4—Burn plots of the 1940's, and 5—Robocker (Curtis, 1951).

Supporting Research

During the 1940's a series of research projects was conducted to learn more about the planting requirements and ecology of prairie plants. During this time Dr. Henry Greene began his large scale prairie experiment in the Grady Tract (see Greene Prairie below). McCabe remained as the Arboretum Biologist for about two and one-half years and then left for a lecture appointment at the University, but from the beginning of his appointment at the Arboretum until about 1950 he continued to conduct experiments in the Arboretum. Another of his experiments tested different methods of soil preparation before planting a mixture of prairie grasses. The test included a control (no preparation), raking the soil, burning and raking, and burning only. The combination of burning and raking the soil gave the best results for the establishment of big bluestem and little bluestem. (*Andropogon gerardi, A. Scoparius*) and Indian grass. In another unpublished experiment McCabe tested the establishment success of wild indigo (*Baptisia leucantha*) using three different seed treatments. One set of seed was treated with sulfuric acid, a second set was collected while still green in the pod and the third set was "normal" seed from the dry pods. The green seed was found to give the best germination and establishment success. McCabe hypothesized that this was an adaptation to the green pods being eaten by large herbivores such as the bison and being passed through the digestive tract before the seeds had dried in the pod.

The most significant management experiment conducted in this period was the research on the effect of fire on competition between bluegrass and some prairie plants by Curtis and Partch (1948). From 1941 through 1946 under the direction of McCabe a strict burning schedule was established for burns in March, May and October on both an annual and biennial basis. The treatment areas included both planted and unplanted prairie in 25′ × 220′ plots with adjacent controls that were not burned. After six years the density of the blue grass sod was reduced to one-fifth its original condition and bare ground was greatly increased in the burn plots. Species that were able to increase in the burn plots include the prairie perennials of rattlesnake master (*Eryngium yuccifolium),* Big bluestem, Stiff goldenrod (*Solidago rigida*) and blazing star (*Liatris aspera*) and certain weedy forbs such as ragweed (*Ambrosia artemisiifolia*), heath aster (*Aster ericoides*) and daisy fleabane (*Erigeron annuus*). Wild indigo showed no response while purple cone-flower (*Echinacea purpurea*) which is a more southern species, out of its range in Madison, was set back by fire. In this experiment the bluegrass was perceived as out-competing prairie plants for water, light and space and its removal or limitation by fire was considered necessary to reduce competition and permit other species to advance.

Further research was done by Curtis and Partch (1950) on the factors affecting flower production in big bluestem. In this study it was found that the most important factor limiting flower production was the presence of a cover of old litter on the crowns. Effective removal of this cover could be obtained either by burning or by clipping and the result was a six-fold increase in flowering and a 60 percent increase in plant height. Additional evidence on the importance of fire was found in the comparison of the Sperry plantings with the Archbald plantings of the 1950's (see below). A decade after the Sperry plantings the original planting blocks were still clearly evident while a decade after the Archbald plantings the plots were no longer distinguishable. The only treatment difference between the two plantings was the use of fire after the Archbold plantings and not after the Sperry plantings (Wilson 1964).

Between 1937 and 1948, Green and Curtis (1950) conducted germination studies on 91 species of prairie plants using seed that had been collected from southern and western Wisconsin remnant prairies. In a group of 51 species where various stratifications (cold treatments) were tested, 73 percent appeared to benefit by some stratification treatment. In a group of 12 species, mostly having hard seed coats, 83 percent were benefited by scarification techniques. Sometimes year-to-year differences were similar in both stratified and non-stratified seeds indicating that physiological conditions may be an important factor in germination success from any one year's seed crop. In general it appears that prairie grasses and composites need cold treatment or overwintering for successful germination, and most Wisconsin prairie plants are absolutely dependent on stratification.

From 1947 to 1949 Curtis and Cottam (1950) studied clones of four species of *Helianthus* (sunflowers) in the Curtis Prairie (Figure 3). Two species, stiff sunflower (*H. laetiflorus* (= *H. rigidus*)) and naked stem sunflower (*H. occidentalis*), were observed to have probable antibiotic and autotoxic effects and most other species did poorly where grown next to them. They found a reduction of flowering and vigor of bluegrass and bergamot (*Monarda fistulosa*) as well as of *H. laetiflorus* itself in the center of the sunflower clone. They concluded that the antibiotic and autotoxic effects exhibited by stiff sunflower were due to chemical toxins derived from the underground plant parts. The toxin was produced in the spring of each year during the period of most rapid decomposition of old rhizomes, and did not persist until the next year.

The Robocker experiments (Robocker et al. 1953) were another contribution to the understanding of requirements for establishing prairie plants (Figure 3). They studied grass seedling emergence and growth in the greenhouse. Using seeds that had been dry stored, they found that the optimum planting time following harvesting was species specific. For example, little bluestem succeeded best the first year after harvest, big bluestem was more successful in the second season after harvest and Indian grass seedling production was equally successful over each of the three seasons of planting following harvest. In a field study of the effects of weed cover on establishment of prairie seedlings, they found 80 percent and 60 percent reductions in seedling density of big bluestem and switchgrass (*Panicum virgatum*), respectively, in unclipped plots compared to plots where competition was minimized by clipping.

Additional Plantings

After the first comprehensive burning of Curtis Prairie in 1950, the second major planting program was begun under David Archbald, then Arboretum Botanist. Most of the plantings were done between 1950 and 1955, but additional plantings were made through 1957. A total of 156 species were introduced into select portions of Curtis Prairie (Figure 4).

A number of methods were employed for plantings including seed casting after a burn, hand insertion of large seeds such as needle grass (*Stipa spartea*), discing with seed casting and cover crop, and importation of sods as had been done by Thomson and Sperry.

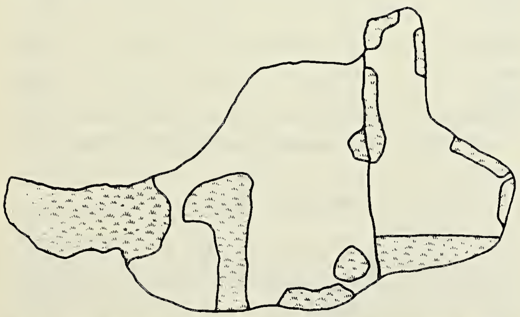

Fig. 4. Major planting areas of the Archbald years (1950-1957).

The use of stratified seed on disced ground under a cover crop gave best results (Wilson 1964). Wilson concluded that the present occurrence of species in the Curtis Prairie was due primarily to 1) the spread of existing plants following the initiation of periodic burning in 1950 and 2) the intensive planting program begun under Archbald in the 1950's.

The Contribution of John T. Curtis

Curtis became interested in the University of Wisconsin Arboretum shortly after his arrival as a graduate student in 1934, only two years after the initial property acquisitions for the Arboretum, and maintained his intense interest and concern for the development of a broad spectrum of Wisconsin and North American communities in the Arboretum until his death in 1961.

In 1937 J. T. Curtis was appointed as instructor in Botany where his research interest in orchids was reflected in his publications from 1936 to 1946. In 1939 he was added to the Arboretum staff as Director of Plant Research and member of the Arboretum Committee, serving with Aldo Leopold who was then Director of Animal Research (Greene 1961, Sachse 1965). During this time Curtis began his research on the ecology of plant communities, including some work in Arboretum forests and prairies.

Curtis's development as an ecologist in Wisconsin was interrupted by his service in Haiti during World War II, but upon his return he resumed his position in Botany and was appointed to the newly formed post of Arboretum Research Coordinator. His research in prairie ecology in the Arboretum and around the state moved into full swing with numerous papers (Curtis and Partch 1949, Curtis and Greene 1949, Greene and Curtis 1950, Curtis and Partch 1950, Curtis and Cottam 1950, Robocker, Curtis and Ahlgren 1953, Greene and Curtis, 1953). Curtis also developed a unique seed exchange with other arboreta and botanical gardens around the U.S. and the world. Unlike most seed exchanges, Curtis' idea was to offer seeds of desirable native plants. This resulted in a great demand for Arboretum seed (Greene 1961).

Because of the many changes in staff that had taken place since the drafting of a master plan in 1939, a new master plan was issued in 1949 which covered plans for the entire Arboretum. The main objective of the new plan was the development of "an outdoor demonstration and research area in which native plants, animals and landscapes can be studied under natural or nearly natural conditions" which would provide many research opportunities for biological sciences. So as not to exclude other academic disciplines, it was also intended to provide "living models or dioramas of the pre-settlement Wisconsin landscapes for the study and inspiration of many students of art, literature, history, geography, hydrology and other disciplines outside the scope of technical biological science" (Sachse 1965). This plan also called for specific master plans for each of the major plant community projects in the Arboretum. Curtis fulfilled that requirement for the Curtis Prairie project with a detailed accounting of history, research, results and management proposals in 1951, the same year in which he achieved the rank of full professor in the Botany Department.

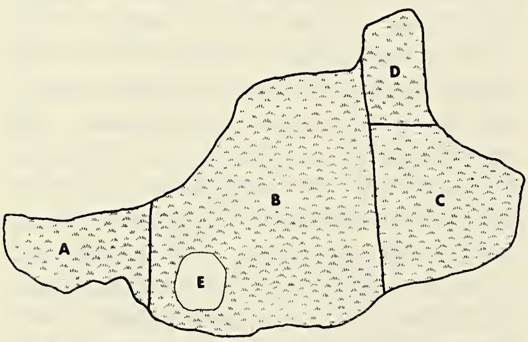

Fig. 5. Burn management units of Curtis Prairie. Unit E was a control that has been lost to the berm that has been constructed in its place.

During the 1950's Curtis was deeply involved in continued prairie restoration work and other Arboretum research projects as well as directing many thesis projects in the Botany Department. Most of these thesis projects involved the study of natural Wisconsin plant communities, from which data essential for the establishment of these com-

TABLE 1. Known burn record of Arboretum prairies from an addendum to Curtis (1951) and Arboretum files.

	Curtis	*Greene*
1950	A,B (burn units)	all?
1951	—	—
1952	C,D	—
1953	B	—
1954	A	all
1955	C,D	—
1956	B	—
1957	A	—
1958	C,D	all
1959	B	—
1960	A	—
1961	C,D	all
1962	B	—
1963	A	—
——		
——		
——		
1970	D*	—
1971	—	all
1972	A	—
1973	A,B,C,D	—
1974	B,C,D	—
1975	A	all
1976	—	—
1977	A**,B,C,D	—
1978	A,C	all
1979	A	
1980	—	—
1981	B,C	—
1982	A***	—

* October burn, other burns usually in March or April.

** Fire set by vandals burned part of A.

*** Fall burn.

Note: Beginning in 1977, a major sweet clover control experiment was conducted which involved several different burning and mowing regimes in Section B. These treatments included April, May, and Fall burns and July mowing. The experiment terminated in 1982.

munities in the Arboretum were acquired. These studies also formed the basis for his greatest work, *The Vegetation of Wisconsin,* finished in 1959. Curtis not only supervised the extensive planting work which was done by Archbald in the early 1950's, but searched the state to find prairie remnants and rare plants that might provide additional seed sources for the prairie plantings. He was helped in this search by his botanist wife, Jane Kurtenacker Curtis, and his students. Some of Curtis' students conducted their research in the Arboretum prairie, for example Dave Archbald's work on the effects of legumes on the establishment of grasses and Bonita Miller's study of differential responses of various grass species to clipping.

Using the results of the experimental work on the effects of fire in prairie restoration and management in the 1930's and 1940's a schedule of prairie burns was initiated. The first comprehensive burn was in 1950 in the western part of Curtis Prairie (A in Figure 5). Through the first decade of burning management the burn frequency for any part of the prairie, including Greene Prairie, was about three years with different parts of Curtis Prairie being burned almost every year. The record of burns can be reconstructed for the period 1950 to 1963 and 1970 to present (Table 1), but the period 1964 to 1969 was not well recorded. It was apparently during the 1960's that the burn frequency tended toward a biennial rotation rather than the earlier three year rotation.

The objectives of the burning according to Curtis' 1951 Master Plan included prevention of invasion by woody plants such as oak (*Quercus* spp), boxelder (*Acer negundo*) and dogwood (*Cornus* spp) and the weakening of the dominant blue grass sod so that native prairie species would be able to advance more readily. At the same time Curtis recognized that in addition to blue grass other problem weeds included white sweet clover (*Melilotus alba*), wild parsnip (*Pastinaca sativa*), and Canada thistle (*Cirsium arvense*) and he projected that leafy spurge (*Euphorbia esula*) could become a problem. In the plan Curtis recommended that a three year burning rotation be used. It is ironic that as the three year rotation turned into a two year rotation, white sweet clover populations seemed to be enhanced until recent efforts of Dr. Virginia Kline, Arboretum Ecologist, to resort to a more variable rotation time. The blue grass sod is gone, but the species occurs as abundant scattered individuals throughout the prairie and sweet clover, wild parsnip, and leafy spurge continue to be a problem today.

Curtis had the foresight to provide excellent documentation of the development of the prairies. In 1946 he initiated a system for surveying the two Arboretum prairies consisting of a permanent baseline from which a grid of regularly spaced quadrats could be established. Every five years since that time, the prairies have been re-surveyed. The 1946 survey was from a "closed" list, and only those species that had been planted on the prairies were surveyed. Since that time every species, including the weeds, has been recorded. Major papers reporting on the results of these surveys are those of Wilson (1964), Cottam and Wilson (1966), Anderson (1968), Anderson and Cottam (1970) and Blewett (1981). Blewett focused on identification of prairie species that appear to have the most reliable success in establishment on restored prairies. The research was also directed at identifying the environmental factors that appear to have the greatest influence in determining whether or not a planted species will survive. Some species, including yarrow (*Achillea millefolium*), little bluestem, rattlesnake master, and prairie dock (*Silphium terebinthinaceum*), were consistently successful while other prairie species, including purple coneflower and gayfeather (*Liatris pycnostachya*), did not show any pattern of success or failure. Still other species such as quackgrass (*Agropyron repens*), whorled milkweed (*Asclepias verticillata*) and cordgrass (*Spartina pectinata*) had consistent declines in their populations.

After examining a number of soil characteristics including texture, depth of the A_1 horizon, soil color, soil nutrients and pH, it was found that patterns of soil pH and long term moisture regime corresponded most closely with species distributions. Long term moisture regime was based on soil drainage characteristics which are influenced by soil texture, soil structure and topography. Soil texture alone was not a useful predicter of species distributions.

The Curtis Prairie experienced several damaging physical changes during this time. The increased drainage across the prairie resulting from construction of the beltline caused erosion problems. So serious was the problem that in 1954 one of the gullys in the west end of the prairie had to be regraded and replanted. In 1956 the beltline was widened from a two lane road to a four lane highway with a median strip. This roadwork resulted in a substantial loss of the coniferous buffer on the south side of the prairie and, worse, resulted in erosion-deposition that buried some of the prairie soil. Additional road work in 1959 again caused some runoff and erosion problems.

In 1959, just as Curtis finished his book, he was appointed Chairman of the Arboretum Committee. In this year a lime prairie project was initiated on the south side of the prairie. Limestone gravel and boulders were brought in and emplaced in a manner that might have led some to believe that there was a new gravel parking lot under construction. The work was done under the direct supervision of Ed Cawley, then Arboretum Botanist, and included the introduction of such dry lime prairie species as blazing star (*Liatris cylindracea*), pasque flower (*Anemone patens*), birds foot violet (*Viola pedata*) and silky aster (*Aster sericeus*).

In 1961 the lime prairie as well as many other parts of the Arboretum were damaged as a result of repeated ''human invasions'' prompted by a radio WISM treasure hunt publicity stunt. The lime prairie survived and additional plantings were made including side-oats grama grass (*Bouteloua curtipendula*), prairie dropseed (*Sporobolis heterolepis*), and little bluestem while the persistent weeds included wild (poison) parsnip and pilose aster (*Aster pilosus*).

1961 also brought a great loss to the Arboretum and the University of Wisconsin as John T. Curtis died at age 47 on June 7. The man had made monumental contributions to the Arboretum and to the field of ecology and had proposed theories about the nature of plant communities that became widely recognized and accepted.

The Curtis philosophy was not lost with his death, but was carried on by Professor Grant Cottam, successor to Curtis as Chairman of the Arboretum Committee (Sachse 1965). Under Cottam many students have learned elements of community ecology and field sampling techniques through the classes he has conducted ever since the 1950's in the Arboretum woods and Curtis Prairie. During Cottam's chairmanship the only significant impacts that affected the prairie were additional road work on the beltline highway and the building of an earthen berm to retain runoff waters and sediment from the beltline in the late 1960's. In 1976 and 1977 a utility corridor was implaced and more berm work was done.

Recent Research

During the 1960's and early 1970's more research was conducted on the establishment of artificial prairies. Cameron Wilson, who was a graduate student under Grant Cottam, began by completing the 1961 vegetation survey of the Arboretum prairies. On the basis of the 1951 and 1961 surveys, Wilson examined community dynamics in Curtis Prairie (Wilson 1964). Using Curtis' indicator species, Cottam and Wilson (1966) defined in the prairie five stands having different compositions and compared these reestablished prairie stands to native prairie stands. On the basis of prairie species, parts of the Curtis Prairie were comparable to native stands. A notable difference, however, was the greater presence of non-prairie species in the planted prairies in comparison to the native stands. They concluded that the nonprairie species are gradually diminishing in importance and that the Curtis Prairie is becoming very similar to native prairies.

In 1969 Jerry Schwarzmeier initiated experimental plots on Wingra Overlook that were designed to test potential benefits of planting prairie seed and seedlings with companion crops (Schwarzmeier 1971, Zimmerman and Schwarzmeier, 1978). The ideal companion crop would persist for several years and provide competition for weed species, but would have minimal interference with the establishment of the prairie species. Wild rye (*Elymus canadensis*), oats (*Avena sativa*), and Indian grass were tested individually as companion crops with plantings of prairie seed and seedlings.

The experimental results (Zimmerman and Schwarzmeier, 1978) showed consistent success with mowed wild rye as a companion crop and with mowing of the weeds in planted plots that used the invading weeds as a cover crop. The oat companion crop apparently was beneficial to the establishment of most prairie species with the exception of legumes, and Indian grass was found to be too competitive to be a good companion crop. Zimmerman (1972) reported on the propagation of spring prairie plants. Four species, pasque flower, prairie smoke (*Geum triflorum*), downy phlox (*Phlox pilosa*) and shooting star (*Dodecatheon meadia*) were examined in detail.

Greene Prairie

Greene Prairie, in contrast to the Curtis Prairie, was a carefully planted prairie that evolved through the monumental efforts of a single individual, Henry Campbell Green, who almost singlehandedly planted the entire prairie. Greene came from long-established and prominent Indiana families that provided financial independence for Henry, allowing him to pursue his interests with little interruption or interference. He studied at Wabash College in Indiana for two years before moving to Washington State University where he completed first a B.A. degree and then a Master's degree in mycology in 1929. That year he came to Madison to continue his graduate studies and in 1933 completed his Ph.D. in botany (Backus and Evans 1968).

For the next few years he remained on campus conducting research on molds with people from the agriculture campus. In 1937 he accepted an instructorship in the Department of Botany at Madison which gave him staff privileges for conducting research and informally assisting graduate students without the cumbersome responsibilities of a professorship. In 1941 he was appointed Curator of the Cryptogamic Herbarium which housed one of the most distinguished collections of parasitic fungi of any state university. Dr. Greene took on the responsibility of the position with great vigor, collecting all over the state and writing nearly 40 professional papers. His uncanny ability to note detail of not only the fungi but their hosts as well led him to become expert in the flowering plants of Wisconsin in addition to parasitic fungi. In fact his knowledge of the higher plants led some taxonomists to seek his assistance in their identifications (Backus and Evans 1968).

Perhaps there was a symbiotic effect that resulted from the close association of John Curtis and Henry Greene. Both men were graduate students at approximately the same time and both were appointed to the Botany Department at about the same time. Curtis started as an orchid physiologist and Greene started as a parasitic mycologist, yet both men became significant ecologists, each in a different way. Together they began to publish their first ecological papers in the 1940's. While Curtis went on to become well known in ecological research literature, Greene became remarkably knowledgeable on the ecological requirements of individual species. Greene's abilities and commitment were clearly illustrated in his 15 year prairie project on the Grady Tract. Greene served for many years as secretary of the Arboretum Committee and as editor of the "Arboretum News" for ten years.

A Sand Prairie Dream

Greene began to develop a compelling interest in prairies around 1940 when he was spending summers near Eagle, Wisconsin, which was located near the extensive Waukesha County prairies. These remnants of the once extensive prairie that covered southern Wisconsin impressed Greene by the variety and beauty of the vegetation in the low prairies. Together, Greene and Curtis visited these and other remnants around the state, gathering collections and observations (Anon. 1966).

Greene conceived the idea of establishing a sand prairie on the arboretum. He found a level portion of the Grady tract which was adjacent to the Lancaster Branch of the Chicago and Northwestern Railroad. This seemed an ideal place to establish an experimental sand prairie for it had many of the general attributes that Greene had observed in sand prairies. North of the opening stood a series of sand hills that were formed at the edge of a glacier and were now covered by scrub oak and some of the characteristic sand prairie species (from communication between Greene and Professor Thwaites of the Geology Department). This resulted in nearly pure sand soils on the adjacent prairie opening which sloped gently toward the south where the sand became buried by a sheet of clay. On the west end was a considerable amount of blackish sedge peat and there were several ephemeral ponds that provided refuge for some prairie plants (Greene 1949).

The original land survey records indicate that the area was originally a brushy oak opening with an understory of prairie grasses and herbs which apparently included such things as prairie dock, New Jersey Tea (*Ceanothus americanus*), ticktrefoil (*Desmodium illinoense*) and wild indigo. When the land was first viewed by Greene in 1942, it was only a few years removed from a long period of "ill-advised" attempts at cultivation. Perhaps as recently as 1937, the land was still planted in corn. There were, in 1942, protected pockets of prairie plants around the ponds and in the southeast corner where a parcel was isolated by a deep drainage ditch. In addition, the railroad right-of-way supported many prairie plants which provided more clues about the original vegetation of the area. All together, there seemed to be sources for seed that would permit the gradual re-establishment of the prairie if returned to natural conditions (Greene 1949). In preliminary vegetation surveys in 1944 and 1945 Greene listed the species present before major introductions.

In his report to the Arboretum Committee in 1944 Greene specified the terms under which he was willing to pursue the experimental establishment of a sand prairie. The project was to be exclusively Greene's and there were to be no other planting experiments on his site. He anticipated that the project would take many years of intense and careful work, and he did not want the use of unskilled labor as had been done with the CCC in the Curtis Prairie project. It was nearly 20 years before public access was provided to the interior of Greene Prairie.

The Planting of Greene Prairie

A few plants were introduced into the prairie in 1943 and 1944, but the major planting effort began in 1945 and continued until 1952. From 1953 to the early 1960's plantings were continued but gradually tapered off. The last period for which Greene left detailed notes in the Arboretum files was 1954 to 1955. The variety of planting methods used can be summarized as follows:

1) Transplanting of mature plants or sods,
2) Transplanting of seedlings started from stratified seed in the greenhouse,

3) Direct sowing or casting of seed,
   a) Planting of individual seed of large deep-rooted species such as *Silphium,*
   b) Spot planting of seed mixtures at select points,
   c) Broadcasting seed mixes over large areas after discing and then dragging to cover some seed (Anon. 1966, Green 1949).

There remained an uneven surface which resulted largely from the plow furrows, and these surfaces were intentionally left by Greene to create a diversity of microclimatic conditions that would increase the opportunities for various species to develop in suitable microhabitats (Allsup 1978, Greene 1949).

Watering was required for many of the transplants, and this was facilitated by the presence of an old well on the north side of the plantings. Greenhouse transplants included paper pot and bare root plantings, the latter requiring special attention for watering. With some of the more sensitive species such as the ladyslippers (*Cypripediums*) and gentians (*Gentiana*) mature plants in sods were carefully placed and watered to improve chances for survival (Greene 1949).

The plantings were initiated in the east end and progressed westward with a slight decrease in planting densities to the west. Much of the seeding was done with seed that Greene had collected himself. The 35 acres of the first plantings were extended to 40 acres in 1946 as the west boundary was advanced by 500 feet to the fire lane. This western segment had been cultivated up through 1946 and after haying had the usual complement of agricultural weeds such as quack grass, timothy, ragweed, red clover, alsike and others. In this western addition Greene introduced a total of 28 species by seeding in 1946 and by 1949 most species appeared to have survived (Greene 1949).

Between 1945 and 1949 about 10,000 mature plants and seedlings were planted by Greene, including a total of 133 species when all planting types are considered together. Of the 133 species, not all were planted in great numbers. The number of individuals introduced ranged from 2 small seedlings for coreopsis (*Coreopsis tripteris*) to about 1,824 more mature individuals of blazing star (Greene 1949). By 1951 Greene had planted an additional 2,000 individuals bringing the total number to 12,000 seedlings and mature plants introduced by hand (Greene 1951). This number excludes the vast number of seeds collected and cast by Greene.

In the end Henry Greene developed a preference for seed casting methods. Like Curtis he felt that the intense labor required for introducing sods or seedlings was not justified by the slight advantage in terms of survival. Some species that were started from seed such as Lupine (*Lupinus perennis*) and Indian paintbrush (*Castilleja coccinea*) have shown excellent success. Other species such as prairie drop seed and blazing star were established more successfully using seedling transplants.

It is evident from the Greene Prairie today that Henry Greene was meticulous in placing each species in the prairie so that it would have the proper set of environmental conditions for survival. True to his original word he carefully planted the entire prairie without the unskilled labor force that planted the Curtis Prairie. Greene Prairie is more spectacular than Curtis Prairie in its display of huge patches of color through the season with such species as lupines, Indian paintbrush, phlox, puccoon and blazing star. In fairness, however, it should be noted that part of the reason for the greater rate of success (at least aesthetically) with Greene Prairie over Curtis Prairie is its relative freedom from disturbance during restoration and the sandy soil types which make it more difficult for some of the weed species to persist. It has not suffered from the erosion and sedimentation caused by construction projects adjacent to its border and has not had as much visitor pressure.

Part of Greene's meticulous method was a detailed record of his plantings. He prepared eight annual reports (Greene 1943 to 1951), one biennial report (Greene 1955), and one six-year summary report (Greene 1949). Greene mapped the prairie with a baseline and grid system that permitted him to record the location, number and type of all his plantings. So detailed is his record that one could reconstruct a data set equivalent to the prairie surveys that have been conducted on Greene and Curtis prairies once every five years since 1951.

A Study of Greene Prairie

Following the Wilson study of Curtis Prairie another of Cottam's students, Rebecca Anderson, studied Greene Prairie (Anderson 1968, Anderson and Cottam 1970). Anderson participated in the 1966 prairie vegetation survey and then in the fall of 1967 conducted a soil survey of Greene Prairie which provided information on the depth of the A_1 horizon and percent sand, silt and clay. Communities were defined on the basis of compositional indices that were calculated for each quadrat sample by using Curtis' (1959) indicator species. The dry-mesic vegetation was found to occur mostly on sandy loam while the wet-mesic to wet prairie vegetation was found on silt loam at the west end and sandy loam at the east end. Available moisture seems to have been the determining factor. Some relationship was also shown between depth of A_1 and the prairie continuum, where the shallowest A_1 occurred only under dry prairie vegetation and the deepest A_1 occurred only under the wet or wet-mesic vegetation.

An analysis of changes in frequency between 1952 and 1966 showed that groups of species within each of the wet, mesic and dry segments of the continuum had increases in frequency that were sufficient to make the species in each group most abundant within the most suitable segment of the environmental gradient. The weed species were found to disappear most rapidly from the driest sites. Anderson concluded that the Greene Prairie was not yet equivalent to a natural prairie, but was progressing toward such a state.

Conclusions

The Curtis Prairie restoration has been much more successful than it had any right to be. This was the first real effort to reconstruct a prairie and it was started at a time when little was known about prairies in Wisconsin. There was no clear picture of the species composition of the different kinds of prairies and even less was known about the life history characteristics and ecological requirements of most of the species involved. The availability of a large work force, the CCC, was mixed blessing. It provided the labor and facilities with which to accomplish a large amount of work, but it came at a time when the state of knowledge about prairie reconstruction was almost nil. Theodore Sperry, who directed the initial efforts, took a philosophical approach to the problem. He went to prairie remnants, mostly located for him by Norman Fassett and John Thomson, and literally lifted the plants out of the ground and replanted them in the Arboretum. Even more of a shotgun approach was the prairie hay experiment of Fassett. Fassett mowed prairie remnants, brought the hay back to the Arboretum, and "planted" it. The first year results were very disappointing to Fassett, but he didn't realize how slowly prairie-plants mature and the prairie hay experiments were eventually much more successful than Fassett initially believed (Sperry, 1982). There is no question that the efficiency of the restoration of Curtis Prairie would have been improved were this restoration to be started today, but for its time, the experiment was remarkably successful.

From the array of individual experiments, the conclusion seems clear that careful planting of stratified seeds on soil that has been cultivated to reduce weeds is the most economical way to re-establish a large prairie. Planting of individual prairie sods has a greater chance of success and is perhaps the method of choice for rare or delicate plants, but it is not possible to plant a 60 acre prairie entirely by transplanting sods, since there are about one million plants per acre on a typical prairie. The major lesson to be learned from the Greene plantings is that success improves when careful attention is paid to the environmental requirements of each species. Greene's spectacular success is attributable to his meticulous matching of the plants with the environment, and also to the fact that prairie plants do relatively better than weeds on sites such as the Grady Tract that are nutrient poor and either too wet or too dry for good crop production.

The two Arboretum prairies present a marked contrast in restoration technique. The Curtis Prairie was planted in a hurry, with more than adequate labor and with a marked uncertainty about how long this labor force would be available. The Greene Prairie was planted after the Curtis Prairie and benefited from the Curtis experiment. It was planted without the massive labor input and was done with extreme care. Both methods worked and both prairies are things of beauty and rich resources for further study of the dynamics of prairies and the ecological life histories of prairie species.

Theodore Sperry, when asked how long it would take to reconstruct a prairie, answered, "about a thousand years" (Sachse, 1974). Sperry was probably an optimist. The conditions that gave rise to prairies no longer exist in the Arboretum. The Arboretum is surrounded by urban areas and bisected by a major highway. The large prairie mammals are gone, and are replaced by just one species, humans, whose impact on the prairie is entirely different than that of the large mammals. Fire, an essential component of the prairie environment in this climate, is difficult to use in the Arboretum, and the opportunity for exotics to invade disturbed areas is greatly increased. It is doubtful that it is possible to really restore a prairie in all its complexity. The best we can do is provide the higher plants, and perhaps some of the small prairie animals that cannot be expected to migrate into this isolated area, introduce enough soil in the form of sods to provide an inoculum of the microflora and fauna, and hope that this facsimile of a prairie habitat will attract the birds and invertebrates that should be there. After that, we wait. But in the meantime, the Arboretum prairies look like the real thing and they provide, for all but the most sophisticated, an experience of the presettlement landscape that is almost impossible to obtain elsewhere.

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SOIL SURFACE DYNAMICS IN SELECTED PRAIRIES OF THE ALDO LEOPOLD MEMORIAL RESERVE

Bruce R. Herrick
Institute for Environmental Studies
University of Wisconsin-Madison

Francis D. Hole
Department of Soil Science
University of Wisconsin-Madison

Abstract

Pedophenology is the study of the relation between seasonal climatic and biological events and periodic phenomena in the soil. Knowledge of the dynamics or the soil surface is necessary to understand the behavior of soils. Two experiments were conducted at the Aldo Leopold Memorial Reserve in which physical changes in the surfaces of soils were monitored during the summer of 1982. Short-term changes in the micro-topography and cover of the soil were studied on three prairies on the reserve. Changes in the relative frequencies of components of the soil surface (litter, plants, and bare ground) and in micro-relief of that cover were measured during four observation periods using a point frame. Because erosion and deposition were equal, there was no difference between the means of the prairies in this regard, but variances were significantly different ($\alpha = 0.10$). The point frame showed that any point may be exposed or covered with various materials over short periods, contributing stochastic effects to soil dynamics. Evidence of micro-erosion and sedimentation was observed over a nine-week period by the device of inserting nails flush with the soil surface and noting their burial or exposure. Changes observed in both experiments reflected biological and physical processes.

Introduction

Micro-topography and cover are important components of the soil environment. To examine short-term changes in the micro-topography and cover of the soil surface, I conducted two experiments on the Aldo Leopold Memorial Reserve during the summer of 1982. The first experiment employed a point frame to measure surface cover and micro-relief. The other was designed to record micro-erosion and deposition using twenty-penny (20 d) nails inserted into the soil.

To understand a terrestrial ecosystem it is necessary to understand its soil, which is the home of the detritus food chain, the reservoir of the sedimentary nutrient cycles, and an important interface between the biotic community and the abiotic environment. The ecology of the soil can be known only by studying it over time; yet such phenological studies are rare compared with such research on birds and plants.

Pedophenology is the study of the relation between seasonal climatic and biological events and periodic phenomena in the soil. One study along these lines was conducted by Nielson and Hole (1964), who examined earthworm populations and their manipulation of forest litter over time.

The surface is the most dynamic part of the soil. Here organic matter accumulates, providing energy and nutrients for a vast array of organisms. Biotic and abiotic components lie closely intermixed. The edge effect is evidenced in the soil surface by the great quantity and diversity of organisms present.

Changes in the soil surface are the result of both biological and physical processes. Hole (1981) discusses twelve categories of animal activity that affect the soil: mounding, mixing, forming voids, backfilling voids, forming and destroying peds, regulating soil erosion, regulating movement of air and water in soil, regulating plant litter, regulating nutrient cycling, regulating biota, and producing special constituents. The effects of many of these activities are evident on the surface. The soil surface may be further altered by raindrop impact, mud cracking, and heaving caused by frost. Even over a short time the effects of these processes can be observed and analyzed to provide useful information about the soil environment.

The Study Area

The study sites were located on three restored prairies on the Aldo Leopold Memorial Reserve. The reserve is in Fairfield Township, Sauk County, north of Baraboo, Wisconsin (43°35′ N, 89°40′ W). The presettlement vegetation of the reserve is discussed by Liegel (1982).

The EBL Prairie is adjacent to the Bradley Study Center and Center Pond, off Levee Road (R. 7E, T. 13 N, Sec. 33). The original soil was a Gotham, sandy, mixed, mesic Psammentic Hapludalf (USDA 1980). This was covered by dredge spoil from Center Pond early in the summer of 1976. After draining all summer, the spoil was spread with a bulldozer to a depth of approximately one meter in the fall. In November half of the area was seeded with prairie species, each in a circular patch with a 5 m radius. The remaining area was planted to oats. In the late fall of 1977 strips of oats were disked, leaving rows of oat stubble for soil conservation. Mixed prairie seeds were then scattered across both disked and fallow areas.

East of the EBL Prairie, situated on a sandy ridge, lies the Coleman Prairie (Sec. 33). The experimental plot was located on a Plainfield loamy sand, mixed, mesic, Typic Udipsamment. Draba Prairie is located on Levee Road (Sec. 33) on a Brems loamy sand, mixed, mesic, Aquic Udipsamment. Both Draba and EBL Prairies were burned in the spring of 1982; Coleman Prairie was not.

The climate is continental. Of the 822 mm of annual precipitation, typically 60% falls from April through September. The most rain falls in June, with an average of 127 mm. As spring advances, "the frequency of precipitation is less and the intensity greater" (USDA 1980).

The Point Frame Experiment

The point frame has been employed in botanical studies to measure the relative abundance and ecological importance (as per cent cover) of plants in a community. The same instrument was used to measure changes in a Wisconsin forest soil by Nielson and Hole (1964). As with their experiment, the point frame I constructed enabled me to measure the relative frequencies of components of the soil surface and to observe temporal changes in these frequencies. In addition, I was able to measure the microtopography and its changes over time.

Materials and Methods

The key part of the point frame is the horizontal piece with its ten holes, spaced 10 cm apart. Through each hole a measuring rod is passed. The remaining parts are used to position the instrument so that the same points are sampled at each observation period. At each recording station two wooden stakes are hammered into the soil and holes drilled into the tops of both stakes. The position of these holes corresponds to two locator pins at the ends of the horizontal beam.

Before measurements are taken at each location, the apparatus is positioned so that the locator pins descend into the holes in the stakes, and the horizontal beam is levelled.

The rod is then passed through the first hole until it contacts either the mineral soil or something lying or growing on the surface. The object struck is recorded, and the distance between the horizontal beam and the top of the rod is measured to the nearest mm. The rod is passed successively through each of the ten holes. Then the sequence is repeated twice and the distances averaged. The height of the locator pins is used as a reference for comparison of measurements made at different times. After correcting for differences in the height of the horizontal beam at each observation period, and after subtracting the smallest integer for each location from all the other values from that location, this procedure yields relative values for the micro-topography of the soil surface.

Measurements were taken over four observation periods: June 23, July 7, July 28 and August 18, 1982. This experiment was conducted on the EBL Prairie alone. There were four positions, A, B, C and D, along the slope of the hillside, and there were three replicates of each position. The line that contained all three of the A positions was termed "row A," and rows B, C and D were indicated similarly. Row A was 0.5 m from the edge of Center Pond. The soil there was wetter and sandier than the other soils and supported abundant vegetation. Row B, 11 m upslope, was drier, with considerably less vegetation. Row C was 11 m further upslope. The soil contained more clay and less sand than the soil downslope. Each of these three rows was in the five year old portion of the prairie. Row D was placed in the four year old portion, 5 m from the division between the two. Except for its younger prairie vegetation and the fact that it lay on the opposite side of the hill crest, Row D was similar to Row C.

Results and Discussion

The point frame experiment yielded quantitative data (per cent cover and relative elevation), as well as a record of nominal changes. Figure 1 presents the frequency data for the distribution of bare soil, litter,

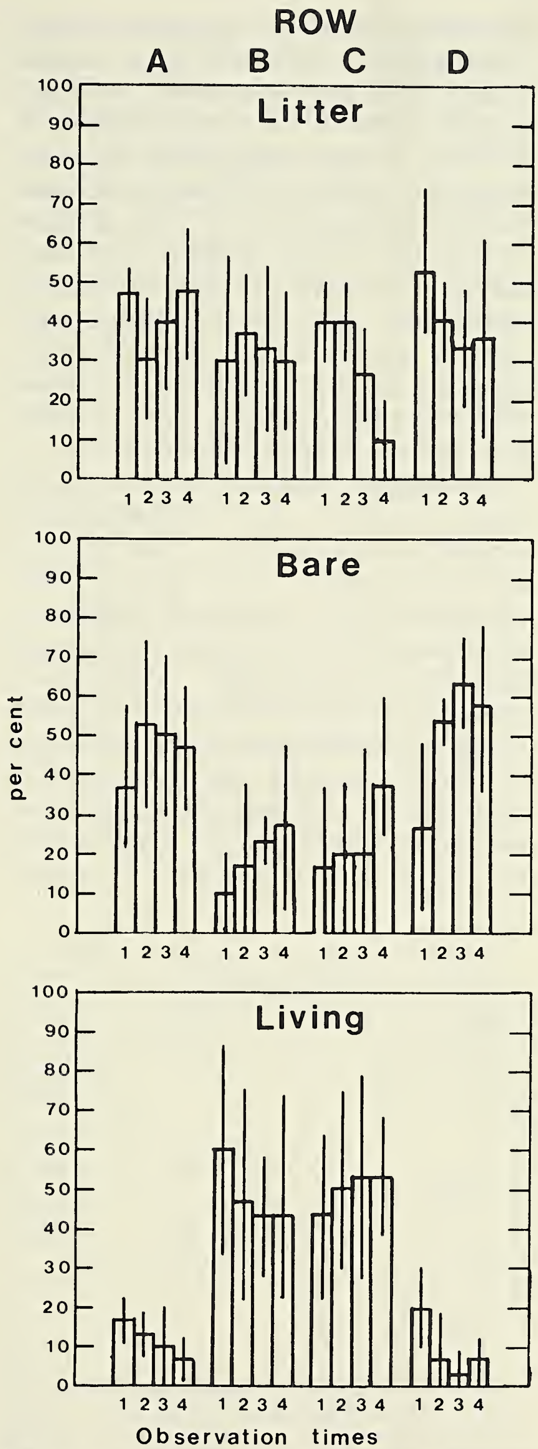

Fig. 1. Average frequencies and standard deviations of litter, bare soil and living plants contacted by the point frame rod along rows A, B, C and D. These measurements were taken during the few days on or after (1) June 23, (2) July 7, (3) July 28, and (4) August 18. (n = 3).

and living material during each of the observation periods. The term, "bare," includes mineral soil, ant hills, stones, and burnt organic matter left from the prairie fire. "Litter" includes dead plant material and occasional fragments of insect exoskeleton, and deer droppings. Grass, forbs, and moss constitute the "living" category. Each bar in the figure is the average across the row (containing three replicates of ten points each) with its corresponding standard deviation. Because most of the standard deviations are large, most of the differences are not significant, although trends are suggested.

For example, the per cent of the soil surface covered by litter declined over the summer on rows C and D, but not on A and B. The reduction on row C was significant. The loss of litter on rows C and D was accompanied by an increase in proportion of bare soil, which the litter had previously covered. Rows C and D were upslope, where vegetation was less dense than in rows A and B, indeed sometimes sparse. Exposure to direct sunlight and consequent higher temperatures at the soil surface might account for higher rates of decomposition, given adequate moisture for microbial activity. Also, the more abundant vegetation on the lower two rows yielded more dead plant material. The decrease in living plants on row B was accompanied by an initial rise in litter and, ultimately, led to exposure of the soil. Naturally, when vegetation dies, its debris remains on the surface for awhile, until broken down or removed by wind, water or animals. Row A showed a decline in living material; bare ground and litter were more variable. The results from all four rows indicate that the soil surface was most protected from erosion in June, which is the month of greatest rainfall. Bare soil, favoring increased erosion, became increasingly frequent over the summer.

That the soil cover is dynamic can be illustrated by following its nominal record over time at specific locations. Figure 2 shows the changes in the cover and corresponding changes in micro-topography for three points at different stations. At BA.6 the litter that was initially present was not observed two weeks later, on July 7. This removal from the soil surface also represented a drop in elevation. Subsequently, ants, by bringing subsoil to the surface, created an increase in the micro-topography.

The interesting thing about point CA.2 is that it shows a different kind of input to the soil surface than one might normally consider. Here the rod of the point frame fell on one of the many insect exoskeletons lying on the ground, seemingly from a mass molt. These were gone on July 7 when bare soil was recorded for this point. Subsequently, plant litter covered the same point.

The very small changes in topography at point CC.8 are evidence of an important phenomenon that was occuring over large parts of the EBL Prairie: the soil's mossy mantle had dried up and was cracking. The increased elevation of the moss on July 28 was due to the rod's striking the curled, upturned edge of the dry moss. By August 18 the moss had curled to such an extent that the rod went by it and struck the bare soil that it had covered.

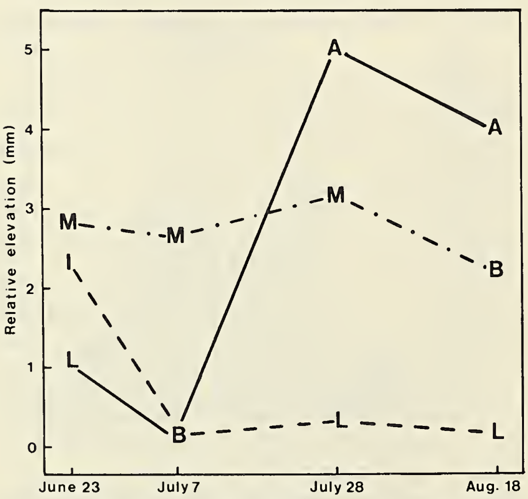

Fig. 2. Differences in relative elevation with changes in type of soil cover, (A) ant hills, (B) bare soil, (I) insect exoskeleton, (L) plant litter, and (M) moss, at three points on the EBL Prairie, BA.6 (______), CA.2 (— — —), and CC.8 (— • —).

There were almost as many different sequences as there were points, most of which showed changes in cover over time. The types of surface changes observed may be categorized as (1) deposition (of litter, insect skeletons, and feces), (2) removal (of anything on the surface), (3) mound building, and (4) cracking and curling of mud and moss. Any given point may be successively exposed, covered, or transformed over very short periods of time. The amount and type of plant cover will affect such physical conditions as soil temperature, rate of evaporation, and erosion potential, as well as biological actions—from ant mounding to root growth. It would follow that these processes are highly variable in this young soil.

The Erosion Pin Experiment

Erosion and deposition are important in soil formation. Several researchers have measured these processes using erosion pins (Leopold, Emmett and Myrich 1966; Imeson 1971; and Imeson and Jungerius 1974). In this study erosion pins were used to determine whether the rate of surface change was affected by the age of the prairie.

Materials and Methods

I pushed each 20 d nail (10.3 cm long) into the soil until the base of the head lay against the soil surface. This was done on June 29 through July 1. Because the experiment was conducted over one summer, with only small changes expected and no danger of frost action, 20 d nails worked well. Bridges and Harding (1971), who also used nails as erosion pins, noted that the nails rusted sufficiently to form an effective bond with the soil, which helped to reduce disturbance.

The erosion pins were placed along four transects, parallel to the contours of the hillsides: the five and four year-old portions of the EBL Prairie (rows C and D, respectively), Draba Prairie, and Coleman Prairie. On each transect were five replicate clusters of nails. The clusters were arranged in a rectangular pattern, which facilitated finding the nails at the end of the experiment. Rows C and D of the EBL Prairie had similar slopes on opposite sides of the crest of the hill. The transect on Draba Prairie was similar to those of the EBL Prairie with respect to slope and proximity to the crest of a gentle rise. The slope of the Coleman Prairie was slightly greater than the others. In contrast to the EBL Prairie, which had been recently planted on a newly-created soil, Draba and Coleman Prairies had supported prairie vegetation for a considerably longer time and had been managed as prairies since 1968. The amount of erosion or deposition was measured to the nearest mm on September 7.

Results

Although the means of data sets for the four transects are essentially the same, dissimiliarities in the ranges of values cause differences among the variances. According to the analysis of variance (Table 1), there is no evidence to reject the hypothesis that the means are equal. Furthermore, one can see from Table 2 that the standard deviations

Table 1. Analysis of variance for the erosion pin experiment.

Source	*df*	*SS*	*MS*	*F*	*Significance*
Replicates	4	12.33	3.08	.285	NS α = .005
Treatments	3	27.52	9.17	.849	NS α = .005
Experimental Error	12	129.62	10.80		
Sampling Error	180	827.87	4.60		
Total	199	997.35			

Table 2. Means ($\bar{x}$) and standard deviations (S_x) of erosion pin measurements (n = 50).

Prairies	$\bar{x}$ *(mm)*	S_x
EBL row C	−0.18	2.64
EBL row D	−0.09	2.59
Draba	0.46	1.89
Coleman	−0.58	1.37

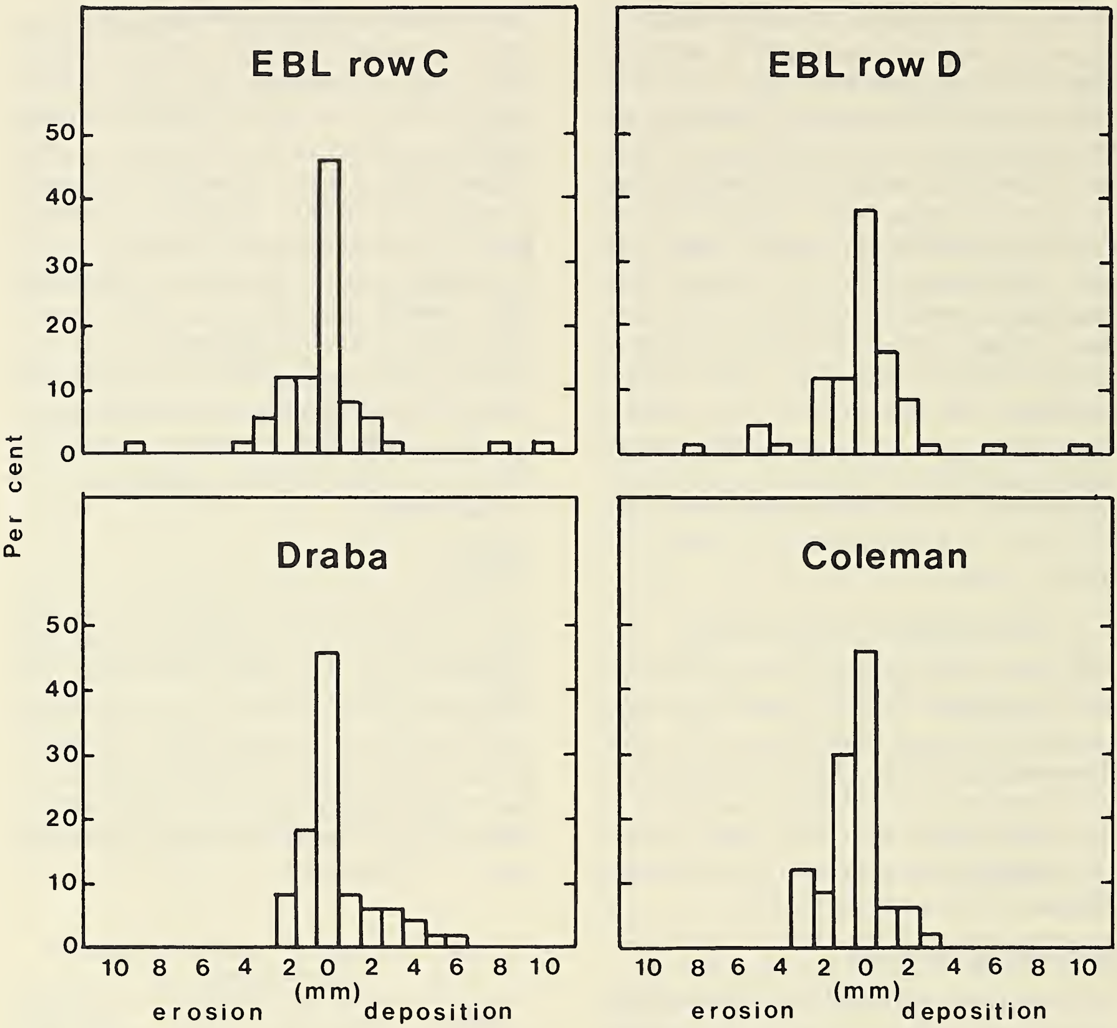

Fig. 3. Frequency of various amounts of erosion and deposition recorded by the erosion pins on each transect (50 nails per transect).

are greater than the differences between any of the means. The means are all close to zero, indicating that on each transect erosion and deposition were nearly equal. The most commonly observed event, as shown by the histograms in Figure 3, is no change. Despite the similarity of the means, Figure 3 suggests differences among the variances. The range of values for erosion and deposition is much greater on the two rows of the EBL Prairie than on the other two prairies. Indeed, the chi-square test of the homogeneity of variances indicates differences at the 10% level of significance.

Discussion

It is generally agreed that erosion is greatest on bare soil. In plotting surface erosion and deposition against vegetation height, Imeson (1971) notes that the greatest variability is found where the vegetation (in his case, *Calluna vulgaris* L.) is the shortest, an observation which Imeson attributes to the more variable amount of soil cover in the young, short stands. Others (Bridges and Harding 1971, and Imeson and Jungerius 1974) report that erosion is limited to unvegetated areas. Vegetation protects the soil, they say, by absorbing the kinetic energy of falling rain, which otherwise would be sufficient to dislodge and move soil particles.

The unvegetated area need not be large for erosion to occur. Imeson and Jungerius (1974) state that the only parts of their forest experiencing measurable erosion are the small areas exposed by animal activity, in their case moles and wild pigs. On prairies the mound-building activity of ants can be significant (Baxter and Hole 1967). Although these ants expose patches of soil to rain drop impact, they also increase the porosity of the soil, which reduces the amount of water flowing over the soil surface after a rainfall. The mounds and tunnels of ants and moles were evident on all four of my sites. The most commonly measured effect of ants in this experiment was the deposition of soil on the erosion pins.

To a greater extent than the activity of ants, the degree of prairie development seemed to bear on the amount of exposed soil. Whereas the older prairies, Draba and Coleman, were well covered by vegetation and plant litter, the younger EBL Prairie was spotted with numerous bare areas. The irregular cover of the EBL Prairie correlated with the greater variance in erosion and deposition there.

While it is not statistically significant, there is an apparent trend toward slightly greater net erosion on the Coleman Prairie than on other sites (Table 2 and Figure 3), which may be related to the fact that Coleman Prairie has a greater slope. Draba Prairie shows a tendency toward more deposition, although, again, this trend is not significant.

Many of the recorded losses on the EBL Prairie were due to the formation of dessication cracks in the soil. The depth of some of the cracks contributed to the variability of the data for these two transects.

One might expect to find increased erosion due to exposure of the soil immediately following a prairie burn. To observe this effect it would be necessary to carry out this experiment shortly after the fire. By the time my experiment was initiated, the prairie species were growing in both the burned and unburned sites, and no difference was observed between the two with respect to means or variances.

Conclusions

Interesting in themselves, these phenological observations of the soil surface have ecological implications. For example, with regard to the interaction of the biotic community with its physical environment several examples were noted. For instance, the vegetation shields the soil from the impact of falling rain. The soil, in turn, acts as substrate for plants and animals. Ants and moles acted as soil mixers and tunnelers that created conduits for air, water and various soil animals.

Primary succession was also observed on the soil that was dredged from the pond. Moss began to grow on previously bare soil. Older patches of moss dried out and cracked, and higher plants sprouted in the fissures.

Evidence of nutrient cycling was recorded. The deposition of plant litter and wastes of animals and insects was followed by their subsequent disappearance. The decomposition of the organic matter represents the release of nutrients and energy.

These processes occur over time. Therefore a phenological approach to their study is appropriate. By careful observation the dynamic nature of the soil surface is noticeable over relatively short periods of time.

Acknowledgements

The hospitality of Nina and Charles Bradley and of Jane and Reed Coleman was deeply appreciated. Support for this study was provided by the Sand County Foundation (nee Head Foundation) of Madison, Wisconsin.

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PHYTOCHEMICAL AND MORPHOLOGICAL DIFFERENTIATION BETWEEN *MYRIOPHYLLUM SPICATUM* L. AND *MYRIOPHYLLUM EXALBESCENS* FERN IN TWO WISCONSIN LAKES

Stanley A. Nichols
Wisconsin Geological and Natural History Survey
Madison

Abstract

M. spicatum and *M. exalbescens* from a common environment were successfully separated using phytochemical techniques and by using the morphological characters of leaf length and numbers of pairs of leaflets. An ordination technique using 25 morphological characters could not successfully separate the two species.

Introduction

Fernald (1919) described *Myriophyllum exalbescens* Fern as a species distinct from *Myriophyllum spicatum* L. However, Patten (1954) and Nichols (1975) have shown that the two display great phenotypic plasticity and are very difficult to differentiate using morphological characters. Jepson (1925) and Fernald (1945) reduced *M. exalbescens* to a variety of *M. spicatum*.

More recently Aiken (1981) is convinced of the distinction between the two species and she found that *M. exalbescens,* previously thought to be a North American species, exists in northern Europe (Aiken and McNeill, 1980). In addition, Ceska (1977) has developed chemotaxonomic techniques which separate the two species.

Aiken and Picard (1980) believe that most of the phenotypic plasticity documented by Nichols (1975) could be explained by habitat variation. This is a valid observation as the plants collected by Nichols were collected from three different lakes and from different habitats within those lakes.

Based on past collections and observations, Fish Lake and Lake Wingra in Dane County, Wisconsin "were thought to" contain populations of both species growing in close proximity to each other so that the morphology and phytochemistry of plants from a common environment could be compared. The question to be answered is whether the *M. spicatum* and *M. exalbescens* like plants from a common environment are morphologically and phytochemically distinct. If the plants are distinct, variations previously observed could be attributed to the environment. If they are not distinct, the variations are attributed to other causes.

Methods

A mass collection of Lake Wingra milfoil plants already existed in the University of Wisconsin herbarium. This collection was made by the author on August 5, 1970 from a common depth, over a common substrate, and from an area about 10 m in diameter. A similar collection was made from Fish Lake on July 7, 1982 from a common depth, substrate and from an area about 10 m in diameter. From field observation both collections were throught to contain both *M. spicatum* an *M. exalbescens* plants. The plants were at similar stages of their life cycle when they were collected (i.e. they were mature plants with flowering spikes).

The morphological characters of all suitable plants were measured according to the criteria used by Nichols (1975). A total of 28 specimens were analyzed. These specimens were ordinated on a two axis, R type ordination using the Axis I and Axis II R values developed by Nichols (1975) for each character.

The ordination array for each lake was divided into quarters and one specimen from each quarter was selected for chemotaxonomic studies. Initial positive results from Lake Wingra caused the selection of four more specimens from the center of the Lake Wingra ordination. In total 12 specimens were sent to O. Ceska, of Ceska Geobotanical Research Co. Victoria, British Columbia to analyze the phytochemistry of the plants using techniques which she developed (Ceska, 1977).

Aiken and Pickard (1980) state that mean internode length, mean leaf length and mean number of leaf divisions can be used to separate the two species from a common environment. Since mean values of the characters for these specimens were not calculated in a fashion similar to Aiken and Picard, leaf length, numbers of pairs and leaflets, and internode lengths as described by Nichols (1975), and combinations of these characters taken two at a time were displayed graphically along with an R-ordination of the 12 specimens to see if they correlate with results from the phytochemical analysis.

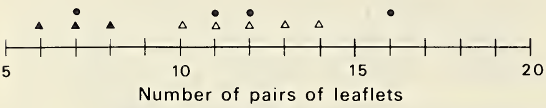

Fig. 1. Numbers of pairs of leaflets for selected *Myriophyllum* plants.

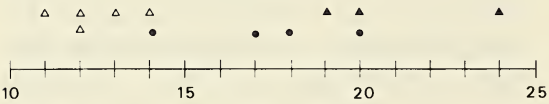

Fig. 2. Leaf length of selected *Myriophyllum* plants.

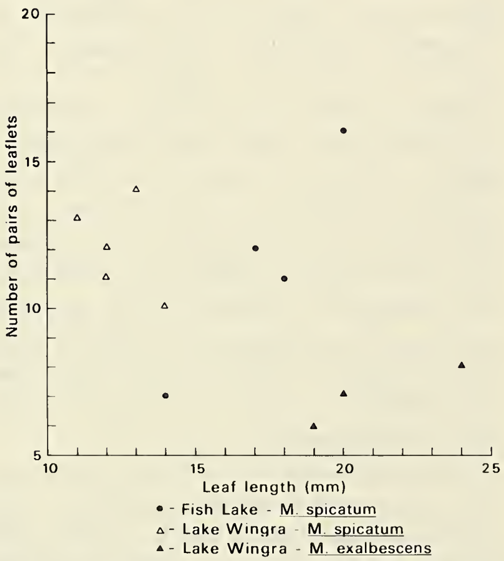

Fig. 3. Leaf length vs. number of pairs of leaflets for selected *Myriophyllum* plants.

Results

Ceska (in. Litt.) reported that all the Fish Lake samples were *M. spicatum* but that three of the eight Lake Wingra samples were *M. exalbescens*. In addition she reported that the differentiation between the two

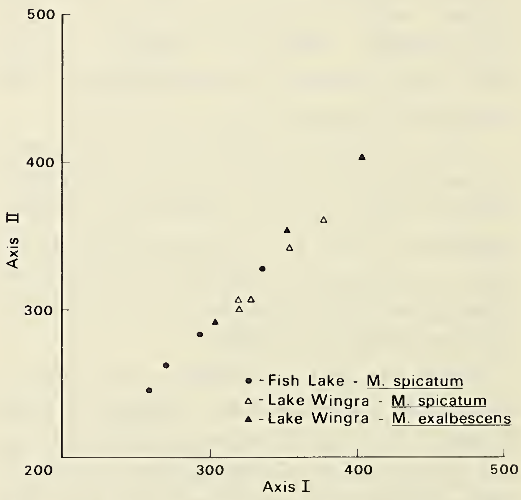

Fig. 4. R type ordination of selected *Myriophyllum* plants based on 25 morphological characters.

species in Lake Wingra was distinct. There was no appearance of intergradation of phytochemical characters (chromatograms are on file at the author's office).

Leaf length and number of pairs of leaflets were both useful characters for separating *M. spicatum* from *M. exalbescens* from a common habitat (Figures 1 and 2). The plot of leaf length vs. number of pairs of leaflets successfully separated *M. exalbescens* from all *M. spicatum* plants (Figure 3).

Ordination was not a successful method of separating the species. The two species from a common habitat could not be separated using this technique (Figure 4). In fact *M. exalbescens* plants occupy both ends of the Lake Wingra ordination.

Likewise internode length was not a good separating character. Used alone it couldn't separate the two species from a common habitat and when used with either leaf length or pairs of leaflets it would separate the species from a common environment but it would not separate *M. exalbescens* from all *M. spicatum* plants.

Using the limited number of samples available the ratio of leaf length divided by numbers of pairs of leaflets was calculated. The mean and 95% confidence limits were 3.0 ± 0.5 for *M. exalbescens* and 1.3 ± 0.3 for *M. spicatum*. These means were significantly different at the 95% confidence level using a Student's T test.

Discussion and Conclusions

This study showed that at least during 1970 there were two distinct species of milfoil present in Lake Wingra. These species were phytochemically and morphologically distinct. Whether both species still exist together in Dane County lakes is open to question. The author searched lakes Wingra, Mendota, Monona, Waubesa and Fish during the summer of 1982 looking for both species. Fish Lake was the only place both species appeared to be growing together. Phytochemical analysis showed that these specimens were all *M. spicatum*. If the author had not spent a great amount of time on Lake Wingra during the summer of 1970 he probably would not have discovered the *M. exalbescens* because its growth was extremely limited. In addition the author searched Lake Wingra and Fish Lake for milfoil turions in mid-April, 1984. Turions would indicate the presence of *M. excalbescens*. No turions were found.

These findings concur with Aiken and Picard (1980) that leaf length and numbers (or pairs) of leaf divisions are useful characters for separating the species. It is interesting to note that Aiken and Picard found that *M. exalbescens* leaves were shorter than *M. spicatum* leaves. This study showed just the opposite.

The ratio of leaf length divided by the number of pairs of leaflets might be a useful criterion to use for separating the species. This criterion would have to be developed by measuring a large number of plants that were known to be from each species from a broad geographical range. The numbers and geographical range of the plants used in this report are much too limited to be considered representative.

This study also shows that the ordination technique based on 25 morphological characters is not a useful technique for separating the species. These characters are apparently too variable to be useful. This variability is not entirely environmental, however, as the ordination technique could not separate the two species from a common habitat.

In conclusion it appears that *M. spicatum* and *M. exalbescens* from the common environment studied can be separated phytochemically and by using the morphological characters of leaf length and numbers of pairs of leaflets. The variability of many morphological characters of plants from a common environment is such that they are not useful in separating the species using ordination technique. Much larger populations of known plants will have to be examined to see if leaf length and leaflet pair criteria can be developed which can be used to separate the species over a broad geographical range.

Acknowledgement

Susan Aiken, Biosystematics Research Institute, Agriculture Canada, is gratefully acknowledged for reviewing the manuscript and for making helpful editorial suggestions.

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THE CADDISFLIES (TRICHOPTERA) OF OTTER CREEK, WISCONSIN*

JEFFREY C. STEVEN *and* WILLIAM L. HILSENHOFF
Department of Entomology
University of Wisconsin, Madison

Abstract

By collecting and rearing larvae, sweeping bank vegetation, and using a black-light trap, 79 species or genera of caddisflies were identified or tentatively identified from collections made at Otter Creek. We believe that all except 9 may have developed in the stream. Six species, *Hydroptila valhalla, H. virgata, Oxyethira anabola, Lepidostoma libum, L. vernale,* and *Triaenodes dipsius* have not been recorded previously from Wisconsin. Most species are univoltine with relatively short emergence periods, but several have many cohorts and extended emergence periods.

INTRODUCTION

Caddisflies or Trichoptera are insects with aquatic larvae, aquatic pupae, and terrestrial adults. They comprise one of the largest orders of aquatic insects. Within the United States there are 18 families, 142 genera, and at least 1213 species (Merritt and Cummins, 1978). Wiggins (1977) estimated more than 10,000 species worldwide. Based mostly on studies by Longridge and Hilsenhoff (1972, 1973), Hilsenhoff (1981) reported 16 families, 71 genera, and 218 species from Wisconsin.

Trichoptera are holometabolous with five larval instars, and most species are univoltine. The larvae are known for their variety of cases, although some build nets and retreats instead. Through a small opening at the tip of the labium caddisfly larvae emit silk that is used either to cement together cases or to construct nets and retreats. Cases aid in respiration, protect against abrasion, and provide camouflage to protect from predation. Nets are used as retreats or to collect food from flowing water. Caddisfly larvae have evolved to exploit resources in a variety of running and still waters ranging from cool to warm streams, and from lakes and permanent ponds to temporary ponds (Wiggins 1977). Because of this broad diversification, caddisfly larvae are important indicators of water quality, as well as an important source of food for fish.

Adults are cryptically colored and resemble moths, but their wings have hairs instead of scales, hence their name Trichoptera (trichos = hair, ptera = wings). They are relatively short-lived, with most species living less than a week or two. Some species may feed, but most only drink water. They are active at night, and most species are attracted to lights, but during the day they are inactive and stay in cool areas. Eggs are laid in masses in or above the water.

Previous collections indicated that Otter Creek has a diverse caddisfly fauna. The purpose of our study was to determine the species of caddisflies and their distribution in this small, spring-fed, woodland stream on the south slope of the Baraboo Range in south-central Wisconsin. Otter Creek has excellent water quality and is one of the cleanest streams in southern Wisconsin (Hilsenhoff 1977). Because of this and other considerations, The Nature Conservancy has purchased much of the land through which the headwaters flow to protect it for future generations.

* Research supported by the College of Agricultural and Life Sciences, University of Wisconsin-Madison.

Within North America in recent years there have been several similar studies of caddisflies in streams or small watersheds. The objectives of these studies have varied as have techniques used to sample the caddisfly fauna. Larval collections have been frequently used (Mingo *et al.* 1977, McElravy and Foote 1978, Karl and Hilsenhoff 1979, Mingo and Gibbs 1980), but only about 39% of the larvae of North American caddisfly species are known (Wiggins 1977). Rearing larvae to the better known adults, supplemented by net collections of adults (Karl and Hilsenhoff 1979, Mingo and Gibbs 1980), or net collections of adults from along the stream (Ellis 1962, Mingo *et al.* 1977), are other techniques that have been used, but some species are difficult to capture by these methods. Light-traps, especially those using black-light, were employed by Ellis (1962), Resh *et al.* (1975), McElravy and Foote (1978) and Morse *et al.* (1980) to capture adult caddisflies from streams being studied, but there are two serious problems with relying on this technique. Some species are not attracted to light and most are excellent fliers that disperse widely, so that individuals from nearby streams, ponds, lakes, and marshes may be captured along with those from the study stream.

OTTER CREEK STUDY AREA

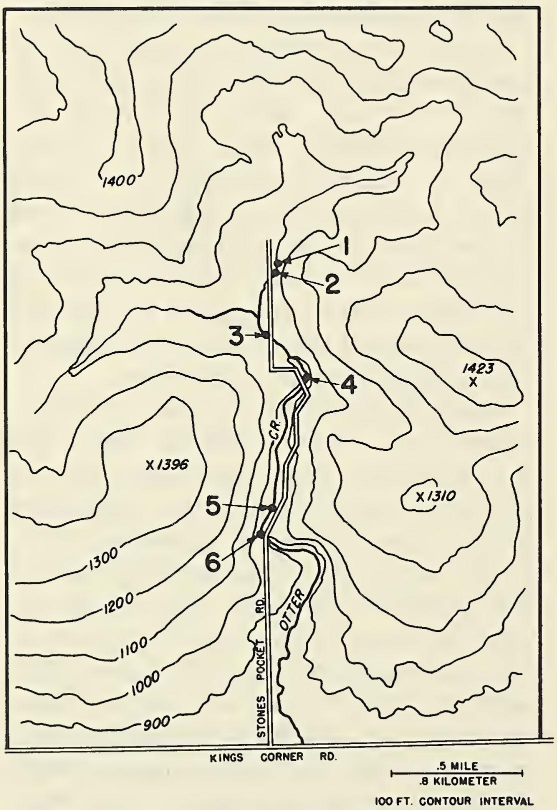

Fig. 1. Location of sampling sites.

Emergence traps placed over the stream provide a technique that assures capture of adult caddisflies from the study stream (Corbet 1966b, Anderson and Wold 1972, Flannigan 1977, Mingo and Gibbs 1980, Masteller and Flint 1980). The only problem with this technique is vandalism to the large and conspicuous traps, and this is often so serious that it precludes the use of traps on streams frequented by the public. In any study, however, it is advantageous to use as many collecting techniques as possible.

Materials and Methods

Our study was conducted on the headwaters of Otter Creek in the northeast corner of Wisconsin's driftless area (T11N, R6E, S-28, 29, 32, 33). This stream descends rapidly, 107 m in 4 km (Narf and Hilsenhoff 1974), from the Baraboo Range onto a flat outwash plain and then flows south about 25 km into the Wisconsin River. The substrate of the creek varies from muck, sand, and accumulated vegetative debris in pools, to boulders, cobbles, pebbles, gravel, and sand in the riffles. Water depths and stream widths depend upon the season and rainfall. Otter Creek is a soft-water stream with low total alkalinity (16 ppm), low total nitrogen (0.30 ppm), low total phosphorous (0.03 ppm), low total solids (62 ppm), and a pH varying from 6.3-7.3 during the year (Hilsenhoff 1977).

Six sampling sites were chosen to represent various ecological habitats within the stream (Fig. 1). *Site 1* is a 6 m long spring seep that feeds into Otter Creek. It flows out between two large sandstone boulders under a large oak tree, dropping 1 m over its 6 m length. The average width and depth are 0.4 m and 5 cm respectively. The substrate is predominantly fine sand and muck with scattered 5 to 12 cm cobbles. Leaf packs line the margins, with up to 20 cm of oak leaves covering the seep in the fall. *Site 2* is a 50 m portion of the creek above and below site 1. Its average width is 4 m and average depth 15 cm, with riffles predominating over pools. The substrate consists of scattered boulders, cobbles, pebbles, gravel, and sand, with leaf mats tending to wedge between larger rocks. *Site 3* is 20 m upstream from the third bridge north of Kings Corner Road. It is dominated by pools averaging 5.5 m wide and 0.5 m deep. The substrate is fine to coarse sand and muck with accumulations of tree branches and logs along the margins. *Site 4* is 10 m upstream from the second bridge north of Kings Corner Road. It is a 3 m wide rocky riffle composed mostly of 12 to 25 cm cobbles, with an underlying substrate of coarse gravel and sand. Leaf packs are common between the rocks. The average depth is about 15 cm. In the fall, filamentous green algae occurs at this site as well as at sites 2 and 3. *Site 5* is a 50 m long run with scattered riffles and is located at a wayside about 0.2 km north of the first bridge. The predominant substrate is large boulders with gravel and sand along the bottom. Leaf packs are numerous along the margins and the tree canopy is more open than at other sites. It is the widest (about 8 m) and deepest site (0.6 m average). *Site 6* is 6 m upstream from the first bridge north of Kings Corner Road. It has a moderate deciduous tree canopy. Most samples were taken from a riffle with large boulders, cobbles, leaf packs, and a sand and gravel base. Shallow pools are located just above and below the riffle. The average width is about 5 m and average depth about 0.4 m.

Using a D-frame aquatic net with 0.7 x 0.9 mm mesh openings, larvae were collected from each study site every two weeks from 19 March 1980 to 14 September 1980, and monthly from 17 October 1980 to 31 March 1981. Samples were collected from riffle, pool and bank areas at each site. Large rocks and logs were inspected, and caddisfly larvae were removed. Larvae from each site were preserved in a single jar of 70% ethanol and returned to the laboratory for identification and enumeration.

From 2 April 1980 to 14 September 1980, a second set of larval samples was collected at each site. This composite of riffle, pool, and bank samples was placed in a polyethylene bag half-full of water, leaves, and aquatic vegetation. In addition, one or two 2-gallon polyethylene pails were filled 3/4 full with typical substrate and aquatic vegetation from the site. Both pails and bags were returned to the laboratory in large coolers containing ice to keep the organisms cool. Approximately 120 liters of stream water were also returned to the laboratory.

Upon returning to the laboratory, substrates from each site were put into a 10-gallon glass aquarium along with enough stream water to fill the aquarium 3/4 full. Predators that were seen were removed. The substrate covered about the bottom 5 cm of each aquarium and was arranged to simulate the stream bottom, with additional vegetation or rocks piled above the water to aid emergence. The contents of the polyethylene bags were then gently poured into each aquarium. A high flow of compressed air through two air stones at one end of each aquarium provided water movement and oxygenation. A screen was placed over each aquarium to retain emerged adults.

The aquaria were maintained at a temperature and photoperiod similar to that of Otter Creek. Material from each sample date was usually reared for 2 months, after which the aquaria were cleaned and remaining caddisfly larvae were preserved in 70% ethanol.

During each visit to Otter Creek, about 10 minutes were spent at each site collecting adult caddisflies with a 30.5 cm diameter sweep net. Tree bark, large rocks and undersides of bridges were visually checked for adult caddisflies. All adults were preserved in 70% ethanol for later identification.

A black light was used every two weeks during the summer of 1980 to trap adult caddisflies, mostly at Site 4. A 6-watt blacklight (G.E. F6T5/BL) was placed in the center of a 24 x 21 cm baffle attached above a 20 cm diameter funnel below which a pint mason jar containing 70% ethanol was attached. A 12 volt car battery, which was kept inside a 10-gallon trash can, provided electricity. The light-trap was set on top of the trash can at the midpoint of a white twin-sized bed sheet stretched between two poles. It was turned on about 1/2 hour before sunset and run about 4 hours. Caddisflies flying down the funnel were trapped in the alcohol, and aspirators were used to collect them from the sheet. They were also collected by sweeping vegetation around the sheet and along the creek.

Larvae and adults in the University of Wisconsin Insect Collection that were collected from Otter Creek between 1963 and 1979 were also examined. Most adults had been reared by Richard Narf during his study of the stoneflies (Narf and Hilsenhoff 1974), and most larvae had been collected by students taking the aquatic insects course. Wayne K. Gall loaned to us additional larvae and adults from his personal collection.

Results and Discussion

Seventy-nine species or genera were identified or tentatively identified from collections made at Otter Creek (Table 1). This represents more than one-third of the species known to occur in Wisconsin (Hilsenhoff 1981). Six of them, *Hydroptila valhalla, H. virgata, Oxyethira anabola, Lepidostoma libum, L. vernale,* and *Triaenodes dipsius* are new records for Wisconsin. In addition, a female *Pseudostenophylax* was reared and tentatively identified as *P. sparsus,* which would also be a new record for Wisconsin. It differed from two other females we tentatively identified as *P. uniformis.* Unfortunately larvae and female adults of many caddisfly species cannot be identified, and male adults frequently had to be relied upon for positive identification.

In addition to the 43 species positively identified from Otter Creek as larvae or reared adults, larvae of at least 6 more

Table 1. Occurrence of species of Trichoptera at Otter Creek.

Species	*Collections*	*Number*	*Dates*	*Habitat*
HYDROPSYCHIDAE				
Cheumatopsyche spp.	larvae	464	year-around	throughout stream
Wallengren, 1891				
Cheumatopsyche gracilis	reared	22m 11f	18May-09Jul	boulder riffles
(Banks, 1899)	light-trap	41m 598f	05Jun-02Sep	at site 6
Cheumatopsyche oxa	reared	19m 13f	09May-29Aug	rock riffles
Ross, 1938	light-trap	22m 368f	25Jun-02Sep	at sites 2 & 4
Cheumatopsyche pasella	light-trap	1m 1f	09Jul,14Aug	
Ross, 1941				

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	Collections	Number		Dates	Habitat
Cheumatopsyche pettiti	light-trap	9m	23f	05Jun-19Aug	
(Banks, 1908)					
Diplectrona modesta	larvae	90		08Jul-24Apr	rock riffles at
Banks, 1908	reared	1m		28May	site 2
Hydropsyche betteni	larvae	71		27Aug-18Jun	rock, boulder
Ross, 1938	reared	1m	1f	25Jul	riffles at
	light-trap	8m	98f	05Jun-02Sep	sites 2 & 6
	sweep	1m		12Jun	
Hydropsyche bidens	light-trap	1m	1f	05Aug,05Jun	probably from
Ross, 1938					Wisconsin River
Potamyia flava	light-trap	1m		05Aug	probably from
Banks, 1900					Wisconsin River
Ceratopsyche bifida	light-trap*		2f	25Jun	
(Banks, 1905)					
Ceratopsyche bronta	light-trap		2f	09Jul	
(Ross, 1938)					
Ceratopsyche riola	larvae	185		12Jul-23May	rock riffles at
(Denning, 1942)	reared	1m		27May	sites 4 & 6
	light-trap	7m		05Jun-22Jul	
Ceratopsyche slossonae	larvae	821		year-around	rock, boulder
(Banks, 1905)	pupae	2m		04Jun,02Jul	riffles at
	reared	34m	37f	28May-22Aug	sites 2-6
	light-trap	55m	614f	05Jun-02Sep	
Ceratopsyche sparna	larvae	20		24Jul-20Jan	rock riffles at
(Ross, 1938)	reared		1f	24May	sites 2 & 4-6
	light-trap	2m	54f	05Jun-19Aug	
	sweep		1f	23May	

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*		*Dates*	*Habitat*
PHILOPOTAMIDAE					
Chimarra aterrima	larvae	556		year-around	rock, boulder
Hagen, 1861	pupae	1m	1	31Jul-14Aug	riffles at
	reared	7m	9f	30May-18Aug	sites 2 & 4-6
	light-trap	2m	3f	05Jun-19Aug	
	sweep	56m	60f	25May-08Sep	
Dolophilodes distinctus	larvae	22		03June-14Jun**	
(Walker, 1852)	light-trap	1m		19Aug	
	sweep	1m		19Apr	
POLYCENTROPODIDAE					
Nyctiophylax moestus	larvae	5		24Apr-02Aug	pools, reduced
Banks, 1911	reared		3f	30Jun-13Jul	current at site 2
	light-trap	250m	936f	05Jun-19Aug	
Phylocentropus placidus	light-trap	9m	7f	05Jun-19Aug	sites 1 & 3
(Banks, 1905)	sweep	1m	2f	04Jun-18Jun	
Polycentropus aureolus	light-trap	1m		09Jul	
(Banks, 1930)					
Polycentropus centralis	larvae*	13		02Jul-02Apr	riffles at
Banks, 1914	light-trap	82m	84f	05Jun-02Sep	sites 2-4
	sweep	1m	1f	02Jun,18Jun	
Polycentropus flavus	larvae*	9		05Nov-19May**	
(Banks, 1908)					
Polycentropus pentus	reared	1m		08Sep	pools at site 3
Ross, 1941	light-trap	5m	7f	05Jun-05Aug	
Polycentropus remotus	larvae*	5		31Aug-20Apr	pools at
Banks, 1911					sites 2 & 3

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*		*Dates*	*Habitat*
PSYCHOMYIIDAE					
Lype diversa	larvae	18		27Aug-18Jun	decaying wood at
(Banks, 1914)	reared	4m		11Jun-01Jul	site 3
	reared (6-Mo.)	49m	20f	17Dec-23Apr	
	light-trap	13m	22f	05Jun-09Jul	
	sweep	16m	15f	04Jun-18Jun	
Psychomyia flavida	larvae	1		19Mar	boulder riffles
Hagen, 1861	light-trap		197f	05Jun-02Sep	at site 6
	sweep		3f	12Jun-18Jun	
GLOSSOSOMATIDAE					
Glossosoma intermedium	light-trap	1m	3f	04May-05Jun	
(Kapalek, 1892)					
Glossosoma nigrior	larvae	1031		year-around	rock riffles in
Banks, 1911	reared	116m	112f	30Apr-19Sep	moderate current
	light-trap	7m	28f	05Jun-19Aug	at sites 2-6
	sweep	4m	12f	23May-14Aug	
HYDROPTILIDAE					
Agraylea multipunctata	light-trap		3f	05Jun	probably from
Curtis, 1834					lakes or ponds
Hydroptila consimilis	light-trap	12m	166f	05Jun-05Aug	
Morton, 1905					
Hydroptila grandiosa	light-trap*		13f	05Jun-09Jul	
Ross, 1938					
Hydroptila hamata	light-trap*		4f	09Jul	
Morton, 1905					

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*		*Dates*	*Habitat*
Hydroptila jackmanni Blickle, 1963	light-trap	2m		25Jul	
Hydroptila valhalla Denning, 1947	light-trap	5m		09Jul-22Jul	
Hydroptila virgata Ross, 1938	reared	2m		01Jul	rock riffles, and pools
Hydroptila waubesiana Betten, 1934	light-trap*		23f	05Jun-19Aug	
Hydroptila wyomia Denning, 1947	light-trap*		393f	25Jun-05Aug	
Ochrotrichia spinosa (Ross, 1938)	light-trap	3m	4f	09Jul-22Sep	
Orthotrichia aegerfasciella (Chambers, 1873)	light-trap*		2f	09Jul	probably from lakes or ponds
Oxyethira anabola Blickle, 1966	larvae*	2		04Apr**	rock riffles
	light-trap		5f	05Jun-25Jun	
Stactiobiella palmata (Ross, 1938)	light-trap	1m	11f	05Jun-25Jun	
BRACHYCENTRIDAE					
Micrasema kluane Ross and Morse, 1973	larvae	83		27Aug-05May	large moss-covered rocks at site 2
	reared	41m	38f	27Apr-08Jun	
	reared (5 Mo.)	10m	5f	10Dec-18Dec	
	reared (8 Mo.)	3m	1f	03Apr-23May	
	light-trap	1m	1f	05Jun	
	sweep	29m	17f	23May-12Jun	

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*	*Dates*	*Habitat*
Micrasema rusticum	larvae	70	14Sep-09May	rock riffles at
(Hagen, 1868)	reared	36m 50f	14May-15Jul	site 4
	light-trap	45m 230f	05Jun-22Jul	
	sweep	39m 12f	04Jun-12Jun	
Micrasema wataga	larvae	17	23May-05Jun	boulder riffles
Ross, 1938	light-trap	3m	25Jun	at site 5
HELICOPSYCHIDAE				
Helicopsyche borealis	larvae	170	year-around	rock riffles
(Hagen, 1861)	reared	1m 4f	01Jul-09Jul	at site 4
	reared (5 Mo.)	1m	29Dec	
	light-trap	10m 8f	25Jun-05Aug	
	sweep	2m 1f	12Jun-18Jun	
LEPIDOSTOMATIDAE				
Lepidostoma bryanti	larvae	39	18Jan-09May	leaf packs in
(Banks, 1908)	reared	4m 2f	11May-25Jul	pools at
	reared (8 Mo.)	3m	23Mar-07Apr	sites 2, 3,
	light-trap	29m 245f	05Jun-25Jun	5 & 6
	sweep	3m	25May-12Jun	
Lepidostoma costalis	larvae	12	12Dec-28Jan	stones in
(Banks, 1914)	reared	3m 2f	28Jul-05Aug	moderate current
				at sites 2 & 6
Lepidostoma griseum	larvae	20	28Jan-08Jul	pools at
(Banks, 1911)	pupa	1	24Jul	sites 2, 4 & 6
	reared	1m	20Aug	
Lepidostoma libum	larvae	656	year-around	leaf packs in
Ross, 1941	pupae	111	17Jun-26Aug	spring seep at
	reared	402m 403f	30Apr-08Sep	site 1
	sweep	2m 4f	14Aug-02Sep	

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*		*Dates*	*Habitat*
Lepidostoma sackeni	larvae*	10		20Jan-29Jul	leaf packs in
(Banks, 1936)	reared	2m	10f	30Jul-26Aug	spring seep at
	sweep	2m	1f	14Aug-08Sep	site 1
Lepidostoma vernale	larvae*	18		07Nov-31Mar	leaf packs in
(Banks, 1897)	reared	4m		07Apr-13Apr	seep at site 1
LEPTOCERIDAE					
Ceraclea tarsipunctata	light-trap	29m	42f	25Jun-09Jul	
(Vorhies, 1909)					
Ceraclea transversa	light-trap	21m	21f	09Jul-19Aug	
(Hagen, 1861)					
Leptocerus americanus	light-trap		3f	09Jul	probably not
(Banks, 1899)					from Otter Cr.
Mystacides sepulchralis	larvae	17		14Aug-05Jun	reduced current
(Walker, 1852)	reared	10m	9f	23Jun-27Aug	at sites 2,
	reared (6 Mo.)		1f	06Apr	3 & 5
	light-trap		1f	19Aug	
	sweep	6m	1f	12Jun-16Jul	
Nectopsyche sp.	light-trap		1f	09Jul	probably not
					from Otter Cr.
Nectopsyche pavida	light-trap*		1f	05Aug	probably not
(Hagen, 1861)					from Otter Cr.
Oecetis avara	larvae	123		02Jul-23May	sandy, swift
(Banks, 1895)	reared	3m	2f	09Jun-23Jun	water at
	light-trap	186m	75f	05Jun-22Jul	sites 2 & 4
	sweep	9m	16f	04Jun-13Jul	

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*		*Dates*	*Habitat*
Oecetis cinerascens (Hagen, 1861)	reared	1m		11Sep	pools at site 3
Oecetis inconspicua (Walker, 1852)	light-trap	28m	25f	05Jun-19Aug	probably from nearby ponds
Triaenodes dipsius Ross, 1938	light-trap		1f	02Sep	
Triaenodes tardus Milne, 1934	light-trap		5f	25Jun-19Aug	
LIMNEPHILIDAE					
Anabolia consocia (Walker, 1852)	larvae	12		12Dec-18Jun	pools, margin
	reared	2m	2f	05Jun-07Aug	of creek at
	light-trap	1m	1f	08Sep,25Jun	sites 2, 3 & 5
Frenesia missa (Milne, 1935)	larvae	8		15Jul-30Oct	spring seep at
	pupa	1		03Oct	site 1
	sweep	2m		05Nov,20Jan	
Hesperophylax designatus (Walker, 1852)	larvae	9		24Jan-28Jan	intermittent
	light-trap	1m	2f	05Jun	feeder
Hydatophylax argus (Harris, 1869)	larvae	46		31Aug-02Apr	pools, in leaf
	light-trap		8f	05Jun-25Jun	packs at
	sweep		1f	12Jun	sites 2, 3 & 5
Ironoquia lyrata (Ross, 1938)	larvae	27		23Apr-11Jul	muck areas near banks at
	reared	1m	1f	11Aug	sites 2, 4 + 6
	light-trap	1m		19Aug	
Limnephilus sp.	larvae	3		09Mar-23Apr	pools at site 3

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*		*Dates*	*Habitat*
Neophylax concinnus	larvae	281		09Mar-28Jan	rock riffles at
McLachlan, 1871	pre-pupae	29		02Jul-31Jul	sites 2, 4 & 6
	pupae	26		12Aug-03Oct	
	reared	2m	4f	10Sep-22Sep	
	sweep	4m	3f	10Sep-03Oct	
Neophylax oligius	larvae	262		20Jan-11Sep	rock riffles at
Ross, 1938	pupae	20		14Aug-27Aug	sites 2, 4 & 6
	reared	30m	22f	08Aug-22Sep	
	light-trap	3m	3f	02Sep	
	sweep	5m	2f	08Sep	
Platycentropus radiatus	larvae	80		17Oct-04Jun	pools at site 3
(Say, 1824)	reared	1m	1f	29Jul,21Jul	
	light-trap	1m	1f	09Jul,05Aug	
Pseudostenophylax spp.	larvae	125		07Nov-26Aug	spring seep at
Martynov, 1909					site 1
Pseudostenophylax sparsus	reared*		1f	09Jun	spring seep at
(Banks, 1908)					site 1
Pseudostenophylax uniformis	pupa	1m		01Jul	spring seep at
(Betten, 1934)					site 1
	reared*		2f	25Jun,16Jul	
Pycnopsyche guttifer	larvae*	745		12Dec-17Oct	pools, reduced
(Walker, 1852)					current at
	pupae	69		11Aug-27Aug	sites 2-6
	reared	330m	318f	22Aug-14Sep	
	light-trap	69m	38f	02Sep-11Oct	

TABLE 1. Occurrence of species of Trichoptera at Otter Creek.—(Continued)

Species	*Collections*	*Number*		*Dates*	*Habitat*
Pycnopsyche lepida	larvae*	94		09Dec-22Aug	pools, reduced
(Hagen, 1861)	reared	3m	10f	18Aug-03Sep	current at
	light-trap	27m	51f	19Aug-08Sep	sites 2-5
Pycnopsyche scabripennis	larvae*	411		12Dec-24Jul	pools, reduced
(Rambur, 1842)	pupae	2		31Jul,14Aug	current at
	reared	3m	4f	17Aug-29Aug	sites 2-6
	reared (5 Mo.)	1m	6f	13Apr-27Apr	
	light-trap	21m	10f	05Aug-08Sep	
MOLANNIDAE					
Molanna blenda	larvae	16		14Sep-18May	sand in moderate
Sibley, 1926	reared	3m	6f	11Jun-01Aug	to slow current
	reared (4 Mo.)	1m		23Mar	at sites 2-4
	light-trap	3m		05Jun-09Jul	
	sweep	1m		05Jun	
ODONTOCERIDAE					
Psilotreta indecisa	larvae	144		12Jul-30Apr	sand in
(Walker, 1852)	pupa	1		15Jul	moderate current
	reared	13m	9f	30Mar-13Jun	at sites 2-6
	light-trap	6m	15f	05Jun	
	sweep		5f	12Jun-02Jul	
PHRYGANEIDAE					
Banksiola crotchi	light-trap	1m		09Jul	probably from
Banks, 1943					lakes or ponds
Oligostomis ocelligera	larvae	2		17Oct,12Dec	pools at site 2
(Walker, 1852)					
Ptilostomis ocellifera	larvae*	54		14Sep-06May	pools at site 2
(Walker, 1852)					

*Identification tentative.
**Collected in previous years, but not during study.

species were collected from Otter Creek. Three *Limnephilus* larvae were collected, but could not be identified to species. The 54 *Ptilostomis* larvae were throught to be *P. ocellifera,* but no confirming adults were reared or collected, and the *Oxyethira* larvae were probably *O. anabola,* the only *Oxyethira* species collected as an adult. Larvae of 3 species of *Polycentropus* were collected and tentatively identified as *P. centralis, P. flavus,* and *P. remotus* using the key by Ross (1944), while adults of *P. centralis, P. aureolus,* and *P. pentus* were collected and positively identified. This indicates that *P. centralis* larvae were correctly identified, but suggests that since larvae of *P. aureolus* and *P. pentus* are unknown, they may have been collected and incorrectly identified as *P. flavus* or *P. remotus.* Similarly, *Hydroptila jackmanni* and *H. valhalla* were identified only from males; their females and those of some other species of *Hydroptila* have not been described. Females of *H. jackmanni* and *H. valhalla* may have been collected and incorrectly identified as *H. grandiosa, H. hamata, H. waubesiana,* or *H. wyomia,* four species that were tentatively identified only from collections of females. Several other species that are known to live in streams similar to Otter Creek were collected in significant numbers, but identified only as adults. These include *Cheumatopsyche pettiti, Hydroptila consimilis, Stactobiella palmata, Ceraclea tarsipunctata, C. transversa, Oecetis inconspicua,* and *Phylocentropus placidus,* all of which probably developed in Otter Creek. It therefore appears that a minimum of 56 species of caddisflies live in Otter Creek, and that 10 to 14 more species that were collected only as adults may also develop in the stream.

Although most species of caddisflies were attracted by the black-light, some obviously were not. *Chimarra aterrima, Glossosoma nigrior, Micrasema kluane* and the species of *Lepidostoma* except *L. bryanti,* and both species of *Neophylax* did not appear to be attracted to light. In addition, females of several species were much more attracted to light than males. These include *Cheumatopsyche gracilis, C. oxa, Hydropsyche betteni, Ceratopsyche slossonae, Nyctiophylax moesta, Hydroptila consimilis, H. wyomia, Micrasema rusticum,* and *Lepidostoma bryanti.* We must point out, however, that males of some species of caddisflies fly mostly just before dawn while females fly in the evening (personal communication: David S. White, University of Michigan). Special mention should also be made of the fact that only females of *Psychomyia flavida* were collected, supporting Corbet's contention (1966a) that populations of this species are frequently parthenogenic. In *Oecetis avara,* males were more attracted to light than females.

Most of the species in Otter Creek are apparently univoltine, some with short periods of emergence and others with several cohorts that emerge over a prolonged period. A few species may be bivoltine, and one, *Psilotreta indecisa,* is probably semivoltine.

The fauna of the spring seep (Site 1) is of special interest. Larvae of *Frenesia missa, Pseudostenophylax uniformis* and/or *sparsus, Lepidostoma libum, L. sackeni,* and *L. vernale* were collected only from this seep. Larvae of the other 3 species of *Lepidostoma, L. bryanti, L. costale,* and *L. griseum* were never found in the seep and occurred only in the stream. Ours is only the second North American record for *L. libum,* which was abundant in the spring seep. Its absence from collections since its discovery in Illinois by Ross (1944) probably results from adults not being attracted to light-traps, which are widely used to collect caddisflies.

Two observations related to terrestrial pupae deserve special mention. *Hydatophylax argus* larvae constructed cases of circular leaf pieces in early autumn, and moved to cases they constructed of bulky wood chunks as winter approached. Larvae with both types of cases were readily collected in the autumn, but were never found in the 2 months prior to their emergence in June. Is it possible that this species has a terrestrial pupa as reported by Flint (1958) for *Ironoquia parvula?* We collected larvae of another species of *Ironoquia, I. lyrata,* and reared them to adults on submerged substrate in an aquarium, showing for the first time that unlike *I. parvula* this species has an aquatic pupa.

Specimens collected in this study are deposited in the University of Wisconsin Insect Collection, except for *Cheumatopsyche pasella,* which is at Florida A & M University, Tallahassee, Florida, and *Ironoquia lyrata,* which is at the Royal Ontario Museum, Toronto, Ontario.

Acknowledgements

We wish to thank Dr. Elizabeth Gordon, Florida A & M University, for verification of *Cheumatopsyche gracilis, C. pasella, C. pettiti,* and *C. oxa,* Dr. Glenn B. Wiggins, Royal Ontario Museum, for verifying *Platycentropus radiatus, Ironoquia lyrata, Neophylax oligius,* and *Anabolia consocia,* Ms. Patricia Schefter, Royal Ontario Museum, for verifying *Ceratopsyche riola, C. sparna,* and *C. slossonae,* Dr. Kenneth Manuel for verifying *Triaenodes dipsius* and *T. tardus,* Dr. Steven Hamilton, Clemson University, for verifying *Nyctiophylax moestus* Dr. John Weaver, Clemson University, for verifying *Lepidostoma libum, L. sackeni* and *L. vernale,* and Mr. Robert Kelley, Clemson University, for verifying the species of Hydroptilidae. We also wish to thank Mr. Wayne Gall for loaning us specimens and Mr. Bryn Tracy for his valuable assistance in light-trap collections.

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GRAY PARTRIDGE IN NORTHWESTERN WISCONSIN

James O. Evrard
Wisconsin Department of Natural Resources
Baldwin

Abstract

Gray partridge (*Perdix perdix*) were first released into St. Croix County in 1923 with the last known release in 1959. The bird is now established in St. Croix and adjacent counties in northwestern Wisconsin at a low but apparently stable population density.

Introduction

The history of gray or Hungarian partridge in Wisconsin has been reported by Leopold (1940), McCabe and Hawkins (1946), Lemke (1957), Basadny (1965) and Dumke (1977). Briefly, Colonel Gustav Pabst introduced the species into Waukesha County in southeastern Wisconsin from 1908-29 through a series of releases totaling 5,000 birds imported from western Czechoslovakia. These introductions and additional private and Wisconsin Conservation Department releases were responsible for the successful establishment and spread of the partridge throughout the southeastern third of the state (Fig. 1).

An isolated population of gray partridge has existed in northwestern Wisconsin for more than 50 years. The earliest release of partridge in this area was in 1923, when 20 partridge were released near Hudson in St. Croix County by Andrew Hope (Leopold 1940). During the period 1925-31, about 300 partridge reared by Joseph Burkhart from eggs bought in Alberta, were released in Polk County by the Rock Creek Trout Club (Leopold 1940). Colonel Pabst was involved in the planning of this effort. In 1930, 20 partridge imported from Europe and 30 birds produced at the State Game Farm were released in St. Croix County by the Wisconsin Conservation Department (Leopold 1940). Leopold stated that 2 coveys were seen in St. Croix and adjacent Pierce Counties in 1932 and 1934, but no partridge existed in the area in 1937. Other early releases in northwestern Wisconsin were in Eau Claire County in 1934 and Dunn County in 1941 (Lemke 1957).

A 1943 survey by McCabe and Hawkins (1946) revealed the existence of small, isolated populations of gray partridge in Polk, St. Croix and Buffalo Counties. However, these populations were not delineated on the range map drawn for Wisconsin in their publication. Leopold (1940) and McCabe and Hawkins (1946) were not sure of the origin of the birds and thought they originated from either the early releases or eastward drift of Minnesota populations.

Lemke (1957) reported additional releases of gray partridge in Barron and Buffalo Counties in 1951. In 1957, 254 partridge hatched and raised at the Poynette State Game Farm were released in St. Croix County (L. E. Hanson pers. commun.). Another 80 birds were released in adjacent Dunn County. The last known stocking effort occurred in 1959 when 40 birds from the State Game Farm were released in St. Croix County, about 3 miles south of Baldwin (E. P. Ruetz pers. commun.).

In the mid-1960s, Besadny (1965) reported that small numbers of gray partridge still existed in Polk, St. Croix and Buffalo Counties although little was known about the populations. A decade later, Faanes and Goddard (1976) stated that the gray partridge was a rare resident of St. Croix and

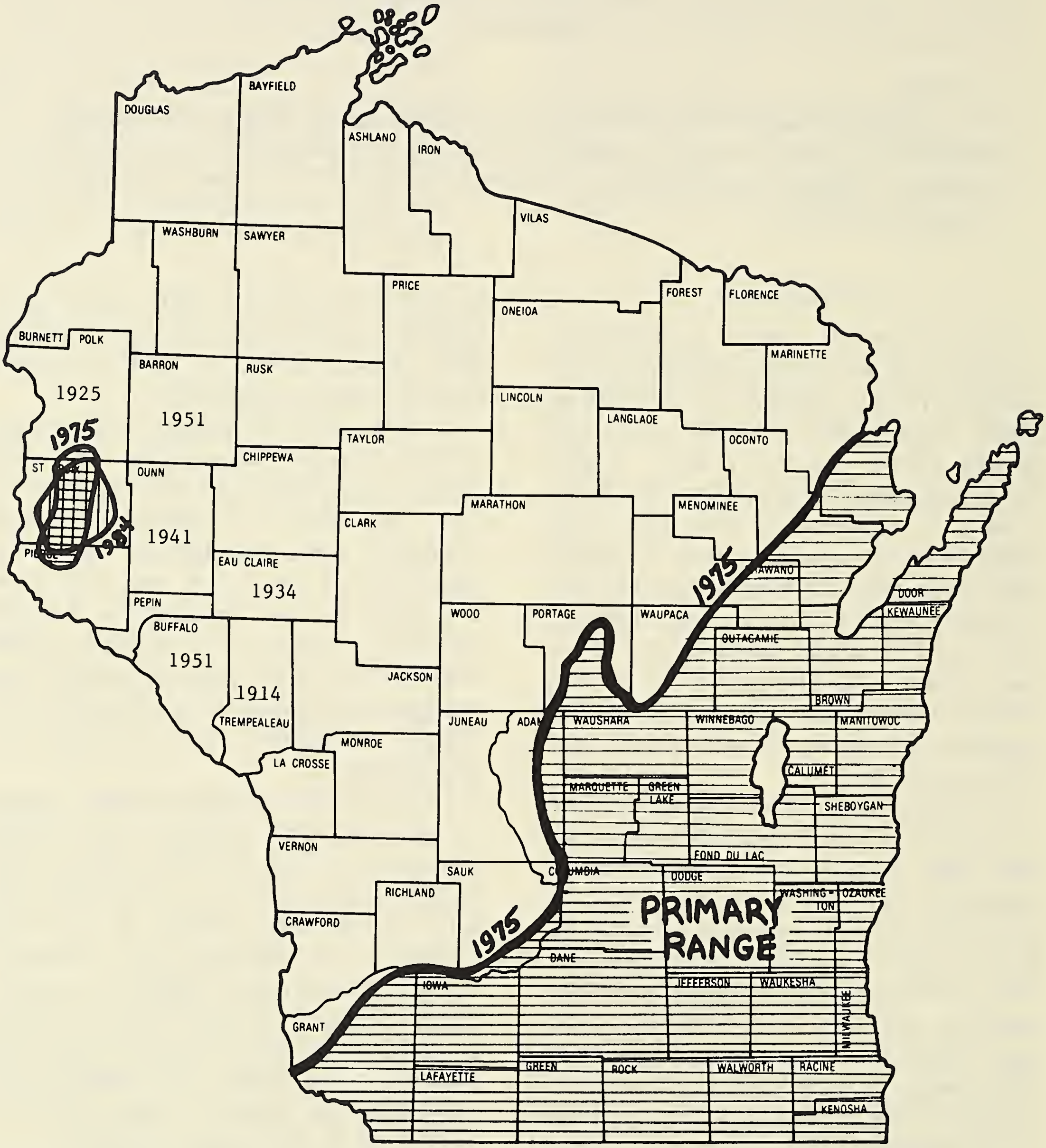

FIGURE 1. Range of gray partridge in Wisconsin (Dumke 1977). Year of first known introductions given for Polk, Barron, Dunn, Eau Claire, Buffalo, and Trempealeau Counties.

Pierce Counties with small coveys occasionally observed northwest of Hammond in St. Croix County. Dumke (1977) also reported the continued existence of the St. Croix and adjacent Pierce County population and its range was delineated on a state map for the first time. The most recent published report was by Faanes (1981) of a small population largely restricted to several townships in central St. Croix County near Roberts.

Status and Range

A search of the Wisconsin Society for Ornithology files produced records only for St. Croix and Pierce Counties and not for Polk, Barron, Dunn or Eau Claire Counties (R. K. Anderson pers. commun.). Kemper (1973) stated that the gray partridge was extremely rare in Eau Claire County with the only record being a covey he saw during the winter of 1962 near Fairchild.

Wisconsin Department of Natural Resources (WDNR) Wildlife Managers J. L. Porter, J. A. Cole and R. K. Bahr working in Barron and Dunn Counties could provide only two records. One observation, made just north of Menonomie in Dunn County by R. K. Bahr, lacked written documentation and the second, reported by J. L. Porter, was a group of 2-3 birds seen near Chetek, Barron County by WDNR Conservation Warden O. A. Anderson sometime during the period 1975-77. A second record for Barron County was a single bird seen near Prairie Farm during the fall of the same period of 1975-77 (J. Pederstuen pers. commun.). These scattered records suggest an extremely low population or juvenile birds dispersing in the fall from the established range in adjacent St. Croix County.

WDNR personnel working in southern Polk, St. Croix and Pierce Counties in 1980-84 recorded observations of gray partridge made incidental to other work. The range delineated by these observations falls within the 1975 limits drawn by Dumke (1977) (Fig. 1).

Table 1. Gray partridge coveys seen per 100 miles by rural mail carriers.[a]

Year	*Poor Range*[b]	*Good Range*[c]
1974	0.4	3.9
1975	0.4	4.1
1976	0.3	9.6
1977	0.3	2.7
1978	0.3	6.1
1979	0.6	11.1
1980	0.4	2.1
1981	0.3	6.1
1982	0.9	10.1
1983	0.4	1.4
Mean	0.4	5.7

[a] DNR Technical Services Section
[b] St. Croix, Polk, Pierce, Barron and Dunn Counties (Dumke 1977).
[c] Manitowac, Calumet, Brown, Kewaunee and Outagamie Counties (Dumke 1977).

During the winters of 1982-83 and 1983-84, gray partridge seen incidental to conducting road transects to census ring-necked pheasants (*Phasianus colchicus*) in a portion of St. Croix County were also recorded. Results of 0.3 and 0.1 coveys seen per 100 miles of road transect were within the density range classified as "poor" by Dumke (1977) and compares to the densities recorded by rural mail carriers in January for northwestern Wisconsin (Table 1). The mail carrier observations in some counties might not be reliable due to ruffed grouse (*Bonasa umbellus*), colloquially known as "partridge," being confused with gray partridge.

The gray partridge has been a member of the wildlife community in the farmlands of St. Croix and adjacent Pierce Counties for more than 50 years. The bird should continue to exist in this region, albeit at a low population density, if present agricultural practices do not intensify dramatically in the future.

I acknowledge the efforts of B. A. Moss, former WDNR Wildlife Manager at Baldwin, for providing the 1980-82 gray partridge observation locations, A. J. Rusch, WDNR Technical Service Section, for the use of unpublished rural mail carrier survey data, and R. A. Hunt and R. T. Dumke, WDNR Bureau of Research, for critical review of the manuscript.

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CHARACTERISTICS OF RUFFED GROUSE DRUMMING SITES IN NORTHEASTERN WISCONSIN

Stephen DeStefano[1]
Wisconsin Cooperative Wildlife Research Unit[2]
University of Wisconsin-Madison

Donald H. Rusch
Wisconsin Cooperative Wildlife Research Unit
University of Wisconsin-Madison

Abstract

The vegetative characteristics around ruffed grouse *(Bonasa umbellus)* drumming sites were sampled and compared among five different cover types. Forty-two drumming logs were located on the Navarino Wildlife Area in northeastern Wisconsin, and the density, height and species of shrubs, saplings and trees around each were recorded by the point-centered quarter method. Vegetation measurements around drumming logs were compared to 40 random points within each cover type. Highest densities of drummers were found in alder *(Alnus rugosa)* and aspen *(Populus tremuloides* and *P. grandidentata).* High shrub density, regardless of species, was the most crucial factor involved in distribution of drumming sites within each cover type. Drumming site characteristics and drummer densities throughout the range of the ruffed grouse were compared to our findings in northeastern Wisconsin.

Introduction

The densest populations of ruffed grouse reported in the literature are usually associated with aspen forests (Dorney 1959, Gullion 1970, Rusch and Keith 1971, Rusch et al. 1978). Within this forest type, males usually select a drumming site with a dense shrub layer (Boag and Sumanik 1969, Boag 1976, Kubisiak et al. 1980). However, ruffed grouse also live in a variety of habitats where aspen is scarce or absent (Marshall 1946, Hardy 1950, Lewis et al. 1968, Hein 1970, Porath and Vohs 1972, Hale et al. 1982) and drumming site selection and drummer densities in these habitats are less well documented. In Wisconsin, drumming male grouse are also found in oak (*Quercus* spp.), mixed northern hardwoods, and alder cover types (Dorney 1959, Kubisiak et al. 1980, Rodgers 1980). We compared drumming site characteristics and drumming male densities among these various cover types in Wisconsin and with other habitats in the ruffed grouse range.

The Navarino Wildlife Area (NWA) in Shawano and Waupaca Counties, Wisconsin, encompasses a variety of vegetative communities. Our objectives were (1) to determine which forest types were used by drumming male grouse; (2) to determine the drumming male densities in each forest type; (3) to describe the vegetative characteristics around drumming logs in each of these forest types; and (4) to compare these characteristics and densities with other published studies. We used presence and densities of drumming males and characteristics of

[1] Present address: Idaho Cooperative Wildlife Research Unit, Moscow, ID 83843

[2] In cooperation with University of Wisconsin-Madison, U.S. Fish and Wildlife Service, Wisconsin Department of Natural Resources, and Wildlife Management Institute.

drumming sites to make inferences about factors which may have been involved in habitat selection.

Our thanks to T. M. Bahti and G. G. Kloes of the Wisconsin Department of Natural Resources for assistance and support in the field. R. Draves and D. A. Buehler helped with the field work, and J. R. Cary assisted in computer programming. Financial support was provided by the Bureaus of Wildlife Management and Research of the Wisconsin Department of Natural Resources, the Federal Aid in Wildlife Restoration Act under Pittman-Robertson Project W-141-R, the Department of Wildlife Ecology of the University of Wisconsin-Madison, and the Ruffed Grouse Society of North America. L. B. Keith, D. A. Rusch, R. E. Trost, and W. Vander Zouwen reviewed the manuscript.

Study Area and Methods

The 6,500-ha NWA is owned by the Wisconsin Department of Natural Resources (WDNR) and is managed primarily for forest wildlife. About 55% (3,600 ha) of NWA is forested with 1,800 ha of aspen, 1,400 ha of hardwoods, and 400 ha of conifers. The predominate hardwoods are red maple (*Acer rubrum*), oaks, and white birch (*Betula papyrifera*), and the major conifers are white and red pine (*Pinus strobus* and *P. resinosa*) and tamarack (*Larix laricina*). In addition, there are 800 ha of brush, predominantly speckled alder and willow (*Salix* spp.; WDNR, unpubl. rep., NWA master plan concept elements, Madison, Wis., 1978). Topography is flat except for several high (10–15 m) sandy ridges separated by marshes of sedge (*Carex* spp.).

From late March to late May 1980 and 1981 we searched for drumming logs by following the drumming sound and locating piles of grouse droppings. Vegetation at 42 of the logs located in 1980 was sampled by the point-centered quarter method (Cottam and Curtis 1956). The drumming stage served as the center point and the distances to the nearest shrub (single- or multi-stemmed woody growth between 1–2 m tall), sapling (stems < 10 cm dbh), and tree in each quarter were measured. The heights of shrubs and saplings, the basal areas of trees and the species of each plant were recorded. Densities of shrubs, saplings, and trees were calculated from distance data (Cottam and Curtis 1956). Herbaceous ground cover was not measured because it was not present at the initiation of the drumming season and probably did not influence selection of drumming sites.

We recognized five forest types within potential ruffed grouse habitat on NWA: (1) mature oak and aspen with witch-hazel (*Hamamelis virginiana*) dominant in the understory, (2) mature hardwoods, predominately red maple and white birch, and aspen with variable understory growth, (3) young (10–15 years) upland aspen with cherry (*Prunus* spp.), blackberry (*Rubus* spp.), hazelnut (*Corylus americana*), and white birch shrub layer, (4) young (10–15 years) offsite (wet lowland) aspen with dogwood (*Cornus* spp.) shrubs predominating, and (5) alder thickets. Estimates of densities of drumming males in each forest type were calculated from numbers of activity centers (Gullion 1967) located within a sample plot of known size. Some drummers were captured in mirror traps (Tanner and Bowers 1948) and marked with numbered leg bands to facilitate identification of primary and alternate logs and activity centers (Gullion 1967).

Within each forest type we sampled vegetation at 40 randomly selected points, using the same sampling procedure as at the drumming logs. We then compared the vegetation at random points with the vegetation on drumming sites in each of the five forest types. When plants are aggregated, density estimates computed from point samples by usual methods tend to be low (Cottam and Curtis 1956); thus we used the modified

TABLE 1. Density estimates of drumming male ruffed grouse in 5 forest types, calculated from a sample plot of known size on the Navarino Wildlife Area (NWA), Wisconsin, 1980 and 1981.

Forest Type	Area (ha)		No. drummers on sample plot		Drummers/100ha	
	NWA[a]	Sample plot	1980	1981	1980	1981
Mature oak-aspen	150	65	2	2	3.1	3.1
Mature hardwoods-aspen	600	39	1	1	2.6	2.6
Young upland aspen[b]	900	103	9	5	8.7	4.8
Young offsite aspen[b]	900	119	7	6	5.9	5.0
Alder thicket	550	90	6	6	6.7	6.7
Totals	3100	416	25	20		

[a] Approximate total ha of each forest type on NWA.
[b] Aspen of approximately 10-15 years of age.

TABLE 2. Comparison of ruffed grouse drumming male densities with forest types and understory densities on several areas of the ruffed grouse range. Alder and aspen habitats appear to support the highest male densities, but when not available other forest types may support relatively high densities (e.g., young hardwood stands with shrub understory in Iowa, balsam fir in northern Wisconsin). Thick understory cover generally supports high male densities, but dense shrubs and saplings devoid of overstory apparently do not support drumming males (e.g., early successional aspen in Minnesota, northeastern Wisconsin and Alberta).

Area of Study	Forest type	Understory[a]	Drumming males per 100 ha[b]	Reference
Northeastern Wisconsin	Early successional aspen[c]	16,582 stems/ha	0	DeStefano and Rusch (this study)
	Alder	15,645 stems/ha	6.7[d]	
	Young upland aspen	12,553 stems/ha	6.7	
	Young offsite aspen	32,810 stems/ha	5.4	
	Mature oak-aspen	914 stems/ha	3.1	
	Mature hardwoods-aspen	2,305 stems/ha	2.6	
Minnesota	Early successional aspen[c]	29,652 aspen stems/ha	0	Gullion 1970
	Mature aspen with hardwood shrubs	14,826 aspen stems/ha	48.6	
	Mature aspen with hardwood shrubs and saplings	7,413 aspen stems/ha	48.6	
	Mature aspen with hardwood saplings	2,471 aspen Stems/ha	12.3	
	Mature hardwoods and mature aspen	494 aspen stems/ha	5.0	
	Mature hardwoods; aspen	0 aspen stem/ha	0-2	
Alberta	Early successional aspen[c]	2,822 stems/ha	0	Rusch and Keith 1971
	Aspen	4,542 stems/ha	46.3	
	Spruce woods	2,624 stems/ha	4.7	Rusch et al. 1971
Georgia	Oak-hickory with ericaceous shrubs	10,550 stems/ha	1.2	Hale et al. 1982

[a] Usually includes shrub and sapling growth except where noted.
[b] Drumming male densities extrapolated to males/100 ha from original data.
[c] No canopy or forest cover *per se* existed at the early successional aspen stage.
[d] Drumming male densities averaged between 1980 and 1981 (see Table 1).

method of calculation described by Rusch and Keith (1971) to estimate plant densities.

Results and Discussion

In 1980 and 1981, 73 and 85 activity centers, respectively, were located on NWA, 46 of which were used both years by the same or a different bird. In both years, drumming male ruffed grouse were found in all five forest types. Highest densities of drummers were consistently found in alder thickets and young upland and offsite aspen (Table 1). These habitats provided shrub and sapling cover ≥ 3 times denser than that in mature oak-aspen or mature hardwoods-aspen. In the latter habitats, only two and three activity centers, respectively, were located on all of NWA. Alder and aspen also supported high grouse densities throughout much of the central portion of the ruffed grouse range (Table 2).

Within alder and upland aspen habitats, male ruffed grouse selected drumming sites with denser shrubs than were found at random points ($P < 0.05$). In young offsite aspen, shrubs were uniformly dense at drumming logs and random points. The three logs in hardwoods-aspen were also located in shrub growth unusually dense for that type. Shrubs were uniformly scarce in the oak-aspen forest, and shrub densities at the two drumming logs were similar to those at random points. However, these logs were found in areas of unusually dense sapling growth. In this forest community with sparse understory, saplings may have provided the necessary understory cover near drumming logs. In all other cover types, sapling densities at random points and drumming logs were similar (Table 2).

Shrub and sapling heights, tree basal area, and tree density were generally not different for random points and drumming logs in each of the 5 cover types, indicating that these characteristics probably did not influence drumming site selection on NWA ($P > 0.2$). However, there were 3 exceptions: (1) sapling heights were greater around random points than around drumming logs in mature oak-aspen ($P < 0.05$), (2) average tree basal area was significantly larger around drumming logs in alder than at random points ($P < 0.05$). and (3) tree density was significantly greater around drumming logs than at random points in young offsite aspen ($P < 0.01$). Shorter saplings indicate younger, and therefore denser, growth in the oak-aspen type where saplings were more important as cover than shrubs. As the saplings got older, natural thinning reduced the amount of vertical cover. The latter two differences might be related to active selection for drumming sites with some overstory in young forests and brushy habitats, or they may be incidental consequences of sites near habitat edges.

Gullion et al. (1962), Berner and Gysel (1969), and Kubisiak et al. (1980) suggested that drumming logs are often located on or near habitat edges. All of the logs in alder located by Kubisiak et al. (1980) in central Wisconsin were within 40 m of a cover type edge, and 91% were within 20 m. On NWA, timber cutting and topography often created sharp lines of demarcation between habitat types, such as aspen-field edges and lowland alder-upland aspen. Of the drumming logs we found, 91% were within 40 m of an edge, and 58% were within 20 m. In addition, drumming logs in young upland aspen had significantly fewer aspen saplings around them than did random points, and significantly more hazelnut shrubs and white birch saplings ($P < 0.05$). Drumming logs in alder thickets had significantly fewer alder shrubs and saplings and significantly more aspen saplings than did random points in alder ($P < 0.05$). This intermixing of species and the proximity of drumming logs to adjacent cover types would seem to indicate that grouse on NWA selected drumming sites near habitat edges. However, drumming log locations were not significantly closer to edges than were randomly located points ($P > 0.5$). Most coverts on NWA were in small, highly interspersed patches, and most drumming sites were consequently near an edge. Drumming site selection thus seemed more dependent upon shrub cover than proximity of edge *per se*.

Four species of shrubs made up 55% of the shrub cover around drumming logs on NWA (Table 3). Dogwoods and winterberry (*Ilex verticillata*) were found more frequently around drumming logs than at random points, and witch-hazel and cherry shrubs less frequently (Table 3). Dogwood and winterberry shrubs were significantly nearer sampling points than were witch-hazel and cherry shrubs ($\bar{x}$ = 1.2 ± 1.6 m vs. 4.3 ± 3.4 m, respectively, t = 8.87, P < 0.01), even though the former were less abundant than the latter (Table 3). This may indicate that dogwood and winterberry shrubs grew in denser clumps and provided better cover. In alder thickets, hazelnut and slippery elm (*Ulmus rubra*) formed the shrub layer more often around drumming logs than at random points (P < 0.01), and their proximity to sampling points (0.6 ± 0.2 m and 0.6 ± 0.5 m, respectively) indicated that these species also may have grown in dense clumps.

Four sapling species made up 71% of the sapling cover around drumming logs (Table 3). Cherry and white birch were found more frequently around drumming logs than at random points, and aspen saplings less so (Table 3). However, mean distance of cherry and white birch from sampling points was significantly greater than aspen (4.9 ± 5.1 m vs. 2.7 ± 4.2 m, respectively, t = 3.40, P < 0.01). Optimal sapling growth on drumming sites may be dense enough to provide protection from avian predators, yet open enough to allow detection of mammalian predators (Gullion 1970). In contrast, Boag and Sumanik (1969) suggested that cover selected by drumming males may represent an evolutionary compromise between cover dense enough for full protection against predators and sparse enough to allow exposure of the visual and auditory displays to conspecifics. Available data on ruffed grouse habitats and densities in North America supported the idea that abundance of grouse was generally related to the density of the forest understory (Table 2). Considering the potential bias and variance in estimates of grouse density, the relationship was surprisingly consistent. Early successional aspen without forest overstory did not support ruffed grouse in Minnesota, Alberta, or northeastern Wisconsin (Table 2). We have witnessed, but not documented, a similar instance in Manitoba. We conclude that understory stem density alone does not govern site selection by drumming male ruffed grouse. Forest overstory also seems to be required, perhaps for protection from avian predation as suggested by Gullion (1970). Although forest understories which are too dense for adequate detection of mammalian predators or too dense for satisfactory auditory and visual communication among ruffed grouse may exist in

TABLE 3. Percent frequency of shrub and sapling species around 42 drumming logs and 200 random points in 5 forest types used by ruffed grouse on the Navarino Wildlife Area, Wisconsin. Four shrubs and 4 saplings per point or log were recorded by the point-centered quarter method.

Species[a]	Random points	Drumming logs
Witch-hazel	16	4[c]
Speckled alder	16	16
Cherries	11	4[c]
Dogwoods	10	15[b]
Blackberry	9	11
Winterberry	5	13[c]
Other shrubs	33	37
Total shrubs	100	100
Aspen	42	24[c]
Speckled alder	17	17
Red maple	14	14
Oaks	9	6
White birch	5	9[b]
Cherries	3	16[c]
Other saplings	10	14
Total saplings	100	100

[a] Scientific names given in text.

[b,c] Significantly different (P <0.05, <0.01, respectively) frequencies at drumming logs than at random points.

North America, as implied by hypotheses of Gullion (1970) and Boag and Sumanik (1969), we have not found this documented in the literature.

Dense shrub-like growth, regardless of species, is probably the most crucial factor involved in drumming site selection in any forest type. Alder and aspen cover types appear to support the highest densities of drumming male grouse, but when not available other forest types may provide suitable cover, such as young hardwood stands with shrub understory in Iowa (Porath and Vohs 1972) and balsam fir in northern Wisconsin (Kubisiak et al. 1980). Thick understory cover generally supports high male densities, but dense shrubs and saplings devoid of overstory apparently do not (Rusch and Keith 1971).

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BROOK LAMPREYS (*ICHTHYOMYZON FOSSOR* AND *LAMPETRA APPENDIX*) IN THE WISCONSIN PORTION OF THE ILLINOIS RIVER DRAINAGE

PHILIP A. COCHRAN
Center for Limnology
University of Wisconsin-Madison

The distribution of Wisconsin fishes has been recently detailed by Becker (1983), with additional work conducted by the Wisconsin Department of Natural Resources Fish Distribution Survey (Fago 1982, 1983). The purpose of this note is to provide new locality information for two species of nonparasitic brook lampreys in southeast Wisconsin. Both species were collected on April 25, 1982, in the Mukwanago River, a tributary to the Fox River in the upper Illinois River drainage.

Northern Brook Lamprey

Two adult northern brook lampreys (*Ichthyomyzon fossor*) were captured with a seine at the County Road E crossing, just downstream from Eagle Spring Lake in Waukesha County (T-5-N, R-17-E, Sec. 36). The stream at this site was 3-5 meters wide and less than 1.5 meters deep throughout, with many shallower riffles. The bottom was variable with some gravel, boulders, and silt. Fantail darters (*Etheostoma flabellare*), banded darters (*E. zonale*), a common shiner (*Notropis cornutus*), and a hornyhead chub (*Nocomis biguttatus*) also were collected. Total lengths of the two lampreys after preservation were 131 and 132 mm. Both specimens were deposited in the fish collection of the University of Wisconsin Zoology Museum (UWZM #8266).

Northern brook lampreys have not been reported previously from the Illinois River drainage in Wisconsin (Becker 1983), although they were collected recently at one location in the adjacent Rock River drainage (Fago 1982). They also have been collected recently in the Kankakee River in the upper Illinois River drainage in Illinois, the only known locality for that state (Smith 1979). The upper Illinois River drainage may have been reached by direct dispersal up the Illinois River from the Mississippi River, since locality records in the lower Missouri River drainage (Rohde and Lanteigne-Courchene 1980) indicate that northern brook lampreys were present at one time near the mouth of the Illinois. Alternately, northern brook lampreys may have gained access to the upper Illinois River drainage through recent secondary connections, as postulated by Bailey (1954) for the brassy minnow (*Hybognathus hankinsoni*).

American Brook Lamprey

American brook lampreys (*Lampetra appendix*) were collected at the County Road CP crossing in Waukesha County (T-5-N, R-18-E, Sec. 32). Several spawning aggregations of 8-10 individuals were observed in the early afternoon at a water temperature of 15.4 C and a depth of 26-40 cm. Bottom substrate was gravel and pebbles, and stream width was 8-10 meters. Other fish species collected were hornyhead chubs, blacknose shiners (*Notropis heterolepis*), fantail darters, banded darters, johnny darters (*Etheostoma nigrum*), and rock bass (*Ambloplites rupestris*). Three lampreys were deposited in the University of Wisconsin Zoology Museum (UWZM #8368).

American brook lampreys were not reported from the Wisconsin portion of the Illinois River drainage by Becker (1983), but they recently have been collected in this drainage by the Wisconsin Department of Natural Resources (D. Fago, personal communication). They also have been recorded in the Fox River drainage in Illinois and elsewhere in the Illinois River system (Smith 1979), and like the northern brook lamprey, have been recorded recently in the adjacent Rock River drainage in Wisconsin (Fago 1982).

Discussion

Brook lampreys may be difficult to detect, even in heavily collected areas (e.g., see Trautman 1981, p. 149). For example, the southern brook lamprey (*Ichthyomyzon gagei*) only recently was discovered in the St. Croix River drainage in northwest Wisconsin (Cochran 1984). That *I. fossor* and *L. appendix* have not been recorded previously from the vicinity of the most densely populated area of Wisconsin is therefore not surprising. It is noteworthy, however, that both species have persisted in this region; populations of brook lampreys have declined near some urban areas (Eddy and Underhill 1974; Trautman 1981). Judging from recent collection records, the American brook lamprey is more commmon than the northern brook lamprey in southeastern Wisconsin.

Brook lampreys often are perceived negatively by the general public, perhaps through association with the sea lamprey (*Petromyzon marinus*) and other parasitic species. Unfortunately, misinformation in certain recent popular Wisconsin publications[1] may serve to perpetuate this tendency. Vladykov (1973) provided ecological, economic, and ethical reasons for the conservation of this relatively vulnerable component of our ichthyofauna.

Acknowledgements

John Lyons and Frank Rahel assisted with the field collections, and John Lyons made several suggestions that improved the manuscript.

Note

[1] Smith (1977) found a "brook lamprey" in the Kickapoo River and stated that ". . . it attaches itself to living fishes and rasps their flesh. It also eats worms and insects." Brook lampreys are not parasitic and no lamprey is known to prey on invertebrates. Also, in a recent newspaper review of Becker's (1983) monograph, Elsner (1983) referred to "detested lampreys." Half of Wisconsin's lamprey species are nonparasitic and do not deserve such a reputation.

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LONG TERM COMPARISON OF THE POPULATION STRUCTURE OF THE CISCO (*COREGONUS ARTEDII* LE SUEUR) IN SMALLER LAKES

LARS G. RUDSTAM
Center for Limnology
University of Wisconsin-Madison

Abstract

Comparisons of the population structure of essentially non-exploited cisco populations in three Wisconsin lakes in 1981–82 with data from 1928–32 revealed that growth has increased significantly in all three lakes and that density appears to have declined since the 1930's. The magnitude of the increase in growth in two of the lakes was comparable to the largest reported differences in growth among years within exploited cisco populations. This change in population structure is consistent with an explanation based on increased predation pressure from introduced piscivores, primarily walleye and muskellunge. Other possible contributing factors are discussed.

Year class strength was variable and asynchronous among lakes both in the 1930's and in the 1980's. This persistent asynchrony among lakes supports Hile's (1936) suggestion that variable year class strength of cisco depends primarily on local conditions within each lake; intraspecific competition may be a major factor.

INTRODUCTION

After Van Oosten's (1929) pioneering work on the age and growth of the cisco or lake herring, *Coregonus artedii,* there was a proliferation of studies describing age and growth of this species in different lakes (Bajkov 1930, Hile 1936, Fry 1937, Carlander 1937 and 1945, Cooper 1937, Smith 1956, Dryer and Beil 1964, Smith 1972 and others (see review by Carlander, 1969). These studies have shown the cisco to be a variable species with large differences in growth rates and condition factors among populations. Investigations dealing with changes within one population over time are not as numerous and the majority of such studies involve exploited cisco populations from the Laurentian Great Lakes (Scott 1951, Smith 1956, Dryer and Beil 1964, Selgeby 1982). Few long term studies have been made on populations in smaller lakes (but see Carlander 1945, Clady 1967, and Hoff and Serns 1983).

The Wisconsin Geological and Natural History Survey's investigations in northern Wisconsin during the 1920's and 1930's included a thorough study by Hile and co-workers on the cisco populations in four lakes and shorter notes on the populations in three other lakes (Hile 1936, Couey 1935, Hile and Juday 1941). These studies provided an opportunity to investigate long term changes in the structure of cisco populations in smaller lakes. Five lakes, including three of Hile's primary lakes, were re-investigated in 1981 and 1982 as part of the Long Term Ecological Research—Northern Lakes project. Of these populations, only the one in Pallette Lake had been studied since the 1940's (Engel and Magnuson 1976, Engel 1976, Hoff and Serns 1983). The populations in Big Muskellunge and Sparkling Lakes are especially interesting, since these populations are currently not exploited and historically have been exploited only to a limited extent if at all. Information on long term changes of unexploited populations is nonexistent.

In the 1930's, the year class strength of cisco was variable but not synchronized

Fig. 1. Map of the study area in Wisconsin's Northern Highland Lake District. The lakes investigated by Hile in the 1930's and re-investigated in 1981–82 were: (1) Trout Lake, (2) Sparkling Lake, (3) Big Muskellunge Lake, (4) Allequash Lake, and (5) Pallette Lake. Note that all the lakes are within eight km of the Trout Lake Station of the University of Wisconsin. The other two lakes investigated by Hile, Clear Lake and Tomahawk Lake, are situated approximately 22 km south of the Trout Lake Station.

among lakes (Hile 1936). Hile, therefore, suggested that year class success depends more on the local conditions within a lake than on weather. Correlations of weather events with year class success have, however, been at least partly successful for other coregonids (Lawler 1965, Christie 1963—temperature; Järvi 1942a, Järvi 1947, Miller 1952—wind); although some investigators have failed to obtain such correlations (Svärdson 1956, Aass 1972). Detailed investigations of the year class structure of cisco populations in lakes in close vicinity to each other are rare. Weather events should affect such lakes in similar ways, although different lake morphometries may modify the effect of storms or air temperature. A persistent asynchrony among strong year classes in these lakes would be consistent with Hile's suggestion and would not support a hypothesis directly relating cisco year class strength to storm events or temperature.

Study Area

The five lakes investigated are located in Vilas Co., in Wisconsin's northern highland lake district. They are surrounded by conifer and aspen-birch forests and all are within eight km of the Trout Lake Station of the University of Wisconsin—Madison (Figure 1). The geology and general topography of the area is described by Juday and Birge (1930). Morphometric and limnological characteristics of the lakes are summarized in Table 1.

Current exploitation of cisco in the lakes investigated is limited or nonexistent. Ice fishing and some seining at spawning time, which includes cisco as an incidental catch, occurs on Trout Lake only. Historically, the Pallette Lake population and to a limited extent the Big Muskellunge and Trout Lake populations have been exploited by seining at the spawning grounds (Serns, DNR-Woodruff, pers. comm., Hoff and Serns 1983).

Methods

Fish sampling

The five lakes were sampled between July 13 and August 18, 1981, and between July 27 and August 19, 1982, with seven vertical gill nets, each with a different mesh size (19mm, 32mm, 38mm, 51mm, 64mm, and 89mm stretch mesh in both years, with a 127mm net in 1981 and a 25mm net in 1982). The nets, 4 m wide and 18 m deep, were made of multifilament nylon twine and mounted on foam rollers following the description by Kohler et al. (1979). The seven nets were set in a straight line for 48 hours per lake along the

TABLE 1. Morphometric and limnological characteristics of the lakes investigated. All lakes are located in Wisconsin's northern highland lake district.

Lake	*Water source (5)*	*Area (ha)*	*Max depth (m)*	*Mean depth (m)*	*Alkalinity 1979–81 (mmol/l)*	*Conductivity 1928–42 (µs/cm at 20C)*	*Conductivity 1979–81 (µs/cm at 20C)*	*P*	*pH*
Pallette	S	69	19.8	9.7	0.15	21	20	N.S.	7.3
Sparkling	S	81	20.0	11.3	0.61	68	74	<.05	7.9
Big Musk.	S	396	21.4	7.0	0.39	45	48	N.S.	8.2
Trout	D	1605	35.7	13.8	0.82	83	90	<.05	8.3
Allequash	D	164	8.0	2.9	0.79	76	81	—	7.9
Source*	1	1,3	1,3	2,3	4	4	4	4	3,4

* 1) Black *et al.* (1963)
2) Juday and Birge (1941)
3) LTER—Northern Lakes (1981 and 1982)
4) Bowser *et al.* (1982), P = significance level of conductivity changes (two-tailed t-test)
5) S = seepage lake, D = drainage lake.

18 m depth contour (14 m depth contour in Pallette Lake and in the deepest part of Allequash Lake). In 1981, Trout Lake was fished for an additional 24 hours with the nets suspended from 13 to 30 m depth, after a large number of fish targets were observed on sonar in water deeper than 18 m in that lake. In 1982 the nets were elongated to allow fishing in Trout Lake from the surface to 30 m depth. The nets were checked approximately every six hours, between 0300–0500, 0900–1100, 1500–1700, and 2100–2300 central standard time in 1981 and once every 24 hours in 1982. Pallette Lake was sampled only in 1981.

All fish caught were identified, total length measured to the nearest mm and depth of catch noted in one meter intervals. Scales and otoliths were collected from up to ten ciscoes of each 10 mm length group. Scales were collected from above the lateral line between the dorsal and adipose fin in 1981 and above the lateral line between the dorsal and pectoral fin in 1982.

Aging

Scales were used for aging to be consistent with historical data. Impressions of larger scales were made on acetate slides. Smaller scales were mounted on microscope slides. The scales or their impressions were read on a microfiche reader (25x magnification). The age determined for the sample of ten fish from each 10 mm size class was assigned to the remainder of the fish of that size. Overlap in sizes of different year classes occurred

TABLE 2. Comparison between ages assigned from scales and from otoliths for cisco from five Wisconsin lakes sampled in 1981. Encircled numbers indicate correspondence between the two aging methods.

		Otolith Age									
Lake	*Scale Age*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Older*	*Total #*
Pallette	1			1	1	3	1				6
	2			(1)	4	5	3				13
	3					1					1
Big Musk	0	(3)									3
	1		(11)	2							13
	2			(3)							3
	3				(1)						1
Sparkling	0	(4)									4
	1		(20)	1							21
	2			(3)							3
	7							1			1
Trout	0	(2)									2
	1		(5)	1							6
	2		1	(1)							2
	3						1	1			2
	4				1	(1)			1		3
	5								1		1
	6								3		3
	7								(1)	1	2

only in Trout Lake. The relative numbers of the different size groups were corrected for gill net size selectivity by taking both the selectivity of different mesh size and size dependent changes in locomotory activity into account (Rudstam et al. in press).

Though the scale method has been used for cisco since Van Oosten (1929), this method has recently been criticized for a lack of accuracy in aging some populations of coregonids, especially for older fish (Aass 1972, Power 1978, Mills and Beamish 1980). To test the validity of scale aging, a representative sample of 20 fish from each lake was aged using both scales and otoliths. Otoliths were heated on a hot plate until brown, cracked in median cross section through the nucleus, and viewed submerged in glycerine under a dissecting microscope (modified from Christensen 1964 and Power 1978). The annulus characters were discussed with Olle Enderlein (Freshwater Institute, Drottningholm, Sweden), who has used otoliths extensively for age determinations of the vendace, *Coregonus albula*.

No difference in the age assigned by scales and otoliths was found in the lakes with the fastest growing populations (Big Muskellunge and Sparkling Lakes, Table 2). Older fish from the slow growing populations in Pallette and Trout Lakes were difficult to age due to crowding of annuli on both scales

TABLE 3. Catch per unit effort (CPUE) of cisco in gill nets in 1930–32 and in 1981–82. The CPUE was calculated as the number of ciscoes caught in 100 square yards of netting of each mesh size set for 24 hours to allow comparisons with historical data. Only depths where the cisco were abundant were included. The catches in 1981 and 1982 are adjusted assuming the nylon nets are 1.33 times more efficient than cotton nets (Berst 1961). Source: Hile (1936) Table 44 and LTER—Northern Lakes (1981 and 1982).

Lake	*Year*	*Date (MM/DD)*	*Depth (m) included*	*Nets used*	*CPUE (1)*	*CPUE (2)*	*CPUE (3)*
Big Muskellunge	1930	08/28–29	9 –11	(4)	106.1	—	106.1
	1931	08/04–23	9.5–10	(4)	143.9	—	143.9
	1932	07/01–08/05	11 –13	(5)	93.4	135.4	135.9
	1981	07/31–08/02	9 – 11	(6)	86.5	121.8	444.0
	1982	08/17–19	11–13	(7)	13.8	18.4	41.5
Sparkling	1930	08/9–10, 08/15	10.5–15.5	(4)	81.6	—	81.6
	1931	07/17, 08/22	10.5–15.5	(5)	75.0	137.0	213.0
	1981	08/07–09	10 –16	(6)	19.6	38.0	136.2
	1982	08/03–05	10 –16	(7)	38.4	73.8	75.3
Trout	1930	07/29–31	15 –33.5	(4)	104.8	—	104.8
	1931	07/22–08/31	15 –33.5	(5)	75.8	136.8	137.8
	1981	08/10–12 08/18	15 –28	(6)	47.1	105.5	126.9
	1982	07/27–29	15 –31	(7)	76.1	121.1	122.2
Allequash	1930	07–08?	—	not reported	total catch 70 cisco		
	1981	08/04–06	0 – 7	(6)	0	0	0
	1982	08/01-03	0 – 7	(7)	0	0	0

1) CPUE in two nets with mesh sizes 38 and 51 mm stretch mesh.
2) CPUE in five nets with 32, 38, 51, 64, and 89 mm stretch mesh.
3) CPUE in all nets used.
4) 38 and 51 mm stretch mesh horizontal cotton nets.
5) 32, 38, 44, 51, 57, 64, and 89 mm stretch mesh horizontal cotton nets.
6) 19, 32, 38, 51, 64, 89, and 127 mm stretch mesh vertical nylon nets.
7) 19, 25, 32, 51, 64, and 89 mm stretch mesh vertical nylon nets.

and otoliths. Otolith readings often resulted in age assignments 1 to 3 years older than scale readings (Table 2). Older age assignments using otoliths have been observed elsewhere (Aass 1972, Erickson 1979). The Pallette Lake otoliths were unusually difficult to read (Enderlein pers. comm.). Since scale ages better corresponded to size frequencies, scales were considered to be more reliable than otoliths in that lake. The use of scales in the present study may have resulted in a bias towards 2 year olds in Pallette Lake and towards 3, 4 and 5 years olds in Trout Lake. Scales were, however, adequate for younger fish in these lakes and for all fish from Big Muskellunge and Sparkling Lakes.

Comparison with historical data

Size at capture in 1928–1932 was tabulated for comparisons with recent data. The sampling seasons for 1928–32 and for 1981–82 did overlap (Table 3). The standard lengths reported by Hile were converted to total length using a conversion factor of 1.18 (Hile 1936). Standard errors for the historical data were calculated from length frequencies (Hile 1936, Tables 21, 22, and 23).

Differences in fishing methods between the two studies could introduce systematic errors in comparisons of catch per unit effort (CPUE). Hile used 46 m wide and 2 m deep horizontal gill nets made of cotton, which were set along the bottom at specified depths. In 1981–82, 4 m wide and 18 m deep multifilament nylon nets set from surface to bottom were used. To minimize possible errors, only catches in identical mesh sizes were compared, and the CPUE were calculated according to Hile (1936). Hile reported the numbers of cisco caught in each mesh size per 24 hours and 100 square yards of netting in the water depth with the highest density of fish. This depth interval included most of the hypolimnion in Sparkling and Trout lakes, but only one to two meters at the bottom of the metalimnion in Big Muskellunge Lake. Thus, the CPUE values reported here are an index of maximum density during summer stratification. In addition, a correction factor for the documented higher efficiency of nylon versus cotton nets was introduced. Multifilament nylon nets have been reported to be from 1.33 to 3.2 times more efficient for coregonids as compared to cotton nets (Lawler 1950, Molin 1951 and 1953, McCombie and Fry 1960, and Berst 1961). Only one of these studies, however, involved cisco, and the ratio from that study (1.33, Berst 1961) was used to

TABLE 4. Number of fish of different species caught in gill nets during the two time periods. Only fish caught at depth occupied by cisco are included. Note that the sampling effort varies among lakes and time periods. Source: Hile (1936, Table 70) and LTER-Northern Lakes (1981 and 1982).

Lake	*Big Muskel.*		*Sparkling*		*Trout*		*Allequash*		*Pall. Clear*	
Year	*28–31*	*81–82*	*28–31*	*82–82*	*28–31*	*81–82*	*30*	*81–82*	*81*	*31–32*
Species:										
Cisco	1863	209	524	181	1197	449	70	—	143	465
Lake whitefish	—	—	—	—	32	5	—	—	—	—
Lake trout	—	—	—	—	32	—	—	—	—	—
Rainbow smelt	—	—	—	11	—	—	—	—	—	—
Yellow perch	1543	361	1	—	—	—	182	15	—	5
Walleye	—	—	—	—	—	—	22	—	—	37
Centrarchids 1)	22	—	—	—	—	—	23	1	—	1
Other sp. 2)	130	—	—	—	1	—	15	2	—	—

1) Centrarchids include: Rock bass, Large mouth bass, Small mouth bass, Bluegill, and Black crappie.
2) Other species includes: Burbot, Muskellunge, Golden shiner, and White sucker.

TABLE 5. Total length (mm) at capture of cisco from three Wisconsin lakes in 1928–32 and 1981–82. Mean and standard deviations of the lengths from 1928–32 were calculated from length frequency distributions. Standard lengths were converted to total lengths by multiplying with 1.18 (Hile 1936). The significance levels (P) are for the comparison of 1981 and 1982 with the year with the largest mean size 1928–32 using a two-tailed t-test. Source: Hile (1936) Tables 21, 22, and 23, and LTER—Northern Lakes (1981 and 1982).

Age	1928			1930			1931			1932			1981				1982			
	mean	S.D.	N	mean	S.D.	N	mean	S.D.	N	mean	S.D.	N	mean	S.D.	N	P	mean	S.D.	N	P
Big Muskellunge Lake:																				
0+	—			—			—			—			98.4	4.5	124	—	99.5	3.9	6	—
1+	161.0	14.6	19	174.1	10.4	17	159.7	4.2	9	164.8	9.4	15	187.3	6.9	61	***	192.8	12.5	8	**
2+	188.7	7.4	252	191.6	6.9	214	175.9	7.7	258	184.3	6.9	24	240.2	5.0	5	***	250.8	6.0	6	***
3+	201.2	9.2	70	196.2	5.5	14	196.1	5.9	347	—			280	—	1	—	—			
6+	—			—			—			—			—				313	—	1	—
Sparkling Lake:																				
0+	—			—			—			—			96.7	3.7	73	—	98.7	4.5	7	—
1+	—			—			166.3	7.4	63	—			195.4	13.6	35	***	176.6	6.9	52	***
2+	185.3	9.8	9	202.9	6.8	7	202.3	8.6	19	—			264.8	3.9	4	***	242.8	8.6	6	***
3+	195.2	8.4	46	213.6	10.8	25	207.2	7.4	61	—			303	—	1	—	287.0	12.0	3	***
4+	205.0	7.4	69	217.5	8.1	58	215.3	8.7	102	—			—				—			
5+	214.2	7.6	10	227.0	7.8	25	221.8	8.2	102	—			—				—			
6+	—			234.4	3.4	3	229.4	6.4	21	—			340	—	1	—	—			
7+	—			—			—			—			373	—	1	—	—			
Trout Lake:																				
0+	—			—			—			—			98.5	3.8	19	—	80	—	1	—
1+	149.9	—	2	151.0	8.3	2	—			—			150.0	4.0	55	N.S.	—			
2+	158.1	5.8	102	165.4	9.5	36	160.7	6.4	61	—			188.0	8.5	15	***	176.0	10.2	210	***
3+	168.3	4.9	61	175.8	6.7	347	167.6	6.1	173	—			197.7	6.8	41	***	197.3	9.5	31	***
4+	173.5	6.7	17	184.0	8.0	99	174.6	6.8	269	—			203.5	7.7	25	***	206.0	3.8	15	***
5+	—			197.0	13.5	9	184.0	7.0	79	—			205.3	4.5	9	N.S.	205.2	13.6	13	N.S.
6+	—			—			194.1	11.6	12	—			210.5	5.9	9	N.S.	199	—	1	—
7+	—			—			206.5	19.5	4	—			232	—	1	—	—			
8+	—			—			—			—			—				244	—	1	—

N.S. = not significant
* = $p<0.05$
** = $p<0.01$
*** = $p<0.001$

adjust the catches in 1981-82. Identical mesh sizes caught similar sizes of cisco in both studies.

Results

Cisco populations are still present in four of the five lakes investigated (Table 4). In Allequash Lake, however, the species has disappeared. The results on changes in growth and abundances are, then, from Trout, Sparkling and Big Muskellunge Lakes. The results from Pallette Lake were used primarily for the comparison of year class structure since Hile (1936) did not report size at capture or CPUE from this lake. Other information on the cisco population in that lake has been analyzed by Hoff and Serns (1983).

The lengths at capture of ciscoes I+ and older (Sparkling and Big Muskellunge) and II+-IV+ (Trout) were significantly greater both in 1981 and in 1982 compared to 1928-32 (Table 5, Figure 2). The significance levels given are for the comparison of 1981 and 1982 with the year having the largest length at capture in 1928-32 (2-tailed t-test, Table 5). Differences in age assignments of larger cisco may account for some of the differences observed in Trout Lake, but not in the other two lakes.

Catch per unit effort (CPUE) in gill nets appears to have declined in all three lakes (two way ANOVA, fixed model, Table 6 and Figure 3). Although an attempt was made to account for differences in fishing methods between the two studies, some bias may still be present. There are reasons to believe, however, that existing bias should be towards higher CPUE in 1981-82. Since growth has increased, the mesh sizes used in the comparison were more efficient for younger fish in 1981-82 than in 1928-32, which would tend to increase the CPUE in 1981-82. Thus, the observed decline in density may be underestimated. Another possible source of bias is that somewhat different areas within each lake were sampled. However, sonar charts showed an apparently uniform layer of ciscoes across the lake at night (Rudstam 1983). The ciscoes were caught almost exclusively at night in 1981.

Hile's (1936) findings of non-synchronous year class structure in four lakes in Vilas Co., were supported by this study (Figure 4). Although the populations in both Big Muskellunge and Sparkling Lakes were

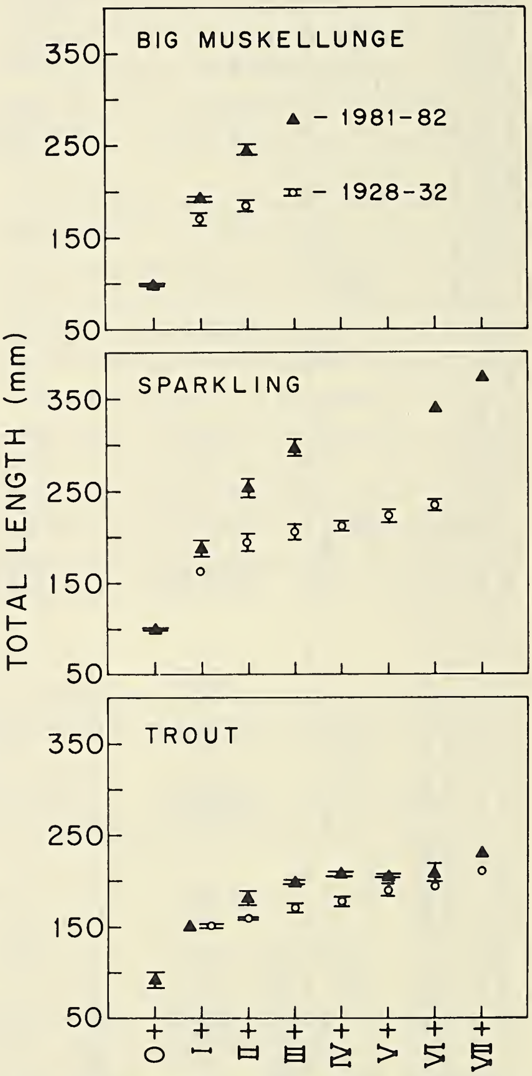

Fig. 2. Differences between 1928-32 and 1981-82 in the lengths at capture of cisco at each age in three Wisconsin lakes. Bars indicate the range of means for the two time periods.

dominated by a strong 1981 year class, the population in Trout Lake had a strong 1979 year class while the population in Pallette Lake had a strong 1978 year class. The 1981 year class was weak in Trout Lake. These results are based on younger fish where errors in aging should be minimal.

Discussion

The reasons for the disappearance of the Allequash cisco are not known. This lake was probably the least suited for a cold water fish such as cisco. It has a maximum depth of 7 m and can go anoxic below the epilimnion (occurred in 1981, LTER-

Table 6. Results from a two way ANOVA (fixed model) of catch per unit effort along lakes and between two time periods, 1930–31 and 1981–82. Log-transformed data give the same P-values.

Source of variation	*DF*	*SS*	*MS*	*F*	*P*
Among lakes	2	1716	858	1.14	N.S.
Between time periods	1	6833	6833	9.06	<.05
Interaction lake x time	2	1163	581	0.77	N.S.
Within groups	6	4523	753		

DF = degrees of freedom
SS = sum of squares
MS = mean square
N.S. = not significant

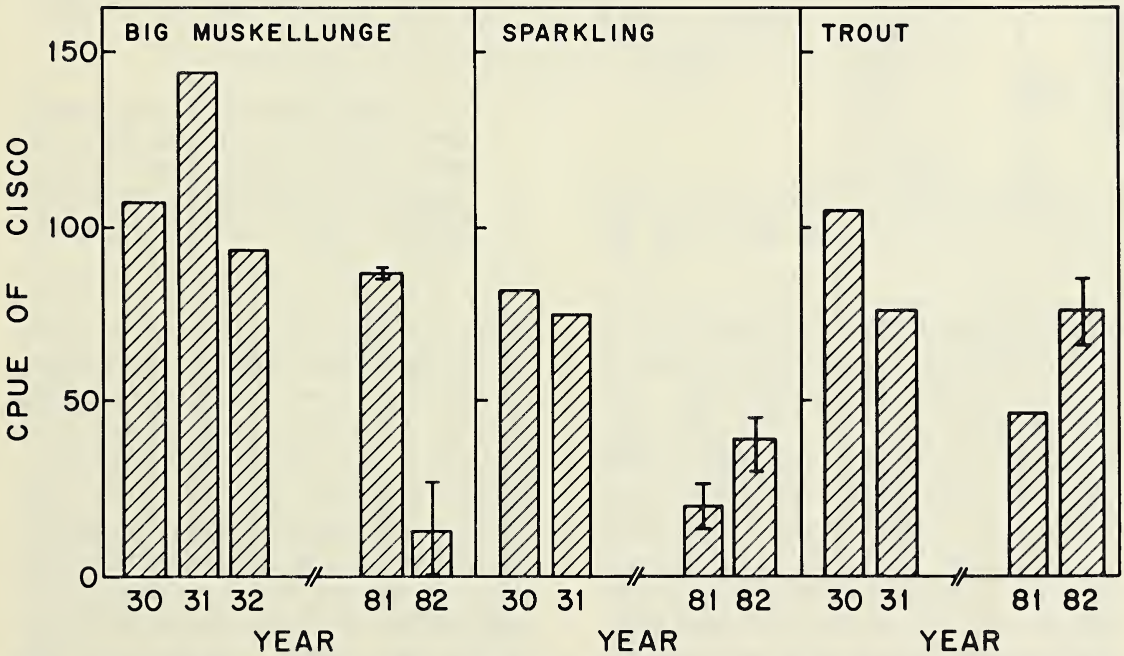

Fig 3. Catch per unit effort (CPUE) of cisco in three Wisconsin lakes in 1930–32 and 1981–82. CPUE is measured as catch per 100 square yards of gill net of mesh size 38 and 51 mm stretch mesh set for 24 hours. Only depths where the ciscoes were abundant are included. Thus, the CPUE is an index of maximum density during summer stratification. The catches in the 1980's are corrected for the documented higher efficiency of nylon nets compared to cotton nets (see text). The ranges for two sampling periods in 1981 and in 1982 are indicated with bars.

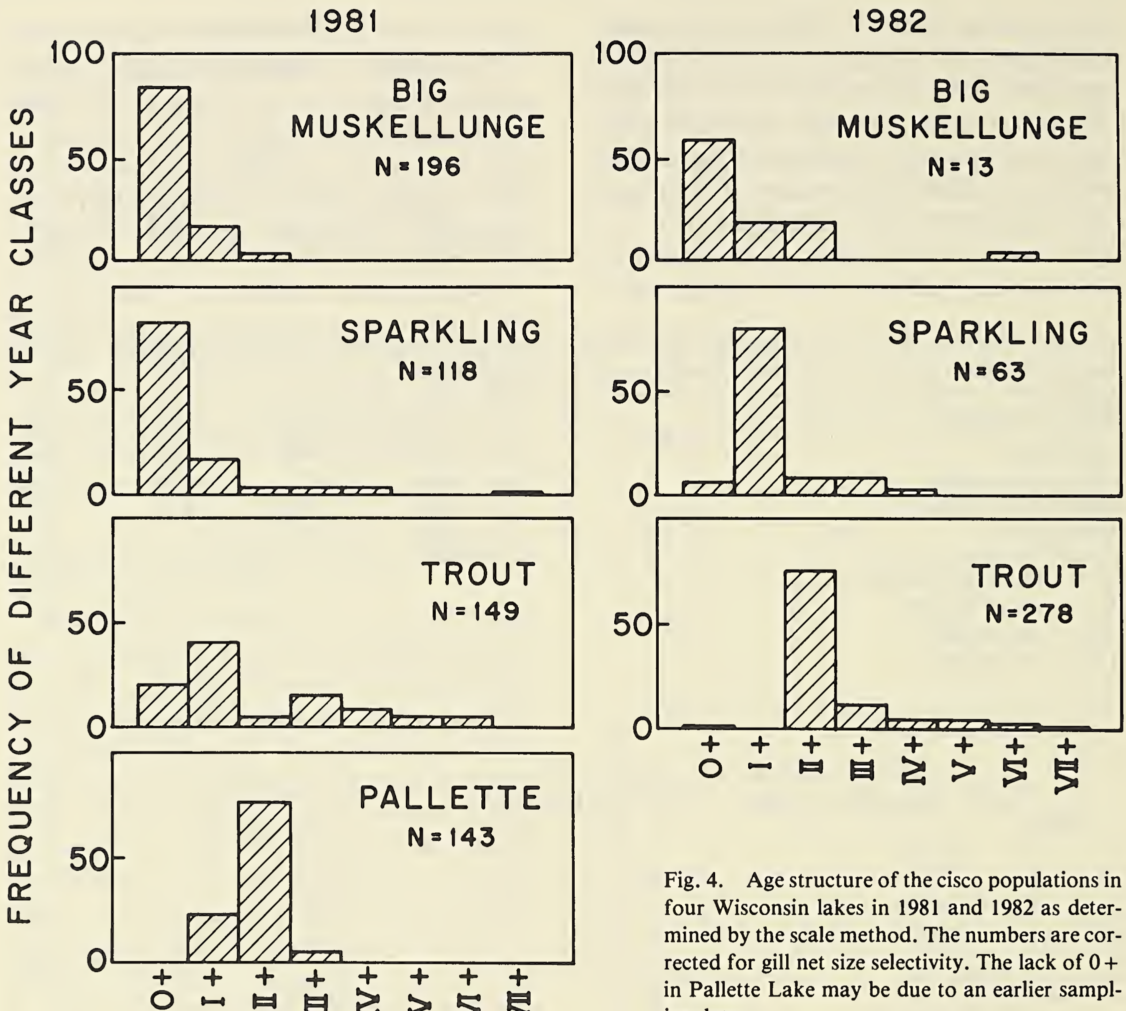

Fig. 4. Age structure of the cisco populations in four Wisconsin lakes in 1981 and 1982 as determined by the scale method. The numbers are corrected for gill net size selectivity. The lack of 0+ in Pallette Lake may be due to an earlier sampling date.

Northern Lakes 1981). Such conditions have been observed to cause summer mortalities of cisco in other lakes (Cahn 1927, Frey 1955, Colby and Brook 1969). However, cisco persist in similar lakes in Indiana (Hile 1936, Frey 1955). Also, recolonization from Trout Lake through Allequash Creek should be possible even if the whole population was eliminated through a summer kill. Conditions causing summer mortalities may occur too frequently to be offset by recolonization.

Growth and Density

An inverse relationship between growth and density of fish populations is well established and has been documented experimentally by Healey (1980) in a study involving different degrees of exploitation of lake whitefish (*Coregonus clupeaformis*) populations. Hoff and Serns (1983) observed a decrease in growth of Pallette Lake cisco following a substantial decrease in exploitation. Density was the only factor Hile (1936) found to correlate with the differences in growth observed among lakes in the 1930's. The decrease in density indicated by CPUE data is correlated with the observed increase in growth ($r = 0.776$, 4 df, $p < .10$, Figure 5). The decrease in CPUE is largest in Sparkling and Big Muskellunge Lakes where the in-

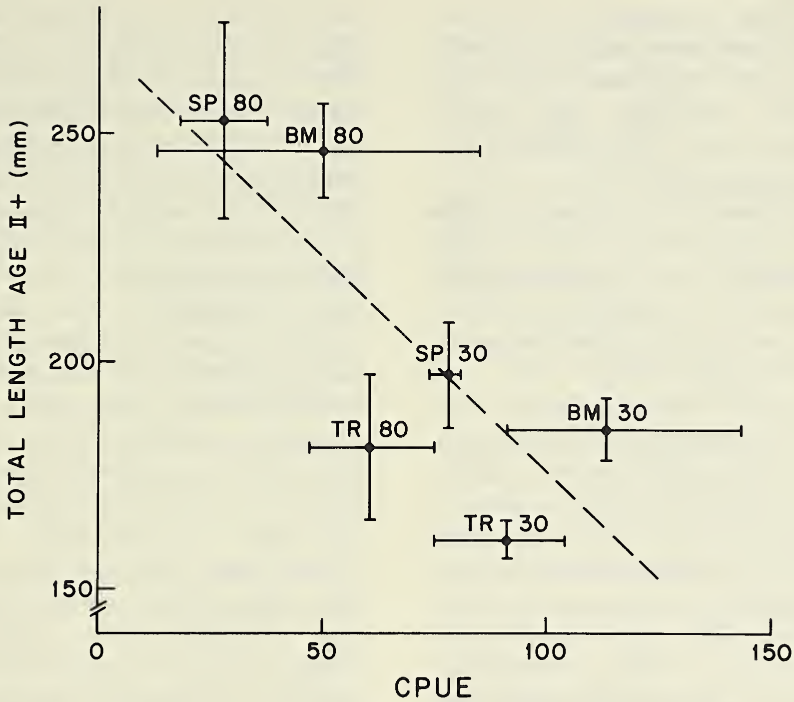

Fig. 5. Size at capture of age II + cisco in July-August plotted against CPUE in Trout, Sparkling, and Big Muskellunge Lake (r = .776, 4 df, p<.10). CPUE is an index of maximum density during summer stratification (see text). Bars indicate two standard errors for the length measurement and the range for the CPUE. Abbreviations: SP = Sparkling Lake, BM = Big Muskellunge Lake, TR = Trout Lake, 30 = 1928-1932, 80 = 1981-82.

crease in growth is most dramatic. The CPUE and growth in these two lakes approach the values obtained from Clear Lake, Oneida Co, in 1931 and 1932 (Hile 1936), where, in the 1930's, the cisco were less dense and had a faster growth than any observed in 1981-82.

The increase in growth could be the result of other factors, such as more favorable temperature and oxygen regimes, increased productivity, and/or decreased inter-specific competition. None of these factors are, however, likely to have changed enough to have had a large effect on growth. The temperature and oxygen profiles measured in 1981-82 (LTER-Northern Lakes 1981 and 1982) are similar to the profiles reported by Juday and Birge (1932) and Hile and Juday (1941). Some increase in productivity may have occurred, since conductivity in two of the lakes has increased since the 1930's (Table 1, Carl Bower, UW Dept. of Geology, pers. comm.). However, this increase is a small fraction of the differences observed in conductivity among lakes. Preliminary analyses of zooplankton samples from the 1930's and 1981-82 show no significant differences in abundances of most taxa in the three lakes (T. Kratz and T. Frost, Trout Lake Station, pers. comm.). Inter-specific competition is unlikely to have decreased. Yellow perch, *Perca flavescens,* the other main planktivore in these lakes, were caught in large enough numbers to warrant any consideration of inter-specific competition only in Big Muskellunge Lake. Although Hile did not present any CPUE data for perch, he did give the number of perch caught with cisco in gill nets. These numbers are similar per cisco caught in both time periods (Table 4). Rainbow smelt, *Osmerus mordax,* have been introduced into Sparkling Lake, which should increase rather than decrease interspecific competition in that lake.

Hence, a decrease in cisco density is probably the principal explanation for the increase in growth of cisco in the lakes studied here. However, since exploitation is limited or nonexistent, other explanations are necessary for this decrease in density.

The decrease in cisco density is most apparent in big Muskellunge and Sparkling Lakes, where the increase in growth rates is most dramatic. Predation pressure on these populations probably has increased. Predatory fish species have been stocked in these lakes on a number of occasions since the 1930's (Table 7). This has resulted in the establishment of a walleye, *Stizostedion vitreum,* and a muskellunge, *Esox masquinongy,* population in Sparkling Lake. Neither of these species were caught in Sparkling Lake in the 1930's (Hile and Juday 1941). Both species were present in the 1930's in Big Muskellunge Lake, but apparently in low numbers. Extensive gill net fishing caught only two walleyes and one muskellunge in the 1930's (Hile and Juday 1941). The density of these predators has probably increased. Hile (1936) hinted at the importance of walleye as a cisco predator, since substantially more walleyes were caught in Clear Lake (Table 4), where the cisco population was less abundant than in the other lakes. Clady (1967) observed an increase in growth of cisco when rainbow trout, *Salmo gairdneri,* were stocked in Birch Lake, Michigan, although few ciscoes were found in trout stomachs.

The density could also have been affected by a series of poor year classes that may or may not be the result of abiotic factors. Smelt, recently introduced to Sparkling Lake (Table 4), are thought to have contributed to the decline of cisco in the Great Lakes through resource competition (Christie 1974)

TABLE 7. Fish species stocked in Sparkling, Big Muskellunge and Trout lakes prior to 1931 and from 1932 to 1981. Stars indicate species that were not known from the lake prior to stocking. Source: Wisconsin Department of Natural Resources, Woodruff.

Lake	*Sparkling*		*Big Muskellunge*		*Trout*	
Species	*Year*	*# of occ.*	*Year*	*# of occ.*	*Year*	*# of occ.*
Prior to 1931:						
Salmon *(Salmo salar)*					*1906	1
Lake trout *(Salvelinus namaycush)*					1920	1
1932–1981:						
Lake trout	*1966–68	3			1942–80	25
Rainbow trout *(Salmo gairdneri)*					*1956	1
Whitefish *(Coregonus clupeaformis)*					1975	1
Muskellunge *(Esox masquinongy)*	*1939–77	10	1934–80	43	1949–67	8
Walleye *(Sizostedion vitreum)*	*1933–59	9	1934–81	6	1952–78	17
Perch *(Perca flavescens)*	1936	1				
Largemouth bass *(Micropterus salmoides)*	*1933–43	2	1942–45,64	4		
Smallmouth bass *(Micropterus dolomieui)*	1952	1	1950	1		
Bluegill *(Lepomis macrochirus)*	1936	1				

or through predation on cisco larvae (Crowder 1980). This species does not occur in Big Muskellunge Lake, but the same mechanism may not have caused the changes in population structure in both lakes.

The magnitude of the increases in growth observed in Sparkling Lake and Big Muskellunge Lake are quite large, comparable to the largest differences among years reported from other lakes (Carlander 1945, Dryer and Beil 1964, Clady 1967). There is, therefore, no indication that non-exploited cisco populations have a more stable population structure over time than exploited populations. However, the populations studied here cannot be considered unaffected by human activity. It is well known from the Great Lakes that introductions of new species may cause dramatic changes in native fish populations (see e.g. Christie 1974).

A posteriori explanations for historic changes are of necessity speculative. I consider a decrease in density to be the most parsimonious explanation for the observed increase in growth since the 1930's. The comparisons of CPUE's are consistent with this explanation. Several factors could have contributed to a decrease in density. The presently available information is consistent with an explanation based on increased predation pressure. However, other explanations can not be ruled out, and there is no guarantee that the same mechanism has caused the changes in both Sparkling and Big Muskellunge Lake. The changes in Trout Lake are of smaller magnitude and can probably be considered the result of "natural" fluctuations in abundance of cisco without larger changes in that system. Variations in growth of similar magnitude as observed in Trout Lake are commonly reported from long term studies on coregonids (Carlander 1945, Järvi 1942a, 1942b, 1947, Dryer and Beil 1964, Clay 1967). Unfortunately, it is not possible to know if the observed changes are the result of long term trends or part of a cycle, nor if the changes occurred slowly over the last 50 years or quickly over a few years. Complete time series are necessary for such detailed analysis.

Year class structure

The persistent asynchrony of year class strength among lakes in northern Wisconsin supports Hile's (1936) suggestion that year class strength of cisco is dependent on local conditions within each lake. This is also consistent with the lack of correlation between year class strength and weather found by some authors for the vendace, *Coregonus albula* (Svärdson 1956, Aass 1972, Hamrin 1979), an ecologically similar species (Smith 1957). Comparative studies among lakes can be criticized for not accounting for differences in the response of different lakes to weather events. A storm could, for example, affect lakes with a large fetch more than smaller lakes. However, the two lakes in this study with the most similar morphometries, Sparkling and Pallette Lakes, show different year class patterns. It appears, therefore, that variations in year class strength of cisco in lakes in northern Wisconsin are not primarily a response to weather events. Aass (1972) and Hamrin (1979) observed regular periods between strong year classes of vendace, that were not correlated with weather. Both authors invoked intra-specific competition as a possible mechanism for variations in year class success of this fish, since both adults and juveniles feed on zooplankton. This is also true for cisco in northern Wisconsin (Couey 1935, Engel 1976, Rudstam pers. obs.). Longer time series, however, are necessary to evaluate this proposition.

ACKNOWLEDGMENTS

Many of the students and staff associated with the Center for Limnology at the University of Wisconsin—Madison helped with parts of the field sampling and laboratory work. A large thanks to them all. Michael Hoff and Olle Enderlein assisted with their expertise in aging cisco. Paul Rasmusen and

Tim Kratz helped with the LTER data bases. John Magnuson, John Lyons, Hannah Hill, Steven Serns and Michael Hoff provided valuable comments on the manuscript. Cheryl Hughes drew the figures.

The study was supported by a Wisconsin Alumni Research Foundation Fellowship and by the National Science Foundation's Long Term Ecological Research Project—Northern Temperate Lakes (#DEB 8012313), Principal Investigator John J. Magnuson.

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THE DISTRIBUTION AND ZOOGEOGRAPHY OF LAKE TROUT, LAKE WHITEFISH, AND NINESPINE STICKLEBACK IN VILAS AND ONEIDA COUNTIES, WISCONSIN

John Lyons
Center for Limnology
University of Wisconsin, Madison

Abstract

Populations of lake trout, lake whitefish, and ninespine stickleback are uncommon in the Mississippi-Missouri watershed, and in many lakes their origin (native, introduced or recently invaded) is unclear. In the Mississippi basin of north-central Wisconsin at least eight lakes contained lake trout at some point during the last 80 years. In two of the lakes, Black Oak and Trout (Vilas Co.), the lake trout are probably native. Trout Lake also contains a native population of lake whitefish, and three ninespine stickleback have recently been captured there, the first record of the species in an inland lake in Wisconsin and only the fourth for the entire Mississippi-Missouri basin. There is some evidence that Trout Lake ninespine stickleback differ morphologically from the nearest other populations examined. Unlike in north-eastern North America, the distributions of ninespine stickleback and two other deepwater species in the Mississippi-Missouri watershed are not strongly correlated with the former distribution of large proglacial lakes, suggesting active dispersal into the area following deglaciation.

In addition to lake trout, lake whitefish, and ninespine stickleback, Trout Lake contains native populations of five other deepwater animals, giving it one of the most diverse deepwater assemblages in the Mississippi-Missouri basin. Future management of the lake should emphasize the preservation of this fauna, and particular effort should be made to prevent the introduction of rainbow smelt, which has become established in several lakes in the area.

Introduction

Although generally believed to have survived Wisconsin (late Pleistocene) glaciation in a Mississippian refugium, populations of lake trout *Salvelinus namaycush*, lake whitefish *Coregonus clupeaformis*, and ninespine stickleback *Pungitius pungitius* are today found in only a few deep lakes at the northern and western edges of the Mississippi-Missouri watershed (Lindsey, 1964; Nelson, 1968; McPhail and Lindsey, 1970; Martin et al., 1980; McAllister and Parker, 1980; Parker et al., 1980). Widespread introductions, possible recent invasions, mixing of stocks, local extinctions, and errors and omissions in the literature have obscured pre-Columbian distributions but it is almost certain that these species existed in only a handful of lakes in the basin before the advent of European settlement (Greene, 1935; Vincent, 1963; Nelson, 1968; Eddy and Underhill, 1974).

Factors affecting the post-glacial dispersal and distribution of these three deepwater fishes have been reviewed for northern and northeastern North America and the Laurentian Great Lakes basin (McPhail, 1963a; McPhail and Lindsey, 1970; Dadswell, 1972, 1974; Bailey and Smith, 1981). In the upper Mississippi drainage their zoogeography has received relatively little attention, primarily due to a scarcity of records and uncertainty and confusion over origins of current populations (Greene, 1935; Lindsey, 1964; Eddy and Underhill, 1974; Becker, 1983). Historical records of lake trout and lake whitefish exist from a small number of lakes in the upper Mississippi basin of north-central Wisconsin (Birge, 1907; Wagner, 1910; Koelz, 1930; Green, 1935), but several general distribution studies on these species have disagreed over whether these populations were native or introduced (Lindsey, 1964; Martin et al., 1980; Parker et al., 1980; Becker, 1983; Black, 1983). Recent collecting has also revealed the presence of ninespine stickleback in the area. In order to clarify the status and origin of these populations, this paper summarizes the current and historical distribution of the three species in north-central Wisconsin and presents evidence that at least some of the populations were native. Particular attention is given to Trout Lake, Vilas Co., which has an unusually rich deepwater fauna.

Sources of Data

Current locality data for north-central Wisconsin (Figure 1) are based on 20 years

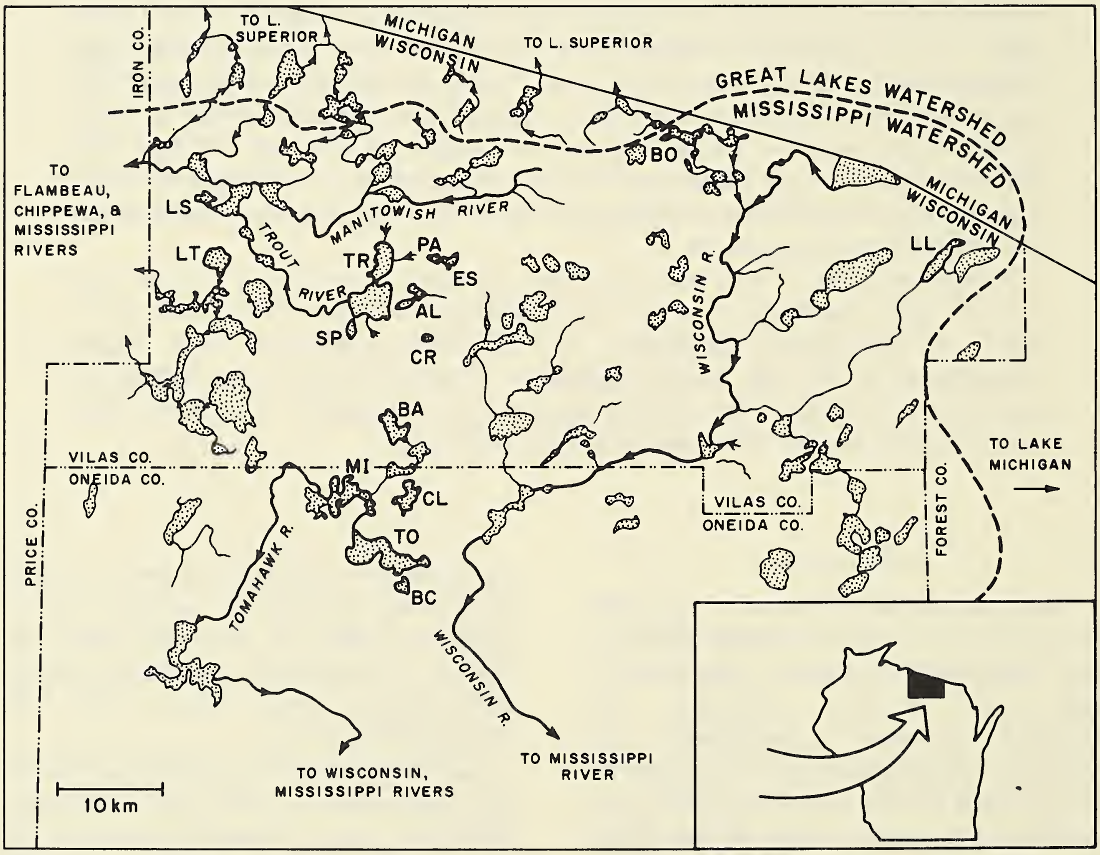

Fig. 1. Map of north-central Wisconsin, showing lakes mentioned in text, and watershed divides. Most of the many lakes and rivers in the area have been omitted for clarity. Labeled lakes are as follows:

AL = Allequash	CR = Crystal	MI = Minocqua
BA = Big Arbor Vitae	ES = Escanaba	PA = Pallette
BC = Big Carr	LL = Long	SP = Sparkling
BO = Black Oak	LT = Little Trout	TO = Tomahawk
CL = Clear	LS = Little Star	TR = Trout

TABLE 1. Location and selected physical, chemical and biological characteristics of lakes in the Mississippi basin of north-central Wisconsin which currently or historically had populations of lake trout, lake whitefish and/or ninespine stickleback. Origin of these three species is as follows: N = Native, NS = Native, but historically or currently stocked, I = Introduced, ? = Uncertain, ( ) = No longer present. Location and physical/chemical data from Black et al. (1963) and Andrews & Threinen (1966).

							Origin of:			
Lake	*County*	*Township/ Range*	*Area (ha)*	*Max. Depth (m)*	*Alkalinity (mg/1CaCO₃)*	*Conductivity (µm hos)*	*Lake Trout*	*Lake whitefish*	*Ninespine Stickleback*	*Other Deepwater Species*
Big Arbor Vitae	Vilas	40N/7E	426	11	51	117			?	None
Big Carr	Oneida	38N/7E	85	22	3	16	(I)			Cisco
Clear	Oneida	39N/7E	420	30	10	27	(I)			Cisco, Burbot?
Black Oak	Vilas	43N/9E	220	26	38	85	NS			Cisco, Burbot?, *Mysis relicta*
Crystal	Vilas	41N/7E	36	21	2	15	I			None
Little Trout	Vilas	42N/5E	393	28	16	43	(?)			Cisco, Burbot?
Long	Vilas	41N/12E	349	29	34	79	(I)			Cisco, Burbot?
Minocqua	Oneida	39N/6E	514	19	35	86			?	Cisco, Burbot
Pallette	Vilas	41N/7E	69	20	13	26	I			Cisco, Burbot
Sparkling	Vilas	41N/6E	51	20	42	92	(I)			Cisco, Burbot, Rainbow Smelt
Tomahawk	Vilas	39N/7E	1450	24	47	106	(I)			Cisco, Burbot
Trout	Vilas	41N/7E	1548	36	27	63	NS	NS	N?	Cisco, Burbot, Troutperch, Slimy Sculpin, *Mysis relicta*

of fish collecting by the Wisconsin Department of Natural Resources (DNR) and University of Wisconsin (UW) students and faculty. The bulk of sampling has been on Trout Lake, Vilas Co., and has included bottom trawling, deepwater minnow trapping, gill netting, SCUBA observation, and examination of stomach contents of piscivores captured in deep water, as well as extensive netting and observation in littoral areas. Voucher specimens for all deepwater species collected can be found in the UW-Madison Zoological Museum, the UW-Stevens Point Museum of Natural History, the Milwaukee Public Museum and/or the University of Michigan Museum of Zoology. Native distributions have been determined from early literature reports, unpublished museum records, and communication with university and DNR biologists and geologists familiar with the region (see Acknowledgments).

Current and Historical Distributions

The lake trout is currently found in four lakes in the Mississippi basin of north-central Wisconsin. All are located in Vilas Co. and are relatively deep and unproductive (Table 1). Lake trout have been present continuously for at least 75 years in Trout and Black Oak Lakes, the only lakes in the upper Mississippi basin which currently support successfully reproducing populations (Birge, 1907; Daly et al., 1962; Becker, 1983; D. Fago, DNR Madison, pers. comm.; J. Underhill, University of Minnesota, pers. comm.). However, both lakes have been regularly stocked during this time period (Daly et al. 1962, McKnight 1977). In Crystal and Pallette Lakes current lake trout populations are due to recent stocking and natural reproduction is probably not significant. There were no records of lake trout in Pallette Lake prior to introduction in 1982 (S. Serns, DNR Woodruff, pers. comm.). Records from Crystal Lake date from the early 1900's, but there were apparently long periods between then and the present when lake trout were absent (Fago, pers. comm.). Lake trout were also recorded from Little Trout Lake, Vilas Co., in the early 1900's, but no longer occur there (Rahel 1982, Fago pers. comm.). In recent years several other lakes in the area, including Long and Sparkling Lakes, Vilas Co. & Tomahawk, Clear, & Big Carr Lakes, Oneida Co., have been stocked without notable success (Becker 1983, DNR Woodruff lake survey files).

The only lake whitefish population currently reported from the upper Mississippi basin of north-central Wisconsin is in Trout Lake, Vilas Co.; the earliest reports are from around the turn of the century (Birge 1907, Wagner 1910). The population reproduces naturally (Hile & Deason 1934) and has been stocked sporadically (DNR Woodruff lake survey files). In the last 40 years there have been single records of lake whitefish from Allequash and Little Star Lakes, Vilas Co. (Fig. 1), both of which are likely to have been strays from Trout Lake (McKnight et al. 1970, Becker 1983, Serns pers. comm.). In Minnesota and other parts of Wisconsin lake whitefish have been reported 25 km or more from established populations (Eddy & Underhill 1974, Becker 1983).

Previously there have been no confirmed records of the ninespine stickleback anywhere in the Mississippi watershed in Wisconsin, and only three reports of it the entire Mississippi-Missouri basin (Nordlie et al. 1961, Nelson 1968, Underhill pers. comm.). A published report from Escanaba L., Vilas Co. (Kempinger et al. 1975) is erroneous (G. Becker, UW-Stevens Pt. pers. comm.). During the last 20 years collections in Trout L., Vilas Co., have yielded three specimens, one in 1965 and two in 1968. Recent intensive sampling of both shallow and deepwater habitats has failed to capture further individuals, suggesting that the species is present at low densities or has been extirpated. There are also reports of single ninespine sticklebacks from Big Arbor Vitae Lake, Vilas Co. and Minocqua Lake,

TABLE 2. Selected counts and measurements for ninespine sticklebacks from Trout Lake and the nearest populations examined. Trout Lake data are for individual fish; for other localities the mean (mode for lateral plates) of a sample of individuals is presented with the range given parentheses. All measurements were from the left side and followed Hubbs and Lagler (1958) unless otherwise noted. Crooked Lake and Lake Michigan basin data are from Nelson (1968) while Lake Superior basin values are from McPhail (1963b).

UWZM = Univ. of Wisconsin-Madison Zoological Museum UMMZ = Univ. of Michigan Museum of Zoology

Basin	*Capture Location*	*Disposition of Specimens*	*Standard Length (mm)*	*Pectoral Fin Length / Pelvic Spine Length*	*# of lateral plates*	*# of dorsal spines*	*# of gill rakers*
Mississippi (Chippewa River)	Trout Lake Vilas Cty, WI	UWZM 7065	62.5	1.8 (right side)	Uncertain (damaged)	10	11
		UWZM 7896	52.0	1.4	0	9	13
		UWZM 7896	53.5	1.3	0	9	13
Mississippi (Ohio River)	Crooked Lake Noble/Whitley Co. Indiana	UMMZ #186442 to 186444 (N=30)	52 (42–56)	1.9 (1.4–2.2)	No Data	8.9 (8–10)	13.1 (11–14)
Lake Michigan	Lake Michigan off Waukegan, Illinois	IL Natural History Survey (N=30)	61 (49–74)	1.9 (1.5–2.3)	No Data	9.1 (8–10)	12.9 (11–15)
Lake Michigan	Gull Lake Kalamazoo Co. Michigan	UMMZ #55278 (N=7)	60 (49–63)	1.5 (1.3–1.6)	No Data	8.9 (8–9)	13.9 (13–15)
Lake Superior	Amnicon River (Mouth, at Lake Superior Douglas Co., WI	UMMZ #80072 (N=8)	No Data	1.8 (1.6–2.1)	0 (0–3)	9.4 (9–11)	13.0 (12–14)
Lake Superior	Lake Superior 46 30′ N Lat. 87 00′ W Long.	UMMZ #81703 (N=23)	No Data	1.9 (1.7–2.2)	1 (0–4)	9.3 (8–10)	13.2 (11–14)
Lake Superior	Gratiot Lake Keweenan Co. Michigan	UMMZ #13301 (N=11)	No Data	1.7 (1.4–1.8)	2 (0.4)	10.1 (10–11)	12.9 (12–14)

Oneida Co. (R. Steuck, H. Carlson, DNR, Woodruff, pers. comm.) (Fig. 1). Specimens are not extant, and thus cannot be confirmed, but if populations do exist in these lakes, it suggests that ninespine sticklebacks are present in at least small numbers in several lakes in this area.

Native Distributions

Lake trout are clearly not native to Pallette Lake and, given its small size and historical absence of reproduction, probably also not native to Crystal Lake. However, there is evidence that lake trout populations existed in Trout and probably Black Oak Lakes prior to European settlement of Wisconsin. Most recent literature reports consider lake trout native to these two lakes (Daly et al. 1962, Lindsey 1964, McKnight 1977, Becker 1983, Black 1983), which are unique in the upper Mississippi drainage in having naturally reproducing populations. In Trout Lake the earliest fish studies reported that lake trout were "native fish, not the result of artificial planting" (Juday & Wagner 1908, p. 19). Trout Lake was named by 1866 (Map of Federal Land Survey plots of Towns 40-43N, R1-8E Wisc, State Historical Society, Madison), well before any introductions were likely to have been made into the area (Jones 1924). Brook trout (*Salvelinus fontinalis*) are native to tributaries of Trout Lake, but are restricted to small streams and spring ponds in the area (Anonymous 1973, personal observations), so the name 'Trout Lake' probably arose due to the presence of lake trout. A similar 'name' argument can be made for nearby Little Trout Lake, which had lake trout in 1907 and 1909 (Fago, pers. comm.). However, the lake's name was changed from 'Sand' to 'Little Trout' sometime between 1866 and 1895 (Federal Plot Maps for Townships 40-43N, R1-8E) and it does not contain lake trout today (Rahel 1982), so the origins of the early records from this lake are uncertain.

The lake whitefish population in Trout Lake is also likely to have been present prior to settlement of the Vilas Co. area by Europeans. Lake whitefish were apparently not stocked as widely or as early in inland lakes as lake trout (Becker 1983), so early records are more likely to to give an accurate representation of their original distribution. The lake whitefish in Trout Lake currently reproduce naturally and have not been stocked in many years (DNR lake survey files). All early authors considered the population native (Wagner 1910, Koelz 1930, Hile & Deason 1934, Green 1935). Koelz (1930) recognized Trout Lake whitefish as a separate subspecies (*C. clupeaformis dustini*) from those in L. Michigan & L. Superior (*C. clupeaformis clupeaformis*), the most likely source of fish for any introductions into Trout Lake. Morphological differences between Trout Lake and Great Lake populations support a long isolation of Trout L. whitefish, but do not conclusively prove that Trout Lake fish did not recently come from the Great Lakes, as many of the morphological characteristics Koelz used in his coregonid taxonomy were shown to be caused by differing environmental conditions rather than by genetic differences between populations (Hile 1936).

The ninespine sticklebacks in Trout Lake were probably not introduced. Because of their small size and difficulty of capture, this species is not likely to be stocked, either intentionally or accidently as bait. Although only three specimens have been collected, the Trout L. population appears somewhat distinct morphologically from the nearest populations examined (Table 2). Trout Lake fish seem to have a relatively low ratio of pectoral fin length to pelvic spine length, and are similar to those of two small inland lakes in the Great Lakes basin, Gull and Gratoit, in that respect. However, they tend to have fewer dorsal spines then those from Gratoit Lake, and somewhat different numbers of dorsal spines and gill rakers than those from

Gull Lake. As in the lake whitefish, morphological differences support the native status of Trout Lake ninespine sticklebacks, but do not prove that they were not introduced into the lake, particularly given the small samples being compared. Among other species of sticklebacks nearby populations in the same drainage are often quite different morphologically (Reist, 1981; Bell, 1982) and some population characteristics, such as frequency

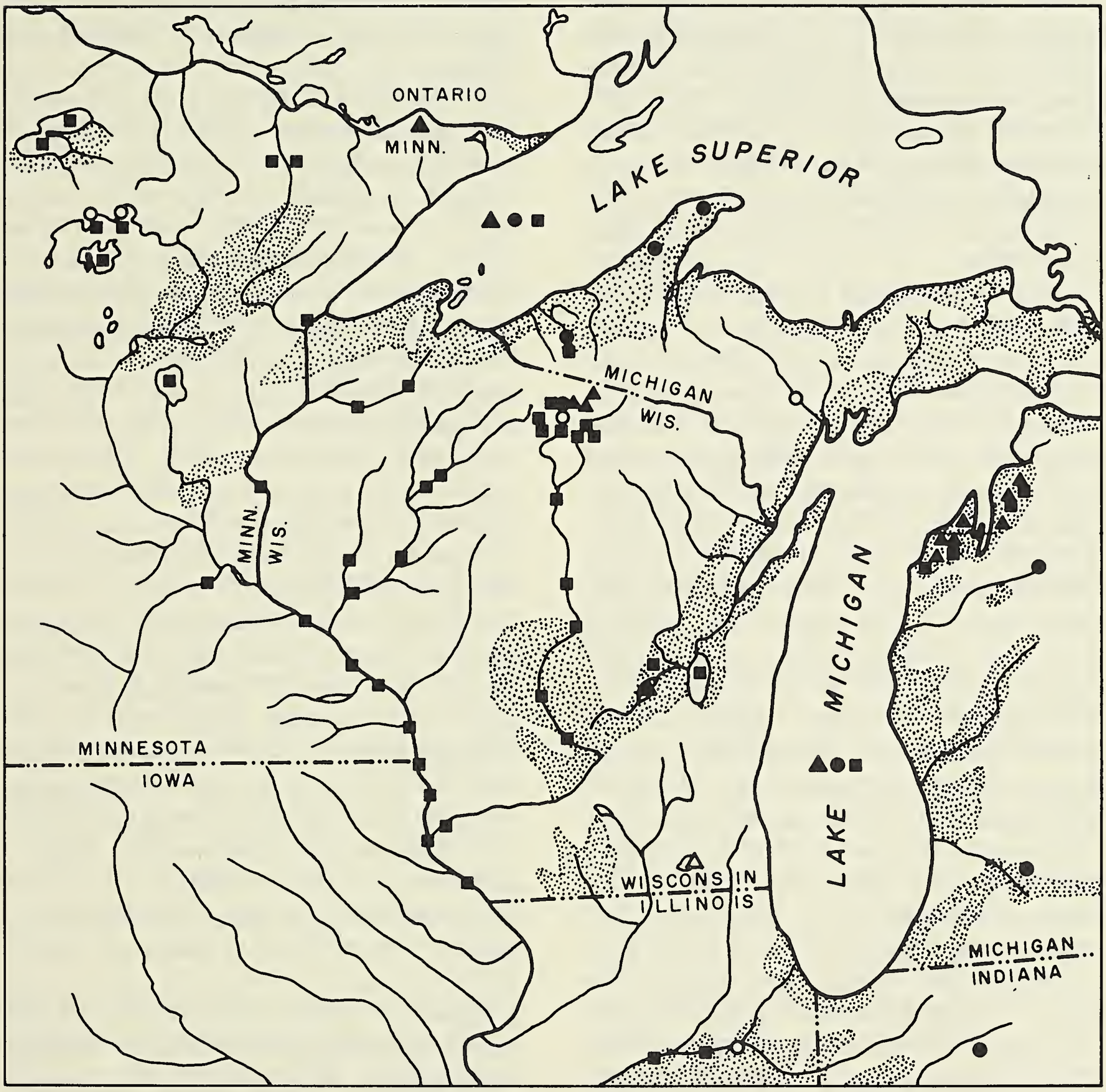

Fig. 2. Map of extent of glacial lakes (Stippled Areas) in the north central United States during late Wisconsin glaciations (after Flint 1969). Current localities for ninespine stickleback (●). trout-perch (■) and the crustacean *Mysis relicta* (▲) are plotted. Unconfirmed records, strays, or possibly introduced populations have an open symbol. Not all trout-perch records have been plotted.

Sources of records: Eschmeyer, (1950); Nelson, (1968); Eddy & Underhill, (1974); Becker, (1976), McKnight, (1976); Gammon et al., (1978); Smith, (1979); Gilbert & Lee, (1980); McAllister & Parker, (1980); Rahel, (1982); Becker, (1983); personal observations.

of certain pelvic-complex phenotypes, change rapidly in response to environmental changes (Kynard, 1979; Reist, 1981).

Origins of Native Populations

In northeastern North America Dadswell (1972, 1974) found that the distribution of several small deepwater fishes and crustaceans agreed closely with the former distribution of large proglacial lakes. In that area these animals dispersed northward following glaciation via interconnected proglacial lakes and their outlet channels, although several fishes later moved up to 60 km upstream from the boundaries of these former lakes.

Three of the species considered by Dadswell (1972, 1974), ninespine stickleback, trout-perch (*Percopsis omiscomaycus*) and the crustacean *Mysis relicta,* are present in the upper Mississippi basin of north-central Wisconsin. The trout-perch clearly is not distributed in accordance with former proglacial lakes in the Mississippi basin (Fig. 2). With the exception of northern Wisconsin and Minnesota it is primarily a river fish, and is found several hundred km south of the southern edge of the Wisconsin ice sheet (Gilbert & Lee 1980). In north-central Wisconsin it is distributed sporadically in scattered rivers and lakes (Rahel 1982, Becker 1983), and appears to have dispersed following deglaciation using lotic pathways.

Mysis relicta is known from only three or four lakes in the Mississippi basin of Wisconsin, including Trout and Black Oak Lakes (Juday & Birge 1927, McKnight 1976). Its distribution, along with that of the ninespine stickleback, does not correspond with that of large proglacial lakes in the Mississippi basin (Fig. 2). Geological studies of north-central Wisconsin indicate that large proglacial lakes were absent following glaciation, and that most lakes in the region were formed by the melting of ice blocks deposited in the glacial till as the ice withdrew (Thwaites 1929, Broughton 1941, J. Attig U.W. Dept. of Geology pers. comm.). Dadswell (pers. comm.) has suggested that short-lived narrow proglacial lakes may have been present along large areas of the ice margin in relatively flat areas such as northern Wisconsin. However, the local topography in Vilas Co. makes formation of such lakes unlikely, and recent core and sediment samples provide no evidence that such lakes ever existed (J. Attig, pers. comm.).

While several of the lake trout, lake whitefish, and ninespine stickleback populations in the Mississippi basin of north-central Wisconsin were probably not the result of stocking, it is possible that they may have arisen from a relatively recent invasion into the Mississippi drainage from the Great Lakes basin. The ninespine stickleback population in Lake Winnibigosh MN may have entered the Mississippi drainage by moving through a marshy connection with the Hudson's Bay watershed (Nordlie et al. 1961) while several other species have crossed the Mississippi-Great Lakes boundary in Wisconsin and Illinois during the last 100 years (summarized in Smith 1979, Becker 1983). Black Oak Lake is less than 2 km from the Great Lakes drainage (Fig. 1), so a movement of lake trout into the lake across the watershed boundary might not be unlikely. However, by current drainage patterns Trout Lake is over 30 km from the nearest likely crossover point (Fig. 1). Most of this distance is unsuitable habitat for deepwater species, although the probable movement of lake whitefish from Trout Lake to Little Star Lake indicates that it might be traversed during colder parts of the year.

Geological studies indicate that in the period immediately following the recession of the glaciers, the drainage divide was 20-30 km further north, and that its current position is probably as far south as it has ever been (J. Attig pers. comm.). There have been no major connections between the two watersheds since deglaciation, and any recent connections have almost certainly been small, shallow and marshy. These factors argue against movement of deepwater fishes from the Great Lakes Basin into the upper Mississippi drainage in this area. Deepwater fishes most likely actively followed the glaciers northward from southern refugia using lotic pathways and colonized lakes in north-central Wisconsin soon after they were formed. Native populations in this area have persisted since then and have probably been isolated from Great Lakes populations since glaciers left the Vilas Co. area, 10-12,000 yrs. before present (J. Attig pers. comm.).

Trout Lake

Trout Lake has one of the most diverse native deepwater faunas in the entire Mississippi-Missouri basin. In addition to lake trout, lake whitefish, ninespine stickleback and *Mysis relicta,* there are reproducing populations of cisco (*Coregonus artedi*), trout-perch, burbot (*Lota lota*), and slimy sculpin (*Cottus cognatus*). Cisco, trout-perch and burbot are common in many deep lakes in northern Wisconsin and Minnesota, but in the upper Mississippi watershed the slimy sculpin is usually restricted to small cold headwater streams 300 to 500 km to the southwest (Johnson 1972, Eddy & Underhill 1974, Becker 1983). Slimy sculpins from Trout Lake are somewhat different morphologically from most Great Lakes and Mississippi basin populations (Lyons, in prep.).

Future fisheries management policy for Trout Lake should take into account the uniqueness of its deepwater fauna and attempt to preserve it. Efforts should be made to keep the numbers of piscivores and prey fairly stable, and in the future the DNR should not introduce lake trout except those derived from Trout Lake brood stock. Horns (1983) has shown that hatching and developmental characteristics of Trout Lake lake trout are different from those of Lake Superior and Lake Michigan fish. Further dilution of the particular genetic characteristics of the Trout Lake population through mixing with other populations may lead to reduced reproductive success, as suggested by the failure of recent efforts to reestablish a reproducing population of lake trout in Lake Michigan (Krueger et al. 1981). The introduction of exotic deepwater species into Trout Lake should be avoided at all costs. Rainbow smelt *(Osmerus mordax)* have become established in several lakes in north-central Wisconsin (Becker 1983), including adjacent Sparkling Lake (pers. observation, Fig. 1). In the Great Lakes rainbow smelt, along with other exotic fishes, are believed to have contributed to the decline, and in some cases the extirpation of the native deepwater fish fauna (Christie 1974, Crowder 1980). During highwater years there is a temporary connection between Sparkling and Trout Lakes (present for 3 mos. in 1983) which rainbow smelt might traverse during their spawning period. To prevent them from entering Trout Lake fish barriers should be installed and the connection should be monitored when flowing. Efforts also should be made to educate the public about the dangers of intentionally or accidently introducing rainbow smelt into other lakes in the area.

Acknowledgements

I would like to express my gratitude to the following people for making available unpublished records and specimens, and/or providing advice and encouragement: George C. Becker, UW-Stevens Point; Harland Carlson, DNR Woodruff; Alexandra Creighton, Univ. of Michigan Museum of Zoology; Michael J. Dadswell, Dept. of Fisheries and Oceans, N. B., Canada; Don Fago, WI DNR Fish Distribution Survey, Madison; William Le Grande, Museum of Natural History, UW-Stevens Point; Donald E. McAllister, National Museums of Canada, Ottawa; Terry McKnight, DNR Rhinelander; Liz Pillaert, UW-Madison Zoological Museum; Steve Serns, DNR Woodruff; Randy Steuck, DNR Woodruff; and James C. Underhill, Univ. of Minnesota, Minneapolis. John Attig, UW-

Madison, provided geological information about the Vilas Co. area. Phil Cochran, UW-Madison, commented on a draft of this paper. John J. Magnuson, UW-Madison, captured two of the sticklebacks from Trout Lake and supported recent collecting efforts through NSF Grant #DEB8012313.

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THE CRYSTALLINE MONADNOCKS OF NORTH-CENTRAL WISCONSIN

Gene E. Musolf
University of Wisconsin-Marathon County
Wausau

Abstract

Located within ten miles of Wausau, Wisconsin are three crystalline quartzite monadnocks—Rib Mountain, Mosinee Hill and Hardwood Hill. This paper is a geographical analysis of these hills stressing their physical and economic features. A review of existing literature preceded map study, air photo examination, personal interviews and field work of these unique landforms.

Composed of resistant Rib Mountain quartzite, the monadnocks exhibit higher elevations, greater relief and steeper slopes than the surrounding landscape. Metamorphosed from ancient sandstones, the quartzite was later recrystallized by igneous intrusions and exhibits great purity. Glaciation of the area apparently occurred in Pre-Wisconsinan time and deposited a shallow drift. Surveyor's notes indicate the original vegetation was a dense hemlock/northern hardwood forest. However, a fire destroyed most of the cover in 1910 and the resultant growth was largely aspen, birch and shrubs. Shallow, moderately-steep, stony silt loam soils (Typic Glossboralf) dominate the hills.

Use of the monadnocks for agriculture has been generally precluded by the steep slopes and stony soils. The lumbering "boom" of the late 1800's largely avoided the hills. Occasional forestry operations by private owners have been carried on in recent years. Mining of quartzite commenced in 1893 and several companies have been involved over the years.

It is in the fields of recreation and communications that the monadnocks have had the greatest economic impact. Rib Mountain State Park dates from 1927 and served 189,000 visitors in 1979. The Rib Mountain Ski Area with four major slopes entertained 97,000 skiiers in a recent year. Serving as a hub for a complex communication network, the "mountain" supports a number of transmitters and microwave facilities for television, radio and telephone.

Introduction

As one approaches Wausau, Wisconsin, from any point of the compass, even the most casual observer soon becomes aware of three brooding, heavily-forested, steeply sloping prominences which dominate the landscape of the area. Projecting above the flat-topped upland of the Precambrian peneplain, they are the sharp, ridge-like Rib Mountain, the twin-peaked Mosinee Hill and the smaller, conical Hardwood Hill (Fig. 1). These unique landforms consist of the very coarse Rib Mountain quartzite, perhaps the most resistant rock in nature, and for this reason they maintained their presence during the general degradation of the surrounding area in Precambrian time and remain as remnant hills, or monadnocks, today. The hills are in marked contrast to the relatively level tops of the upland forming the peneplain. They are the remnants of a land surface older than the present peneplain and are typical monadnocks like their namesake, Mount Monadnock in New Hampshire, which bears a similar relationship to

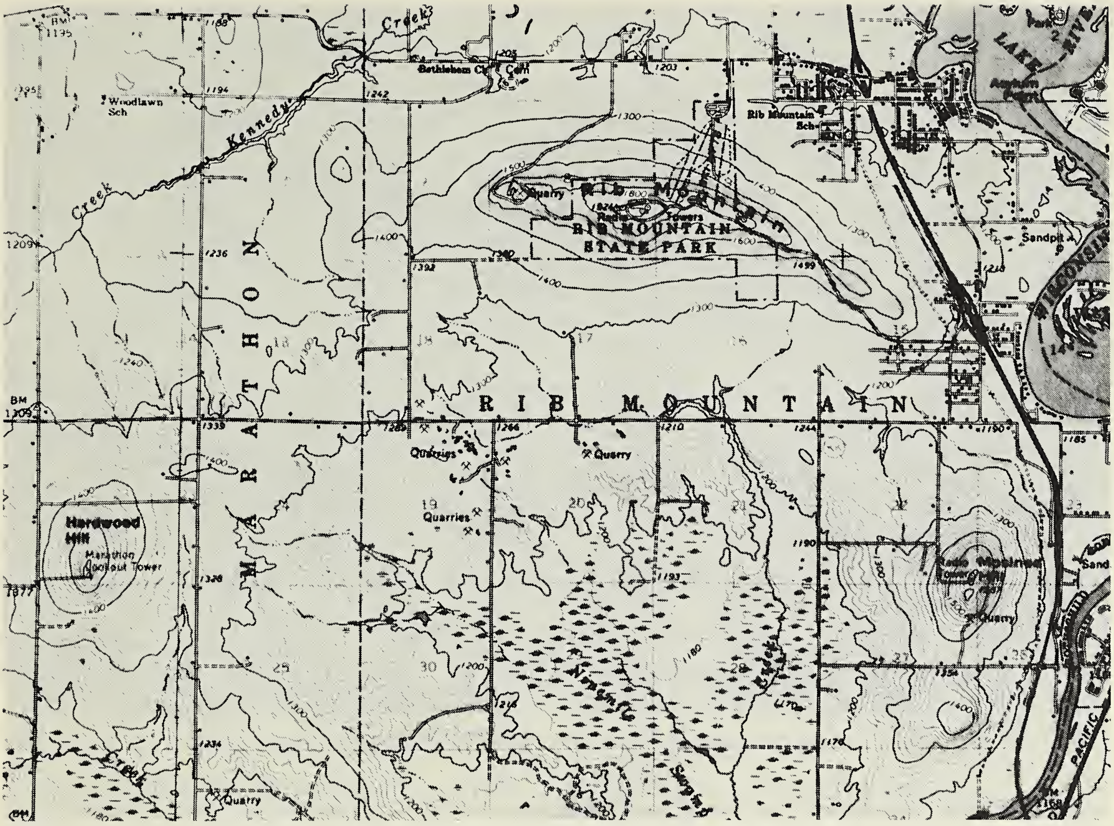

Fig. 1. The crystalline monadnocks of north-central Wisconsin (from USGS Wausau and Marathon Quadrangles, Scale-1:62,500).

the peneplain of erosion in southern New England. It will be the major purpose of this paper to provide a geographical analysis of the hills which emphasizes their physical and economic characteristics. In addition, a brief review of the geology of the area is included.

Physical Environment

Landform Geography

Largest of the monadnocks is Rib Mountain which is located in central Marathon County approximately four miles southwest of downtown Wausau (Fig. 2). Formerly called Rib Hill, then Rib "Mountain," this prominence is now called Rib Mountain. Less than a mile from the Wisconsin River (i.e., Lake Wausau), the "Mountain" extends four miles east-west and one and one-half (1½) miles at its maximum width north-south. Slightly arc-like in form, which has been likened to a human "rib," its total area is 3.63 square miles. The fame accorded Rib Mountain, however, tends to be based rather on its vertical dimensions—elevation and local relief. For many years it was recognized as the highest point of elevation in the State of Wisconsin at 1,940 feet above sea level. However, a number of years ago U.S. Geological Survey investigators identified two hills northwest of this area (Tim's Hill and Pearson Hill in Price County) which have slightly higher elevations. Rib Mountain still enjoys the distinction of possessing the greatest local relief in the state as it rises 780 feet above Lake Wausau and about 650 feet

Fig. 2. Rib Mountain, from the northeast.

Fig. 3. Mosinee Hill, from the tower on Rib Mountain to the northwest.

above the average level of the crystalline peneplain. This landform feature also includes some of the steeper slopes to be found in northern Wisconsin. Areas near the summit on both the north and south flanks are covered by a talus of quartzite blocks and exhibit slopes of 20 to 30% with the north slope being steeper. A majority of the "Mountain's" total area displays 12 to 20% slopes while near the base 6 to 12% is more common.

Located one and one-half (1½) miles south-southeast from the eastern end of Rib Mountain and only several hundred yards from the west bank of the Wisconsin River is the second of the monadnocks, Mosinee Hill (Fig. 3). Two summits, located about one mile apart, are seen on the hill which led them to be identified in earlier times as Upper and Lower Mosinee Hills. They are connected by a continuous stretch of quartzite although separated from Rib Mountain by a lower area of quartz syenite bedrock. The northern summit is the larger of the two and reaches an elevation of 1,610 feet above sea level and rises 465 feet above the alluvial plain of the Wisconsin River nearby, while the southern summit has an elevation of 1,472 feet and a relief of only 325 feet. Both of these hills are more gently-sloping on their western flanks (i.e., 2 to 12%), while their eastern sides adjacent to the river possess steeper slopes (i.e., 12 to 20%). Like Rib Mountain, Mosinee Hill's upper levels are covered with a talus deposit of quartzite blocks, but its total area is considerably smaller occupying 1.18 square miles. Aligned north-south its maximum length is one and three-quarters (1¾) miles and varies from ¾ to one mile in width.

Smallest of the three monadnocks is Hardwood Hill which is located three and one-half (3½) miles in a west-southwesterly direction from the summit of Rib Mountain (Fig. 4). While the two hills previously described are largely in the Town of Rib

Fig. 4. Hardwood Hill, from the east.

Mountain, Hardwood Hill is in the Town of Marathon. Dome-like in form and covering only one-half (½) square mile, the top of the hill has an elevation of 1,610 feet which is 300 feet above the peneplain surface and about 400 feet from the valley floors within a mile or two of the summit. Slopes vary from 12 to 20% near the summit to 6 to 12% on the flanks of the hill. Quartzite blocks are frequently seen near the summit.

Quartzite bedrock with its superior resistance to erosion is certainly responsible for the higher elevations and considerable relief of the hills. The three monadnocks give to the Wausau area Wisconsin a rather unique topography that may be better described as "plains with high hills" instead of as a rolling plain which is more characteristic of most of northern Wisconsin.

Geology Review

The geologic formation responsible for the three monadnocks is Rib Mountain quartzite, an extremely resistant Early Proterozoic (Middle Precambrian) metamorphic rock. Metamorphosed from ancient sandstones and recrystallized more recently, the quartzite is remarkably pure (99.07%SiO_2), white to pale pink in color, vitreous and firmly cemented (Weidman 1907). It varies from medium-grained to coarse-grained with the latter predominating. Quartz crystals range from 3 to 8 millimeters in size. Nevertheless, though being extremely resistant to weathering, the quartzite is somewhat brittle and because of this is often seen as talus on the steeper slopes. Jointing in the quartzite is common but no persistent pattern of jointing is noted. The monadnocks are composed of masses of nearly vertical south-dipping quartzite with an estimated thickness of from 1,000 to 4,000 feet (Weidman 1907). Age of the formation is placed from 1.45–1.50 billion to 1.64–1.67 billon years, probably nearer the latter (LaBerge and Meyers 1972). The large quartzite block at Rib Mountain, and several others nearby, were once part of the roof rock above a syenite intrusion (i.e., Wausau quartz syenite—1.45 to 1.50 billion years old) (Paull and Paull 1980). When erosion breached the roof rock, the underlying intrusive was removed much more rapidly than the resistant quartzite. In time, isolated masses of quartzite stood high above the general erosional surface. It has also been hypothesized that the three monadnocks may be connected at sub-surface levels but no substantive evidence has yet been presented.

Samuel Weidman, author of "Geology of North-Central Wisconsin" (1907), the definitive work on this region, was convinced that this locality was part of the Driftless Area and so mapped it. The absence of quartzite boulder trains marginal to the three monadnocks furnished, he thought, the strongest kind of evidence of the non-glaciated character of the vicinity. Later research by Thwaites (1943) and Hole (1943) suggested that the extension of the Driftless Area along the Wisconsin River valley from Stevens Point to Merrill was glaciated in early Wisconsinan time, possibly Altonian, but as a result of severe erosion by the Wisconsin River and its tributaries most of the drift had been removed. More recent investigations indicate that a pre-Wisconsinan glacial advance moved eastward across this area (Mickelson, Nelson and Stewart 1974). Wausau Drift is the name applied to the thin, discontinuous till deposited by this ice sheet that rests directly on deeply weathered, Precambrian rocks (LaBerge and Meyers 1972).

Vegetation

Federal land surveyors' notes reported that the natural vegetation of Rib Mountain in 1840 was a hemlock/northern hardwood forest. Presumably, Mosinee and Hardwood Hills supported a similar forest community. Included among the hardwoods were yellow birch, sugar maple, red maple, white ash, basswood and white birch. Due to their steep and rocky slopes, the monadnocks were largely bypassed by the loggers of the late 1800's, and the forest remained essentially in its native state until 1910. In late July of that year, however, following a severe drought period, a disastrous crown fire destroyed nearly all of the canopy trees on the "Mountain" (Schaetzl 1980). Mosinee and Hardwood Hills were not affected by this conflagration.

Vegetation growth after the fire was dominantly aspen, with considerable white birch and various shrub species. The vegetation remained in this state for nearly twenty years. Upland hardwoods fringed the base of the hill and continued to gain in importance. In 1927, Rib Mountain State Park was established, and the natural succession of vegetation has been encouraged within its boundaries.

A map of forest types prepared for the park in 1971 revealed the continued advance of northern hardwoods up the slopes of the hill. Yet, many areas were still dominated by white birch and aspen. A map compiled by Schaetzl (1980) confirmed the nearly complete dominance of northern hardwood communities on the more gentle slopes while white birch/mountain maple and aspen/white birch/yellow birch communities were predominant on the steeper north and south slopes, respectively. Well over three-quarters of the total area of the monadnocks still supports a forest cover today.

Soils

Soil mapping of Marathon County is currently in progress, and coverage of the three monadnocks is complete. In the area is a group of soils that have developed in part from weathered bedrock or shallow till. A silty covering about two feet thick often overlies these parent materials and probably originated as a local, non-calcareous loess. As a result, moderately-deep to deep, moderately-steep to steep, stony, Gray-Brown Podzolic (mostly Typic Glossoboralf) soils cover the hills. Ribhill, Fenwood, Rietbrock and Sherry are the principal soil series. A summary of the major soil types of the monadnocks including land use capability ratings and current uses appears in Table 1.

Economic Geography

Agriculture and Forestry

Utilization of the monadnocks for agriculture has largely been precluded by the steep slopes, stony soils and dense forest vegetation. Only along the base of the hills have the farmers cropped and pastured the land. They cultivate up to the level where the soils become too shallow or stony. A number of stump pastures are present around the base of Rib Mountain and while some have been cleared for cropland most of the acre-

Table 1. Major Soils of the Crystalline Monadnocks of North-Central Wisconsin.

Soil Type	*Topographic Position*	*Capability Rating*	*Current Use*
Ribhill stony silt loam	Summit and steep talus slopes	6,7	Woodland
Fenwood stony silt loam	Intermediate slopes	6, 7	Woodland
Rietbrock stony silt loam	Lower slopes	5	Woodland
Sherry stony silt loam	Lower slopes	5	Woodland
Fenwood silt loam*	Lower slopes, marginal	2, 3	Cropland, Woodland
Mosinee loam*	"Sag" area, Mosinee Hill	3, 4	Cropland

* Limited acreage

age remains in permanent pasture. Many farmers own land farther up the slopes but since they cannot utilize it for crops or pasture they have wisely left it in forest. At the present time there are four farmsteads on Rib Mountain (all near the western end), four on Mosinee Hill (located on the gentler western slopes and "sag" area) and none on Hardwood Hill.

Following the ruinous forest fire of 1910, loggers moved in and by the latter part of 1911 had removed all of the salvable timber from Rib Mountain (Schaetzl 1980). An inventive operator devised a wooden chute that made it possible to slide large logs down the steeper slopes allowing for more rapid removal. Occasional forest harvesting operations have been carried on by private owners in recent years. Minnesota Mining and Manufacturing Company (3M) has cut timber selectively on its two properties on Rib Mountain, and the Tigerton Lumber Company owns 144 acres of forest land on the western end of the "Mountain." A private owner has engaged in selective cutting of timber on Hardwood Hill recently (Brechler 1981, personal communication). A fire tower was constructed on Hardwood Hill to serve central Marathon County but is now abandoned.

Mining

Mining (or quarrying) of quartzite on Rib Mountain and Mosinee Hill began near the end of the last century, and several companies have subsequently been engaged in

Fig. 5. Quartzite quarry on the northwestern slope of Rib Mountain.

this activity until quite recently. The Wausau Sandpaper Company commenced production in 1893 using quartzite blocks hauled from Rib Mountain to their factory in Wausau (Marchetti 1913). Later they opened a small quarry on the northeastern section of the hill. By 1910 the company was producing 9,000 sheets of sandpaper a day based on the excellent quality of the ground quartzite. In 1901 the Wausau Quartz Company started production of crushed quartz at their ball mill in Wausau (Marchetti 1913). All grades from finest powder up to ¼ inch diameter were ground from quartzite obtained from their two properties on Rib Mountain. The various abrasive purposes for which the quartz was utilized included the manufacture of flint sandpaper, sand blasts, sand belts, pumice stone, marble cutting and match sand. Additional uses for the crushed quartz were for filters, bird grit, wood fillers and stone facing.

Minnesota Mining and Manufacturing Company (3M) purchased 281 acres on the north slope of Rib Mountain in 1929 in order to establish a quarzite quarry (part of the acreage had been owned by the Wausau Quartz Company) (Fig. 5). Operation of the quarry was continuous until 1976 and in that period about one million tons of quartzite were removed to be ground into sandpaper grit. Company officials indicate that production may resume at some future date if the need arises. Duffek Sand and Gravel Company of Antigo operated a quarry on the south end of the northern summit of Mosinee Hill for a short time to procure road aggregate. It was closed after a petition of nuisance was circulated by nearby land owners.

Five exploratory shafts and drifts were opened on Rib Mountain in attempts to strike gold ore of commercial richness; the first as early as 1897 (Berger 1979). One of the abandoned shafts is located just north of the State Park road. Unfortunately, none of the ventures "panned" out although one of the mines was reported to have been salted with California gold dust in an attempt to lure unwary investors.

Recreation

The heart of recreational development is Rib Mountain State Park which occupies 860 acres on the summit and north and south slopes. Inception of the park dates from 1923 when forty acres were given to the state by the heirs of the Jacob Gensman estate for that purpose. Four years later in 1927, it officially became a state park. Completion of a winding three-mile road up the east side of Rib Mountain in 1931 gave the public access. Six subsequent gifts of land by individuals, a club, corporations and Marathon County plus Department of Natural Resources land purchases totalling $164,000 expanded the park to its present size. The park includes a 31-unit campground, 3.1-acre picnic area, 3,200-foot nature trail with signs, 1.25-mile snowmobile trail, 2.5-mile hiking trail and a forty-foot tower with three observation platforms that affords a 30-mile view. Table 2 summarizes attendance at Rib Mountain State Park in recent years (Wisconsin Blue Book 1981).

A newly-proposed master plan for Rib Mountain State Park calls for a $1,000,000 expansion and improvement over the next two decades. Total area of the park would be increased from the present 860 acreas to 1,219 acres at an estimated cost of $500,000. However, private development is encroaching on some boundary areas of the park and causing land values to soar. Improvements called for include expanded day use, new water system, expanded picnic area, new

Table 2. Visitor Attendance at Rib Mountain State Park*

1966—115,571	1972—251,807	1978—271,061
1967—142,624	1973—204,400	1979—189,475
1968—163,266	1974—199,837	1980—199,224
1969—211,613	1975—195,216	1981—204,743
1970—221,149	1976—240,871	1982—221,333
1971—262,137	1977—221,782	1983—194,995

* Includes skiers at Rib Mountain Ski Area

parking lot, open shelter, playground equipment, observation deck adapted to wheelchairs, expanded trail system, new office/visitor entrance station, road repairs and rebuilt park entrance. Total cost of the above would be $500,000 and take at least ten years to complete.

Also located within the state park on a 160-acre tract on the north slope is the Rib Mountain Ski Area (Fig. 6). Cleared of timber and rocks by the Civilian Conservation Corps in the 1930's, it features a 550-foot drop between the elevations of 1,250 feet and 1,800 feet. For many years the ski area was operated by the Wisconsin Conservation Department (now the Department of Natural Resources) who later turned the operation over to a group of local businessmen, who in turn, worked directly under the supervision of the Marathon Civic Corporation. The latter group, a division of the Wausau Area Chamber of Commerce, holds the ski concession and in 1964 contracted with a private concessionaire, the Rib Mountain Ski Corporation, to run the ski area. Between 1965 and 1976, a total of $780,000 in improvements were instituted at the ski area by the concessionaire.

Skiing at Rib Mountain Ski Area offers fifteen slopes which vary from gradual to steep, to suit each skier from beginner to expert. Included are four major slopes that are groomed by an extensive snow-making system which is employed when necessary to compensate for nature's deficiencies. Ownership of facilities at the ski area is a cooperative venture. The state owns the land, the main chalet and eight other buildings, four rope tows and a T-bar while the concessionaire owns two chairlifts (one is

Fig. 6. Rib Mountain Ski Area, from the north.

TABLE 3. Skier Attendance at Rib Mountain Ski Area

1964-65—13,000	1971-72—66,000	1978-79—85,000
1965-66—15,000	1972-73—52,000	1979-80—51,000
1966-67—27,000	1973-74—65,000	1980-81—38,000
1967-68—28,000	1974-75—78,000	1981-82—57,000
1968-69—30,000	1975-76—85,000	1982-83—40,000
1969-70—57,000	1976-77—65,000	
1970-71—61,000	1977-78—95,400	

3,300 feet long), a T-bar and several buildings. Services available at the area include a ski shop, rental shop, repair shop, ticket sales shop, sun porch, cocktail lounge and cafeteria. Drawing heavily on southern Wisconsin and Chicago areas for its clientele, the ski area has suffered at times from the lack of natural snow. Following the record 1977-78 season, the attendance dropped dramatically in the 1979-80, 1980-81 and 1982-83 seasons when the winters were abnormally mild with meager snowfalls. Table 3 indicates the numbers of skiers using the ski area in recent seasons (Oliva 1983, personal communication).

Communications

While Mosinee Hill supports a single corporate radio tower and Hardwood Hill an abandoned fire tower, Rib Mountain is the hub of a complex communications network. As one of the state's highest points of elevation plus having its greatest local relief, it lends itself well to this type of economic activity. A 746-foot television tower, looking like a gigantic toothpick stuck into the "Mountain," dominates the electronic apparatus atop the hill. The tower is jointly owned by WSAW-TV (Channel 7-CBS) and WAOW-TV (Channel 9-ABC), and its highest point serves as the antenna for the two stations. Somewhat lower on the tower is the antenna for WHRM-TV (Channel 20-PBS) which went on the air in October of 1975. Farther down are the antennas for WIFC-FM radio and WHRM-FM radio. Below that are various governmental communications antennas such as NOAA's 24-hour radio and the Wisconsin State Patrol network plus a radio repeater that receives signals from amateur radio operators and rebroadcasts them to a 60 to 70 mile radius. Closer to the bottom of the tower is a series of cone-shaped antennas to receive microwave signals for all incoming television network programming. At the base of the tower are the transmitter facilities for the three television stations which although they appear to be in one building are separate. The transmitter produces about 35,000 watts of power which concentrates into 316,000 watts at the tip of the tower and allows the stations to serve some seventeen counties in northern Wisconsin.

Rib Mountain is the key to communications for Marathon County agencies through a smaller tower that controls radio traffic of the sheriff's department, highway department, park department, office of emergency government and Wausau fire department. Also on top of the "Mountain" are microwave facilities of General Telephone and Electronics and American Telephone and Telegraph that handle long-distance telephone calls for the area. From two rather small buildings at the base of two bulky microwave towers, the GT&E facility can handle about 7,000 conversations and the AT&T equipment upwards of 20,000 conversations at a given moment.

CONCLUSIONS

Having traversed Rib Mountain, Mosinee Hill and Hardwood Hill on foot, the author can attest to their unique character and scenic beauty. Largely due to stony soils and steep slopes, agriculture and forestry have only marginally touched the monadnocks. It is in the fields of recreation, communications and mining that the hills have had the greatest economic impact in the past and, most likely, in the future.

ACKNOWLEDGMENTS

Research was supported by the University of Wisconsin-Marathon County Foundation, Inc., during the summer of 1981. Special thanks is extended to Professor Marcel Grdinic, UW-Marathon County, for the photography used in the figures. I also thank Professor Francis D. Hole, UW-Madison, for constructive criticism of the manuscript.

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ADDRESSES OF AUTHORS: *Transactions* Wisconsin Academy, 1984

ALESCH, DANIEL J.
Public and Environmental Administration
University of Wisconsin-GB
Green Bay, WI 54302

ALEXANDER, JAMES
Department of English
University of Wisconsin-Wood County Center
P.O. Box 150
Marshfield, WI 54449

ATKISSON, ARTHUR (Deceased)

BLEWETT, THOMAS J.
Biology Department
Clarke College
Dubuque, IA 52001

BRITO, SILVESTER J.
Department of English
University of Wyoming
Laramie, WY 82071

COCHRAN, PHILIP A.
Division of Natural Sciences
St. Norbert College
De Pere, WI 54115

COTTAM, GRANT
Department of Botany
University of Wis.—Madison
Madison, WI 53706

DESTEFANO, STEPHEN
Idaho Cooperative Wildlife Research Unit
Moscow, ID 83843

EVRARD, JAMES O.
Wetlands Wildlife Research
Wisconsin D.N.R.
P.O. Box 61
Baldwin, WI 54002

GRAMM, KENT
Department of English
Ottawa University
Ottawa, KS 66067

GRAYBOSCH, ANTHONY J.
Department of Philosophy
Mount Senario College
Ladysmith, WI 54848

HERRICK, BRUCE R.
Institute for Environmental Studies, 70 Science Hall
University of Wis.-Madison
Madison, WI 53706

HILL, DENNIS AUBURN
Memorial Library
University of Wis.-Madison
Madison, WI 53706

HILSENHOFF, WILLIAM L.
Department of Entomology
237 Russell Laboratories
University of Wis.-Madison
Madison, WI 53706

HOLE, FRANCIS D.
Department of Soil Science
University of Wis.-Madison
Madison, WI 53706

LANGE, KENNETH I.
Park Naturalist
Devil's Lake State Park
Route 4, Box 36
Baraboo, WI 53913

LINDBORG, HENRY J.
English Department
Marian College of Fond du Lac
Fond du Lac, WI 54935

LYONS, JOHN
Center for Limnology
University of Wis.-Madison
Madison, WI 53706

MUSOLF, GENE E.
Department of Geography and Geology
University Wisconsin-Marathon County Center
Wausau, WI 54401

NICHOLS, STANLEY A.
Wisconsin Geol. & Nat. Hist. Survey
University of Wis.-Extension
Madison, WI 53706

PETAK, WILLIAM J.
Institute for Safety and Systems Management
University of Southern California
Los Angeles, CA 90007

PIEHL, KATHY
410 Clark Street
Mankato, MN 56001

POPP, EDWARD E., D.D.S.
543 N. Harrison Street
Port Washington, WI 53074

RHODES, BENJAMIN D.
Department of History
University of Wisconsin-Whitewater
Whitewater, WI 53190

RUDSTAM, LARS G.
Askö Laboratory
Institute of Marine Ecology
University of Stockholm
Stockholm, SWEDEN 106 91

RUSCH, DONALD H.
Wis. Cooperative Wildlife Research Unit
University of Wis.-Madison
Madison, WI 53706

SCHULTZ, FREDERICK H. C.
Department of Physics
University of Wisconsin-EC
Eau Claire, WI 54701

SINGER, MARCUS G.
Department of Philosophy
Helen C. White Hall
University of Wis.-Madison
Madison, WI 53706

STEVEN, JEFFREY C.
Metropolitan Sewerage District
1610 Moorland Road
Madison, WI 53713

THURIN, SUSAN SCHOENBAUER
Department of English
University of Wisconsin-Stout
Menomonie, WI 54751

TURCHENESKE, JOHN A., JR.
Rural Route One
River Falls, WI 54022

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TRANSACTIONS

of

the Wisconsin Academy of Sciences, Arts & Letters

Volume 73
1985

TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

Volume 73, 1985

Funds for this issue of the *Transactions*
have been provided by
the Elizabeth F. McCoy Memorial Fund

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Established 1870
Volume 73, 1985

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SEVERE THUNDERSTORM HAZARD IN WISCONSIN

Waltraud A. R. Brinkmann
Department of Geography
University of Wisconsin-Madison

Abstract

This paper presents the results of a study of the spatial and temporal variations in severe thunderstorms and of two of the components—tornadic storms and hail—in Wisconsin. Results of factor analyses of the seasonal variations in the storm indices for each of the nine climatological divisions show that the seasonal migration patterns—from the southern portion of the state in spring toward the northwest in summer and back south in fall—are similar for thunderstorms in general, tornadic storms, and hailstorms, and reflect the seasonal migration and seasonal changes in the importance of different cyclogenetic regions and associated storm tracks across Wisconsin. The influence of these storm tracks is also reflected in the spatial distributions of the average annual storm indices by county which show two general regions of maximum activity for severe thunderstorms and the two components. Although lightning is the overall number one severe thunderstorm killer (total deaths/yr) for the state, the April tornado is highest in deaths per storm day.

Introduction

Severe thunderstorms generally occur in conjunction with squall lines ahead of cold fronts of extratropical cyclones. Since the development and direction of motion of cyclones is closely linked to the location of the jet stream, cyclone and severe thunderstorm activity and associated hazards—such as tornadoes, hail, and lightning—migrate with the season. Thus, maximum activity is located over the Gulf Coast in winter, it is in the central Great Plains in spring, and in the northern Great Plains and southern Canada in summer. The temperature contrast between polar and tropical air masses begins, however, to weaken in late spring which, in turn, is reflected in a weakened jet stream and reduced extratropical cyclone intensity. Consequently, the intensity as well as frequency of severe thunderstorms decreases as the area of maximum activity migrates northward. Thus, at the time of maximum thunderstorm frequency over the Canadian portion of the Great Plains, the number of days with thunderstorms observed there is only about three-quarters the number observed over the southern Great Plains of the United States. In fall, the temperature contrast intensifies again, and severe thunderstorm activity quickly retreats south toward the Gulf Coast (Kelly et al., 1978; McNulty et al., 1979).

Lightning kills more people in the United States—about 200 annually—than any other component of the severe thunderstorm hazard (Mogil and Groper, 1977). This may come as a surprise to some since lightning fatalities usually are single events that do not make national headlines. Most lightning deaths occur in the open where a person can serve as a relatively easy target; large structures and cars provide important protection from lightning strikes in urban areas. Tornadoes, on the other hand, account for only about 140 deaths annually (Mogil and Groper, 1977). Tornadoes vary, however, in their intensity and destructiveness: While extremely intense and violent tornadoes make up only about three percent of all tornado occurrences, they account for almost 70 percent of the deaths (Wilson and Morgan, 1971; Kessler and Lee, 1978; Kelly et al., 1978); and violent tornadoes tend to occur most frequently in spring.

The spatial and seasonal variations of the severe thunderstorm hazard components in the United States and some of their social costs are thus known in general terms. In addition, some studies have provided information on the climatology of hazard components at the state level, such as the work on tornadoes in Illinois (Wilson and Changnon, 1971), in Wisconsin (Burley and Waite, 1965), and in Michigan (Snider, 1977), or the work on hailstorms in Illinois (Changnon, 1960) and in Wisconsin (Burley et al., 1964). Many of the regional studies were, however, done more than a decade ago and have, similar to national studies, tended to focus on a single component of the severe thunderstorm hazard. The purpose of the present study is to develop a more comprehensive description of the spatial and seasonal variations in severe thunderstorms in Wisconsin by (1) analyzing these variations not only for severe thunderstorms in general but also for the two most reliably and widely reported components—tornadic storms and hailstorms; and by (2) interpreting the results in terms of the seasonal and spatial variations in their common generating mechanism—extratropical cyclones—and their tracks across Wisconsin. The state of Wisconsin is located near the northeastern margin of the center of severe thunderstorm activity; strong gradients across the state should therefore be present and make patterns relatively easily identifiable.

Data and Method

The source of the basic data used in this study was *Storm Data* (NOAA, 1959-) which provides information on all reported severe weather events by state and county. All Wisconsin events described as having been caused by or having occurred in association with thunderstorms were noted and comprise the basic data for this study. All of these events were, for the purpose of this study, considered 'severe thunderstorm' events. 'Tornadic storm' events, a subset of the 'severe thunderstorm' events, include all reports of tornadoes and/or funnel clouds. 'Hailstorm' events, also a subset of the 'severe thunderstorm' events, consist of all reports of hail. Excluded are winter storms that produced snow, freezing rain, or widespread strong winds, and flooding that was at least partly caused by snow melt.

The study covers the 24-year period 1959-1982. This period does not include the early 1950s when nationwide changes in reporting procedures and increased public awareness resulted in an abrupt increase in the reporting of weak tornadoes and thus in an increase in the total number of tornadoes (McNulty et al., 1979; Tecson et al., 1979). In the early 1970s, the reporting responsibility moved from the State Climatologist Office to the National Weather Service Forecast Office; there are, however, no significant changes in the number of reported storms for Wisconsin at that time.

The quality of the *Storm Data* listings has been questioned, particularly that for tornadoes. However, while the results of some investigations have suggested that not all tornado occurrences are observed and thus reported (Eshelman and Stanford, 1977; Snider, 1977; Schaefer and Galway, 1982) others have indicated that some reported tornadoes were actually straight-line winds associated with severe thunderstorms (Changnon, 1982). In spite of the limitations of *Storm Data,* it is still the best severe weather data base available.

The basic analysis of the spatial and temporal distribution of severe storms was done at the county level since *Storm Data* lists severe weather events by county. At the next level of aggregation, county data were summed over all counties within each of the nine climatological divisions of Wisconsin (Fig. 1); at the highest level of aggregation, county data were summed over all counties within the state.

For the present analysis, storm event reports were first converted into storm days per county. This was done because of differences in the size and duration of different types of storms which, for instance, permit very specific information on the location of tornadoes but only very general information for a line of thunderstorms moving across a portion of the state. Furthermore, there are occasional problems even with tornado reports: It is not always clear whether two separate reports from the same county actually represent two different tornadoes. If a storm affected more than one county, it was counted once for each county affected.

The probability of an event occurring in a county is a function of county size, while the probability of it being observed and reported is affected by rural population density. County size in Wisconsin ranges from about 600 km^2 to about 4000 km^2. In general, counties in the northern half of the state are larger than counties in the southern half (Fig. 1). Rural population density ranges from about 3 people per km^2 to about 48 people per km^2. Rural population density is generally highest in the southeastern portion of Wisconsin, reflecting the proximity of Milwaukee and Chicago; a secondary peak in rural population density is found in the west-central portion, reflecting the proximity of Minneapolis. In a nationwide study of population biases in tornado reports, Schaefer and Galway (1982) have found that Wisconsin's most densely populated counties report 1.25 times the number of tornadoes that would be expected if they were distributed uniformly across the state, while the least densely populated counties report only one-third the expected number. Each storm day was therefore standardized by converting it into a storm index, which was defined as

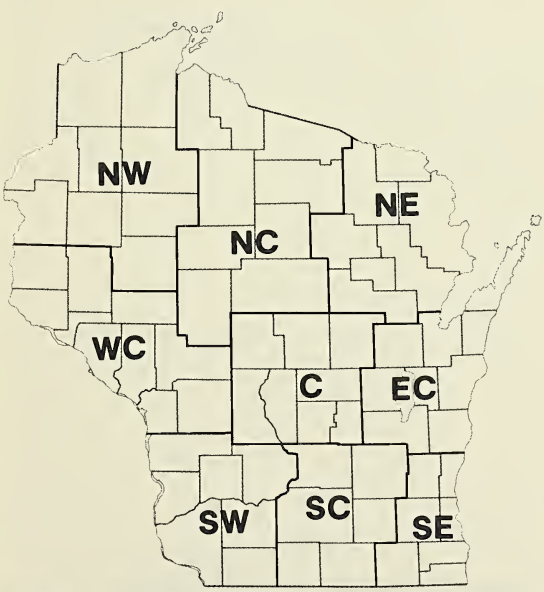

Fig. 1. The nine climatological divisions of Wisconsin.

$$\text{storm index} = \frac{\text{storm day}}{\text{county area} * \text{rural population density}}$$

Since rural population has in some cases increased by as much as 50 percent between 1960 and 1980, an estimate of the rural population for the year of the storm day was used to compute the storm index. Rural population for years between population census years was estimated by interpolating between years with census data.

The number of injuries and fatalities caused by a given storm is a function of the population-at-risk, or the total population density, of the county. Injuries were therefore standardized by converting each injury into an injury index, which was defined as

$$\text{injury index} = \frac{\text{injury}}{\text{total county population density}}$$

Deaths were standardized in the same way. Total population for the year in which the injury or death occurred was again estimated by interpolating between census years.

For some parts of Wisconsin—particularly Door County and North-Central Wisconsin—the population density increases considerably during the summer vacation season. Rough estimates by the Door County Chamber of Commerce and researchers at the University of Wisconsin-Extension (pers. comm.) of the size of the tourist population of Door County on the bases of the number of hotel rooms and summer homes and estimates of the average number of occupants of these rooms and homes suggest that it could, at times, be the size of the total permanent population of Door County. However, since neither average annual nor average monthly data on tourist population per county is available for the state of Wisconsin, it was not possible to include this population in the computation of the indices.

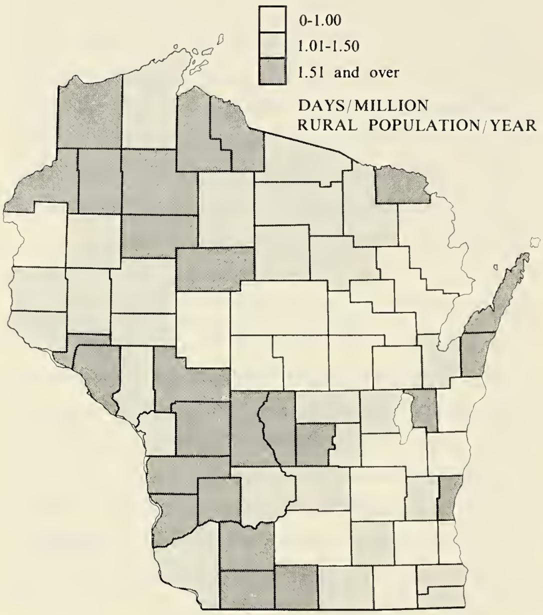

Fig. 2. Average annual severe thunderstorm index by county.

Severe Thunderstorms

The spatial pattern of the average annual severe thunderstorm index by county (Fig. 2) shows two regions with relatively high values: A southern one which extends from the SW and WC divisions eastward and northeastward (hereafter referred to as the Southern Track), and a northwestern region which extends from the WC division northeastward (hereafter referred to as the Northwestern Track). One area of relatively low values, extending across the central and northeastern portion of the state, divides the two regions of maximum activity; another area of relatively low values covers portions of the western shore of Lake Michigan.

The seasonal variation in the severe thunderstorm index for the state is shown in Fig. 3. (This curve was obtained by summing the average index over all counties for each half-

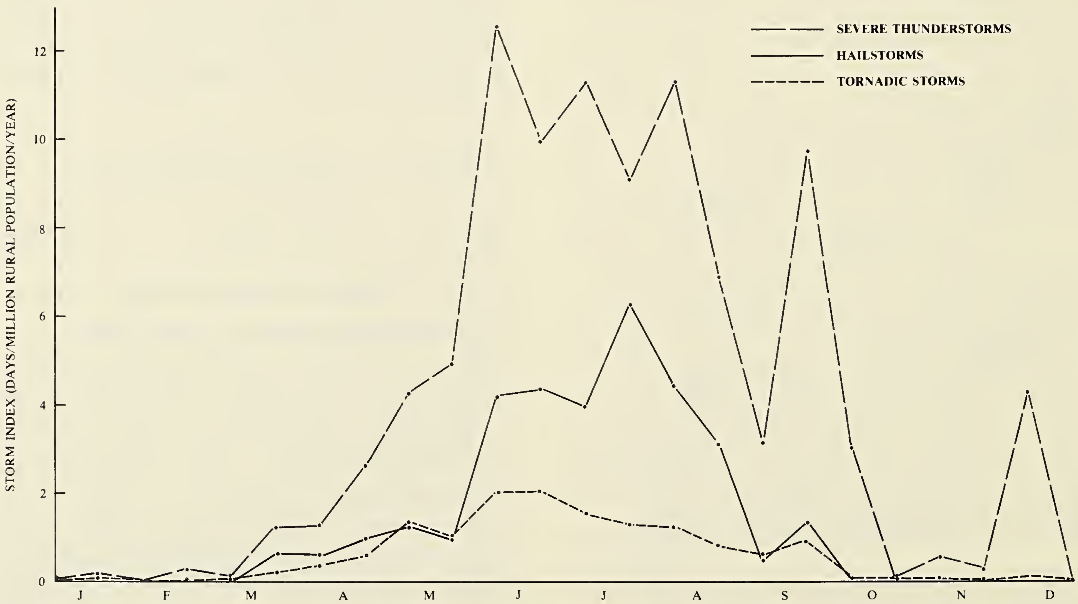

Fig. 3. Average semi-monthly storm indices for the state, adjusted for unequal number of days.

month: days 1-15 and days 16-the end. The data were adjusted for unequal length of the two halves. Since the index for the state is a summation over county-day indices, a high state index represents frequent and/or widespread activity.) The severe thunderstorm index for the state increases rapidly from late March through April and May, reaching its peak in early June. A relatively constant high level of activity persists through late June, July, and early August. It then decreases during late August and early September to a level similar to that of late spring. A drastic increase in activity to a summer-like level occurs briefly in late September. Another, but minor, peak occurs in early December.

There are, however, regional variations in the timing of the peak in severe thunderstorm activity. To quantify these regional variations, the average semi-monthly severe thunderstorm index was summed over all counties within each of the nine climatological divisions. The nine time series of the semi-monthly indices for the severe thunderstorm season, April through September, were then subjected to factor analysis to identify the most predominant temporal patterns. (More specifically, orthogonally rotated (varimax) factors were extracted from the covariance matrix.)

The first four factors of the divisional severe thunderstorm indices explain 84 percent of the total variance; the associated loadings are shown in Fig. 4. The first factor represents a July peak in severe thunderstorm activity; the second represents a May/early June and a late August peak; the third represents an early July and a late

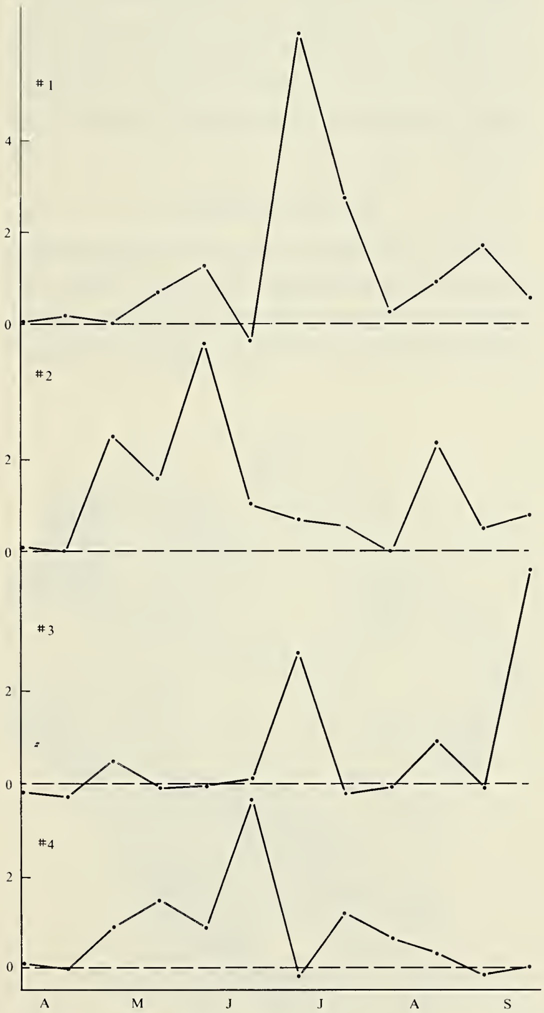

Fig. 4. Loadings for the first four factors of the severe thunderstorm index.

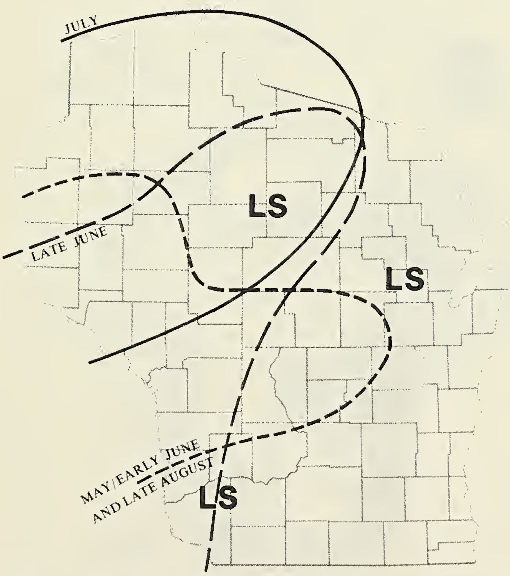

Fig. 5. Seasonal shifts in severe thunderstorm activity (LS = late September; based on the scores of the first four factors).

September peak; and the fourth represents a late June peak. (Minor peaks in the factor loadings, although important in the modulation of the divisional seasonal variations, are not considered here since the emphasis is on the most predominant temporal and spatial patterns.) The curve for the state (Fig. 3) is thus the result of several divisional curves with different seasonal peaks. The spatial patterns of the scores associated with each of the factors not only show these divisional differences but they can also be used to delineate seasonal shifts in the location of severe thunderstorm activity (Fig. 5; the lines delineate the general area experiencing a peak in activity at the indicated time or times).

In Wisconsin, severe thunderstorm activity begins in early spring over the southern portion of the state, but because of the still fairly low level of activity at that time, this beginning is not captured by the first four factors. In May and early June, the area of maximum activity is over the northern portion of the Southern Track; activity over the Northwestern Track is just beginning. In late June, it is over the southeastern portion of the Northwestern Track. By July, the region of maximum severe thunderstorm activity has reached its most northerly position, running across the northwestern portion of the state. By late August, it has shrunk back in the north but is quickly expanding southward and eastward across the northern portion of the Southern Track, to a position similar to its late spring position of May and early June. The southward migration of severe thunderstorm activity is, however, interrupted in late September when activity moves briefly back to a more northerly position, similar to that of mid-summer. This brief northward jump lacks, however, spatial uniformity; and the drawing of isolines is therefore not possible. Instead, divisions with late September peaks are labeled 'LS' in Fig. 5.

Tornadic Storms

The spatial pattern of the average annual tornadic storm index by county (Fig. 6) shows two regions with relatively high values which are similar to the two regions of maxi-

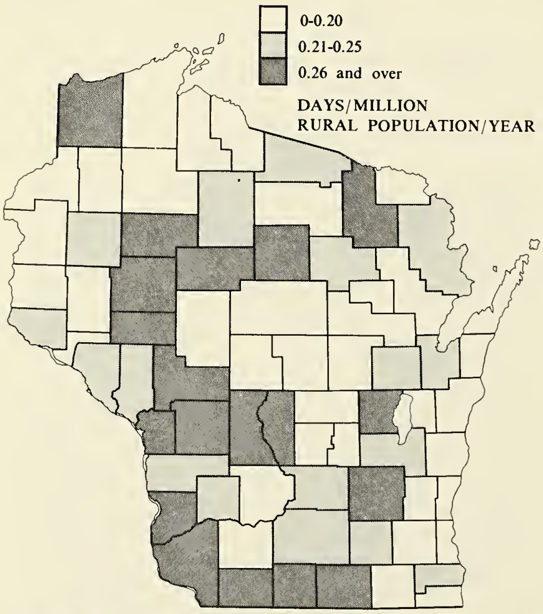

Fig. 6. Average annual tornadic storm index by county.

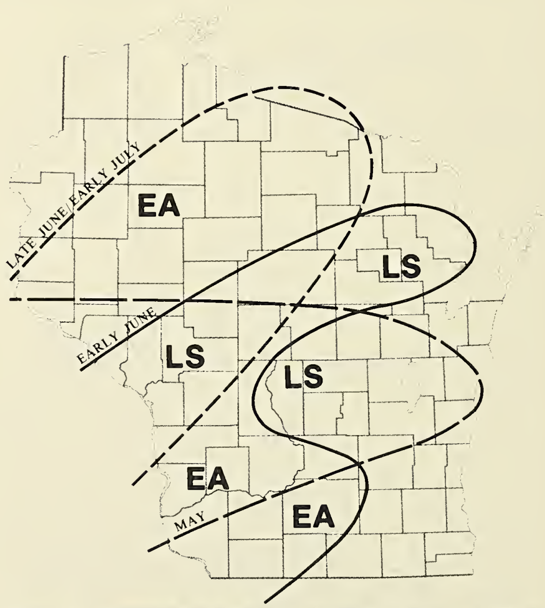

Fig. 7. Seasonal shifts in tornadic storm activity (EA = early August, LS = late September, based on the scores of the first four factors).

mum severe thunderstorm activity. A belt of minimum values runs southwest-northeast across the state, separating the two regions or tracks; another belt of minimum tornadic storm activity covers the western shore of Lake Michigan.

The seasonal variation in the tornadic storm index for the state is shown in Fig. 3. The index increases rapidly during the spring to a secondary peak in May and the main peak in June; this is followed by a gradual decrease during July, August, and early September. A small increase in the tornadic storm index occurs in late September.

The time series of the average semi-monthly tornadic storm indices for each of the nine climatological divisions were subjected to factor analysis to identify divisional variations in seasonality. The loadings for the first four factors, which explain 89 percent of the variance, indicate that the tornado season peak for the state consists of several divisional peaks which are similar to the severe thunderstorm peaks. Early spring activity is, again, not captured by the first four factors because of the generally low tornado activity at that time of year. The spatial distribution of the factor scores (Fig. 7) indicate the following seasonal migration of tornadic storm activity: In May, maximum activity is located over the northern portion of the Southern Track. (When comparing the patterns in Fig. 7 with those for severe thunderstorms in Fig. 5, the slight differences in timing need to be considered.) In early June, the area of maximum activity has begun to shrink in the south and to expand in the north across the southern portion of the Northwestern Track. By July, it has reached its most northerly position, running from the WC division northeastward across the northwestern portion of the state. In early August, tornadic activity is rapidly shifting southward, In late September, however, it moves briefly back to a more northerly position.

Hailstorms

The spatial pattern of the average annual hail index by county (Fig. 8) is very similar to that for severe thunderstorms, consisting of a Southern Track and a Northwestern

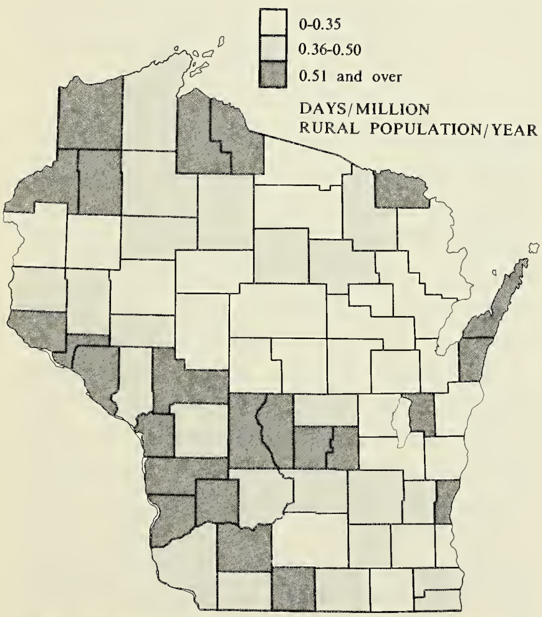

Fig. 8. Average annual hail storm index by county.

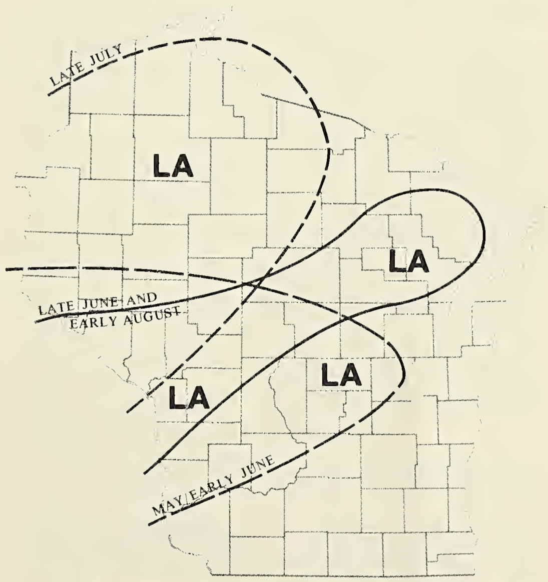

Fig. 9. Seasonal shifts in hail storm activity (LA = late August; based on the scores of the first four factors).

Track; an area of minimum activity divides the two tracks, another area of minimum activity covers portions of the western shore of Lake Michigan.

The seasonal variation in the hail index for the state is shown in Fig. 3. The index is low in spring. In early June, there is an abrupt increase in hail activity to a level that is maintained through most of June and early July. The main peak in hail activity occurs in late July and is followed by a relatively rapid decrease during August and September. A small increase occurs in late September.

Factor analysis of the nine divisional time series of the hail index indicate a seasonal migration similar to that for severe thunderstorms and tornadic storms (Fig. 9): During the early part of the main hail season (May/early June), maximum activity is over the Southern Track. In late June, activity decreases in the south while activity in the northern portion expands eastward. By July, it has reached its most northerly position, running across the northwestern portion of the state. By August, hail activity is rapidly migrating southward again.

Deaths and Injuries

Of the average annual severe thunderstorm death index for the state, over 50 percent is caused by lightning, 34 percent by wind and rain, and only 15 percent by tornadic storms. This reflects not only the frequency and severity of severe thunderstorms in Wisconsin but also the state's many lakes and the vast forested regions of northern Wisconsin. There are, however, some regional variations in the cause of death. While lightning is the main cause of death for the northern divisions (where fishing, boating, and hunting are major tourist attractions), rain and wind—particularly drowning—tend to be more important in the more densely populated southern divisions.

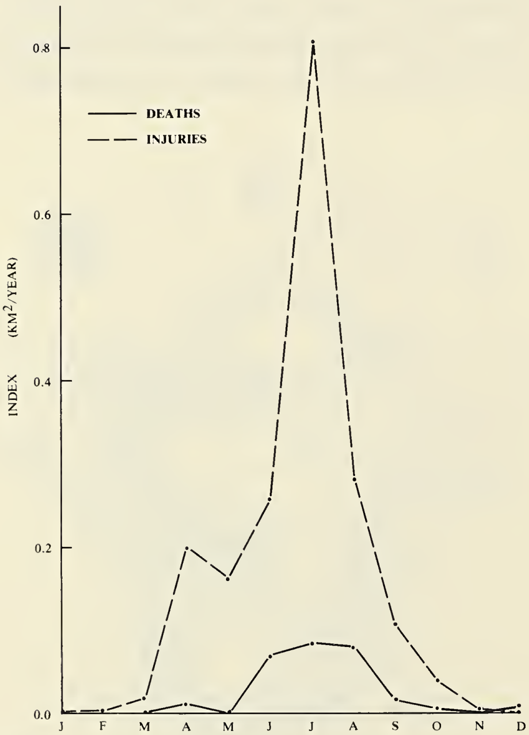

Fig. 10. Monthly severe thunderstorm death and injury indices for the state.

Fig. 11. Monthly death/storm and injury/storm ratios for the state for tornadic and non-tornadic storms.

Tornadic storms are a secondary cause of death everywhere in the state, but they are the primary cause of injuries. Of the average annual severe thunderstorm injury index for the state, over 50 percent is caused by tornadic storms, 32 percent by wind and rain, and only 16 percent by lightning. These proportions are about the same everywhere in the state.

The average monthly severe thunderstorm death and injury indices (Fig. 10) increase during spring, reach a peak in summer, and then decrease again in fall. These changes reflect, to a large degree, the seasonal changes in the occurrence of severe storms.

To remove the effect of seasonal variations in the occurrence of storms, death-storm and injury-storm ratios were computed, defined as the death or injury index for the state divided by the storm index for the state (Fig. 11). Both the death-storm and injury-storm ratios are highest for tornadic storms occurring in April. During the remainder of the severe thunderstorm season, the death-storm ratios for tornadic and non-tornadic storms are comparable in magnitude while the injury-storm ratios for tornadic storms are somewhat higher than those for non-tornadic storms.

Summary and Discussion

The severe thunderstorm season starts in Wisconsin in early spring and reaches its peak in June, July, and early August. A secondary maximum occurs in late September. During the storm season, the area of maximum activity migrates across the state. The migration pattern is, however, not a simple north-south shift as would be expected from the generalized and simplified view of a north-south migration of the jet stream and cyclone tracks across the country. Instead, the migration pattern—which is very similar for severe thunderstorms in general, for tornadic storms, and for hailstorms—is from the southern portion of the state toward the *northwest* and back, which reflects seasonal changes in the degree of activity over the two main cyclone tracks affecting Wisconsin (Whittaker and Horn, 1984). In spring, cyclones generated over the Great Basin and Colorado move northeastward and affect the southern and eastern portion of the Great Lakes Basin; in summer, cyclones generated over Wyoming and Alberta affect the northwestern portion of the Great Lakes Basin before heading northeastward to James Bay.

Activity begins in early spring when one of the primary North American extratropical cyclone tracks, extending from the Great Basin/Colorado cyclogenetic area eastward, shifts northward and reaches southern Wisconsin. Severe thunderstorm activity is still fairly low at that time of year, and severe thunderstorm-related deaths and injuries are therefore also still fairly low. Tornadic storm and hail storm activity is also low but, because of the relatively low severe thunderstorm activity, as much as one-third of the severe thunderstorm index is tornado activity and another one-third is hailstorm activity. The tornadic storms are, furthermore, extremely intense and destructive at that time of year. No severe thunderstorm component at any other time during the season causes as many deaths and injuries per storm day as the tornadic storm in April.

By May, the area of maximum activity extends from the southwest and west eastward across the southern portion of the state. Severe thunderstorms are increasing, but tornadic storms and hailstorms are increasing as well so that each still comprises about one-third of the severe thunderstorm index. Severe thunderstorm-related deaths and injuries are still relatively low; and tornadic storms become less intense and destructive as the temperature contrast between polar and tropical air masses decreases.

By June, the Great Lakes Basin comes increasingly under the influence of eastward and southeastward tracking Alberta and Northwest Territory cyclones. The severe thunderstorm activity pattern in Wisconsin takes on a two-pronged appearance, with activity over the Southern Track decreasing and activity over the Northwestern Track increasing. Severe thunderstorm activity is thus widespread and high; hailstorm activity represents about 37 percent of the severe thunderstorm activity; while tornadic storm activity, although at its peak, comprises only about 20 percent of the total activity. Severe thunderstorm-caused deaths and injuries are also high. Drowning and other water-related deaths (an important cause of death in the southern third of the state) reaches its peak in June, while lightning deaths continue to increase into July.

In July, the Colorado and Great Basin cyclogenetic areas become inactive, and only Montana and Alberta cyclones, swinging eastward and southeastward before converging over James Bay, affect the northwestern portion of the Great Lakes region. In Wisconsin, maximum severe thunderstorm activity is located in a belt running across the northwestern portion of the state. Severe thunderstorm activity as a whole is still high; hail activity is at its maximum and now comprises more than half the severe thunderstorm activity; while tornadic storm activity is declining. Deaths and injuries caused by severe thunderstorms are at their peak; in particular, deaths caused by lightning—the number one severe thunderstorm killer for the state and particularly for the northern third of the state—are most frequent in July. Tornadic storms, on the other hand, are responsible for only 15 percent of the deaths but over 50 percent of the injuries in July.

In August, cyclogenetic activity along the Rocky Mountains begins to extend southward again and the more southern tracks across the country become increasingly active. Severe thunderstorm activity in Wisconsin begins a rapid and irregular retreat to a late spring-early summer position: Activity decreases over the Northwestern Track and expands eastward in the south. Severe thunderstorm activity is still relatively high but declining. Hailstorm and tornadic storm activity are also rapidly decreasing, with hail representing about 38 percent of the total storm activity and tornadic storms making up 10 percent. Deaths and injuries are decreasing as well.

By early September, there is a drastic decrease in severe thunderstorm activity. Activity increases, however, briefly in late September to a mid-summer level and shifts northward to a mid-summer like pattern. But the activity is not very intense: Little of it produces tornadic storms or hail, and deaths and injuries per storm day are much below their mid-summer levels.

Not only is this seasonal migration pattern a reflection of the influence of the two extratropical cyclone tracks across Wisconsin but the spatial patterns of the average annual severe thunderstorm activity are also a reflection of these two tracks. The patterns for severe thunderstorms in general as well as those for tornadoes and hail show two general areas of maximum activity: one across the southern portion of the state, the other across the northwest. An important region of activity for severe thunderstorms, tornadic storms, and hail storms is the WC division where the influence of the two cyclonic storm tracks appears to overlap.

A belt of minimum activity separates the two maxima. This belt could be the northern end of the slanted 'trough' line identified by Tecson et al. (1982). This line is a slanted narrow line of minimum tornado occurrence—extending from southern Texas to Upper Michigan and dividing Wisconsin into a northwestern and a southeastern half—that separates 'eastern' from 'western' tornadoes. Eastern tornadoes become active in Mississippi in February; from there they spread northward; peak activity is in March and April. Western tornadoes, on the other hand, become active in the Tornado Alley in April and reach their peak in May; activity then decreases while they spread northward toward the Canadian border. The present results, which show such a trough line not only in the distribution of tornadoes but also in the distribution of hail and severe thunderstorms in general, suggest that the cause of this line may have a synoptic basis, rather than topographic or population-related bases as has been suggested.

Another area of minimum activity in severe thunderstorms in general as well as in tornadic storm and hailstorm activity, extending along the western shore of Lake Michigan, is caused by the relatively low temperature of the surface water during spring and summer which suppresses convective activity.

Acknowledgements

This work was supported by the Wisconsin Alumni Research Foundation.

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PREGLACIAL RIVER VALLEYS OF MARQUETTE, GREEN LAKE, AND WAUSHARA COUNTIES

CHARLES M. FLEMING
Greendale, Wisconsin

Abstract

Buried preglacial river valleys lying in three Wisconsin Counties were identified and mapped. Their physical dimensions were obtained by way of a mathematical model that was used to describe a valley cross section. The network of buried valleys that was discovered corresponds in part with the successive damming of the ancient Wisconsin River by the advancing and most recent glacier. The underlying Precambrian bedrock apparently influenced the glacier's direction of movement as well as the courses of some of the preglacial rivers in this region.

INTRODUCTION

In preglacial times, the ancient Wisconsin River flowed from the northern highland of Wisconsin and Michigan southward into central Wisconsin. There it had carved out of the Baraboo hills the famous Devils Lake gorge and, turning westward at Merrimac, concluded its journey at Prairie du Chien where it met the ancient Mississippi River (Martin, 1932). If glaciation had never occurred, the modern Wisconsin River would still be following this course, but the invasion of the last continental glacier squeezed the Wisconsin River out of its ancient valley in central Wisconsin and permanently diverted its flow to its modern valley bordering Adams and Juneau Counties (Alden, 1918). Prior to glaciation, the ancient river made a great loop in central Wisconsin which extended from the vicinity of Friendship to Green Lake before it entered the gorge at Devils Lake. Neither the loop nor the gorge are used by the river today.

Even though glaciation had significantly scoured the land, the buried bedrock underlying Marquette, Green Lake, and Waushara Counties still has etched in it the preglacial river valleys that once contained the Wisconsin, Wolf, and Fox Rivers. The existence of these buried preglacial valleys has been known for more than one hundred years; their presence, however, is inconspicuous and their exact locations can only be found by means of well drillings and borings. Occasionally, the top of an ancient valley is visible, but, generally, the valleys are completely buried beneath glacial drift. On top of the drift lacustrine deposits have created, along practically all these ancient valleys, the wetlands that abound in these three counties.

Immediately prior to the four Pleistocene glaciations that are known to have touched Wisconsin (USGS, 1976), most of the limestone bedrock that once uniformly covered this region had already eroded away (Martin, 1932). Rolling hills of sandstone dotted with crags, buttes, and pinnacles were features of the preglacial landscape as they are in the landscape of the Driftless Area of Wisconsin today. In preglacial times, the Wisconsin River was one of the largest rivers in Wisconsin. In central Wisconsin, its valley was approximately 600 feet deep and 4 miles wide at the crests. The river entered Marquette County from the west in the town of Westfield, at an elevation of 503 feet above sea level with respect to the bottom of its channel, and proceeded eastwardly on the first leg of a great loop as shown in Fig. 1. The Wisconsin River met the ancient Wolf River at Neshkoro and the ancient Fox River at Green Lake, the eastern extreme point of

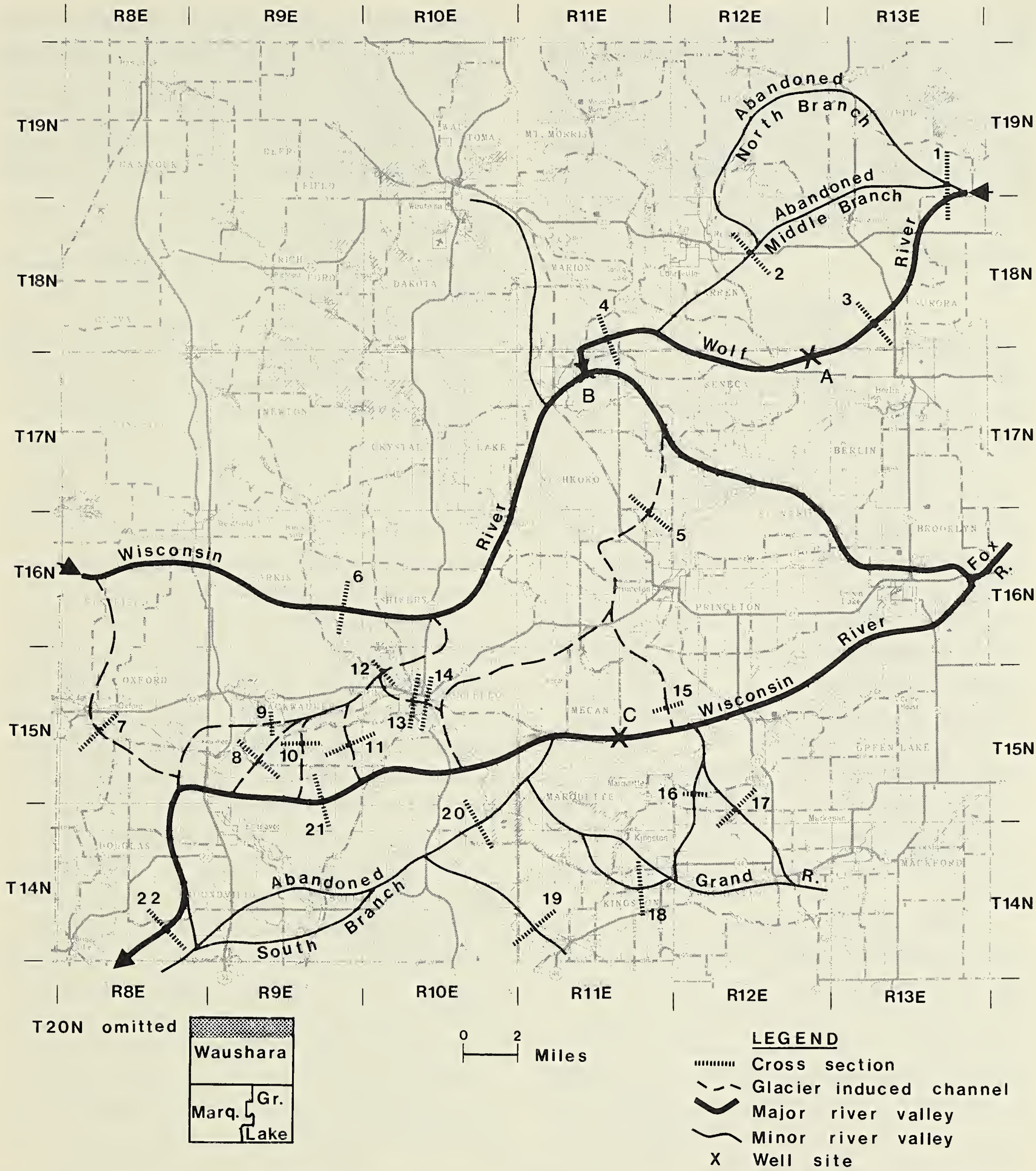


Fig. 1. Map of preglacial river valleys of the Wisconsin, Wolf, Fox, and Grand Rivers. The three wells A, B, and C are listed in Table 1. The twenty two cross sections of the river valleys and channels are listed in Table 2.

Table 1. Important Wells Marked in Figure 1.

Well	*Elevation of bottom above sea level*
A	473 feet
B	462
C	420

the loop. Turning abruptly to the west at Green Lake, the Wisconsin River, on its westward course, dug the basins in which Green Lake and Lake Puckaway lie. It reentered Marquette County on the last leg of the loop and, in the town of Douglas, left the county at an elevation of 382 feet above sea level enroute to the Devils Lake gorge 20 miles away.

History

The history of the Fox River in central Wisconsin was probably first discussed by John Petitval in 1838. In his report to Congress of the survey of the Fox River, he speculated that the upper Fox River valley had at one time been a chain of lakes which suddenly drained, leaving the Fox River as a meandering stream. In 1876, Warren submitted to Congress a more comprehensive geologic report of the Fox River. In that report, Warren asserted that the Fox River in preglacial times had flowed in the opposite direction and had actually been a tributary of the ancient Wisconsin River. According to Warren, their confluence was located at Portage, while the ancient Wisconsin River, as Warren tacitly assumed, followed the same course as the modern Wisconsin River follows.

In 1877, Irving's treatise on Wisconsin geology was published, yet it did not contain any more information than Warren's report about the history of either the Wisconsin or Fox Rivers. Forty years later, though, William Alden squarely addressed the topic of ancient river valleys in *The Quaternary Geology of Southeastern Wisconsin,* published in 1918, and his opinion about the ancient Wisconsin River has been the authoritative one ever since. He offered two conjectures pertaining to the course of that ancient river. The first was that the confluence of the ancient Wisconsin and Fox Rivers was located in the town of Oxford where the Wisconsin River, flowing southeastwardly through the village of Oxford, joined the Fox which was flowing westwardly through Rush Lake, Green Lake, and Lake Puckaway. The second conjecture was that the Wisconsin River had flowed directly south from Stevens Point through Wautoma and Neshkoro to meet the Fox in Oxford. Relying on Alden's work, E. F. Bean apparently incorporated Alden's second conjecture into his *Geologic Map of Wisconsin,* published in 1924, by drawing a narrow trigger shaped contour depicting an extension of the exposed Precambrian bedrock of Portage County through Waushara County and well into Marquette County as if that extension was the exposed granite of the ancient Wisconsin River bottom. (For an illustration, see Martin, p. 35). This narrow trigger shaped contour of Precambrian rock is a characteristic mark of Bean's map and has been reproduced in many publications since; nevertheless, the existence of it can not be substantiated and it no longer appears on the latest map of the geology of Wisconsin (Mudrey, 1985). The erroneous belief that the ancient Wisconsin River had flowed south from Stevens Point through Waushara County and Neshkoro Township to meet the Fox River in Oxford, as Alden had hypothesized and to which Bean alluded, was reiterated by Lawrence Martin in *The Physical Geography of Wisconsin,* published in 1932. There the issue remained at rest until 1976, when Mark Stewart wrote his doctoral thesis. In that thesis, Stewart presented a map of the preglacial Fox-Wolf River basin that finally delineated the course of the ancient Fox and Wolf Rivers in Green Lake and Marquette Counties with a good deal of accuracy.

Discussion of the Data

For the purpose of this article, the information obtained from the Wisconsin Department of Natural Resources well constructor's reports, from the Wisconsin Department of Transportation highway test borings, and from Alden (1918) provided 780 data points upon which the locations of the preglacial river valleys were deduced.

The data points were scattered over an area encompassed by the mapping of the bedrock topography shown in Fig. 2 and which equaled approximately 1,000 square miles. Even though very few wells ever reached the bottom of a river valley, the information obtained from many other neighboring wells provided sufficient circumstantial evidence to permit, by means of an appropriate mathematical model and standard statistical methods, an accurate description of the sizes and locations of the preglacial river valleys.

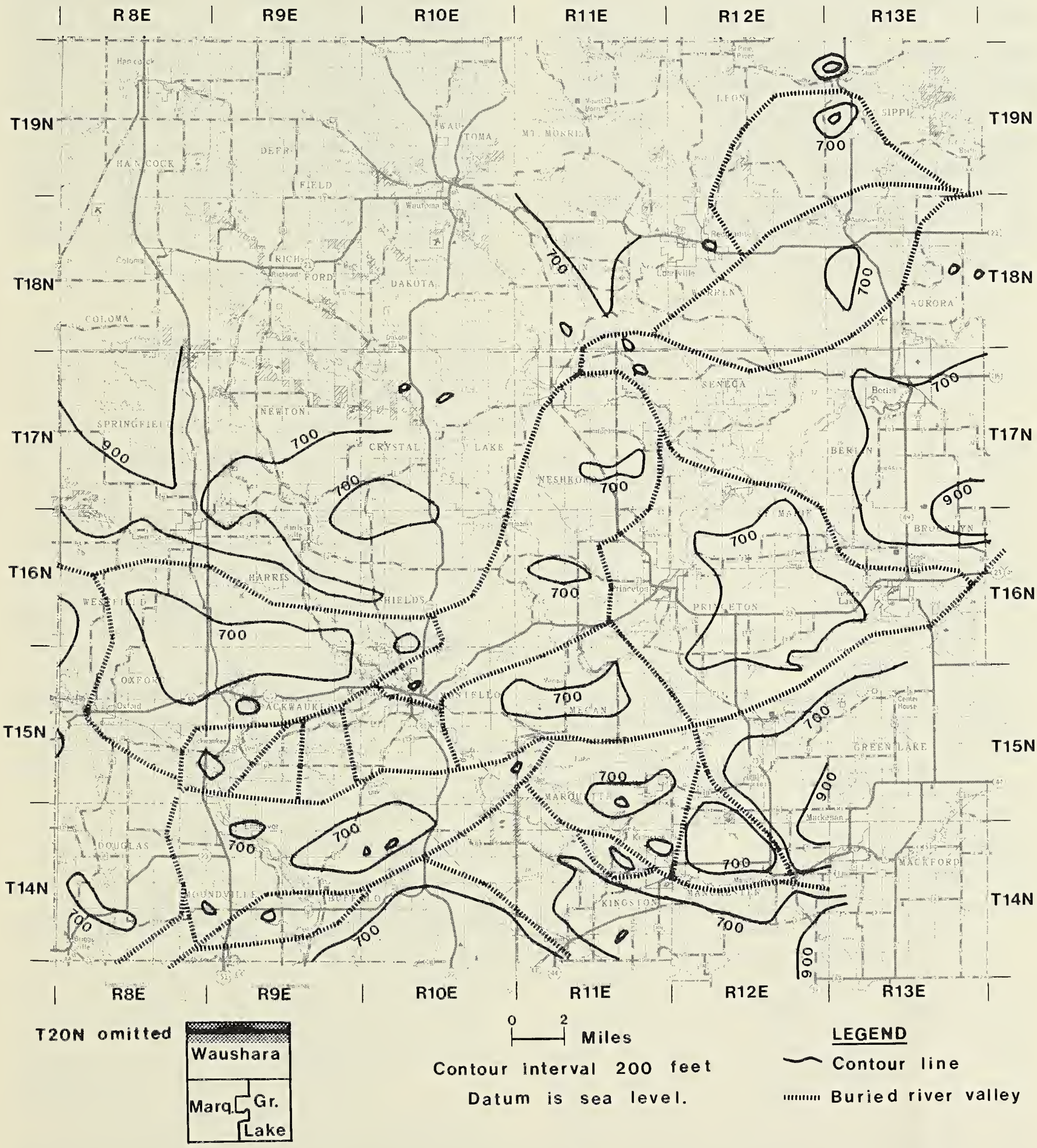


Fig. 2. Topographic map of the bedrock of Marquette, Green Lake, and southern Waushara Counties. It is based on data found primarily in well constructor's reports.

Knowing the dimensions of the river valleys helped to discriminate between what was a tributary, a glacier induced channel, and the main Wisconsin River valley itself. The analysis revealed a complex network of buried river valleys which was a result, in part, of the glacier's movement across this region.

The direction of glacial striae, the axes of drumlins, and the trend of surface soil types and features are telltale signs indicating a glacier's direction of movement. Soil surveys of Marquette and Green Lake Counties, published by the United States Department of Agriculture, delineated the boundaries of soil types and soil features on aerial photographs. (The soil survey of Waushara County (1909) is out of print and was not available). The direction of the longitudinal axis of a drumlin and the trend of soil features as outlined on the aerial photographs represent vectors of the glacier's movement.

The soil surveys of Green Lake and Marquette Counties utilized 69 non-overlapping aerial photographs. Each photograph was divided into two equal parts and each half constituted a separate sample area. On the average, seven vectors were drawn at random from each sample area. Some sample areas were rejected because they happened to cover an area too small to conduct a satisfactory sampling. The number of useful sample areas totaled 134 from which 921 vectors were drawn and used to ascertain the direction of the glacier's advance.

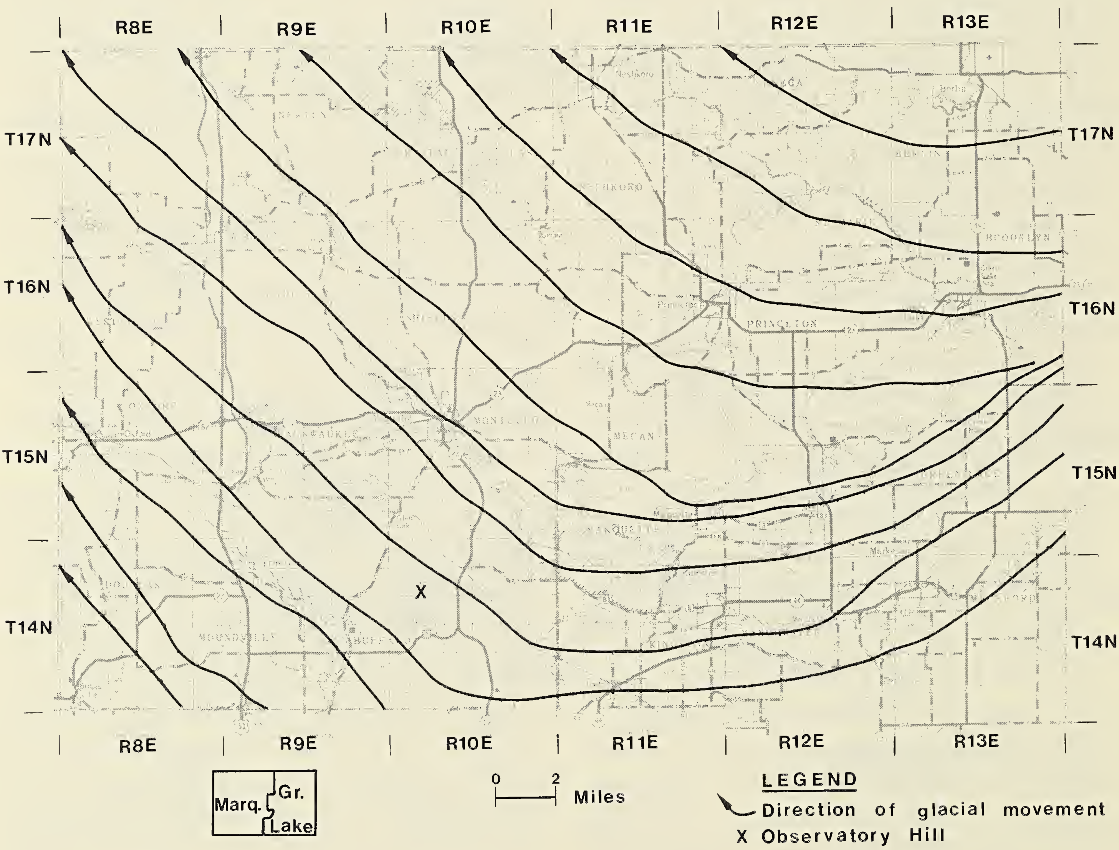


Fig. 3. Movement of the Green Bay Lobe of the continental glacier. Surface soil features indicated on USDA soil survey aerial photographs were used to map the direction of movement of the glacier. The glacier moved on a bearing of approximately 46° west of north through Marquette County.

The horizontal township lines of the Wisconsin coordinate system served as the reference lines throughout the task of measuring the direction of each vector. The angle which a vector made with one of these lines was considered a random variable with a common variance. Actually a different variance could have been associated with each sample area but, because the surface soil features indicating the direction of the glacier's movement were made by the same ice sheet, a common variance was assumed. In each sample area, A_j, the i^{th} vector made an angle θ_{ij}, with a township line. For each A_j, the sample mean, $\bar{\theta}_j$, was computed by the formula: $\bar{\theta}_j = \frac{1}{n_j} \sum_{i=1}^{n_j} \theta_{ij}$, where n_j is the number of vectors drawn from the sample area, A_j. Parallel lines of slope tan $(\bar{\theta}_j)$ were assigned to each A_j for every j in order to make a field of tangents. The resulting envelope of these lines is represented by the lines of movement which are outlined in Fig. 3. The direction of the glacier's movement, obtained in this manner by piecing together the trend of surface soil features of one sample area with another, still retains the uncertainty inherent to the data. The variance, σ^2, of the random variable, θ_{ij}, was assumed, as previously noted, to be the same for all i and j. It was estimated by the mean sum of square errors, as follows:

$$\hat{\sigma}^2 = \frac{1}{N-k} \sum_{j=1}^{k} \sum_{i=1}^{n_j} (\theta_{ij} - \bar{\theta}_j)^2$$

where $N = \sum_{j=i}^{k} n_j$ and k is the number of sample areas; specifically, k = 134, N = 921, and σ^2 = 75.4. The standard deviation of ±8.7° indicates how much the direction of a vector varies about the mean direction of a sample area.

Presumably, the surface soil features in this region owe their existence to the most recent glaciation and subsequent weathering. If previous glaciers had covered the area, then the soil features made by them would have been obliterated by a succeeding glacier. The Wisconsin stage of glaciation is the most recent of the four Pleistocene glaciations that have touched Wisconsin. According to Maher (1982), the Green Bay Lobe of that glaciation disappeared from Marquette and Green Lake Counties approximately 12,400 years ago.

Based on the orientation of drumlins and other surface features which the Green Lake Lobe created, the direction of movement of the glacier in Marquette and Green Lake Counties, as outlined in Fig. 3, agrees with the direction of glacial striae reported by Alden (1918) at a level of significance of 0.05. This high degree of correlation between the direction of glacial striae reported by Alden and the surface soil features forming the basis of Fig. 3 suggests that both the striae and soil features were made by the same glacier.

As the Green Bay Lobe moved south from Green Bay, it simultaneously expanded laterally to the west, so that in Marquette County the glacier actually moved from the southeast to the northwest (Fig. 3). In so doing, as the ice advanced, it encountered the eastern extent of the Wisconsin River and dammed it (Fig. 4). When the resulting impoundment overflowed, the water cut a new channel. In time, a total of eight drainage channels were cut (Fig. 1). The presence of well defined channels indicates that each was used for many years, perhaps for centuries at a time, in order for the impounded Wisconsin River to erode away an average of 200 feet of sandstone for each drainage channel.

Mathematical Model

To find the physical dimensions of a valley, the shape of each valley cross section was described by a mathematical model from which the depth, width, and other characteristics were found. The model consists of three parabolas joined together in a manner that ascribed a parabolic shape to the sides and bottom of a hypothetical valley

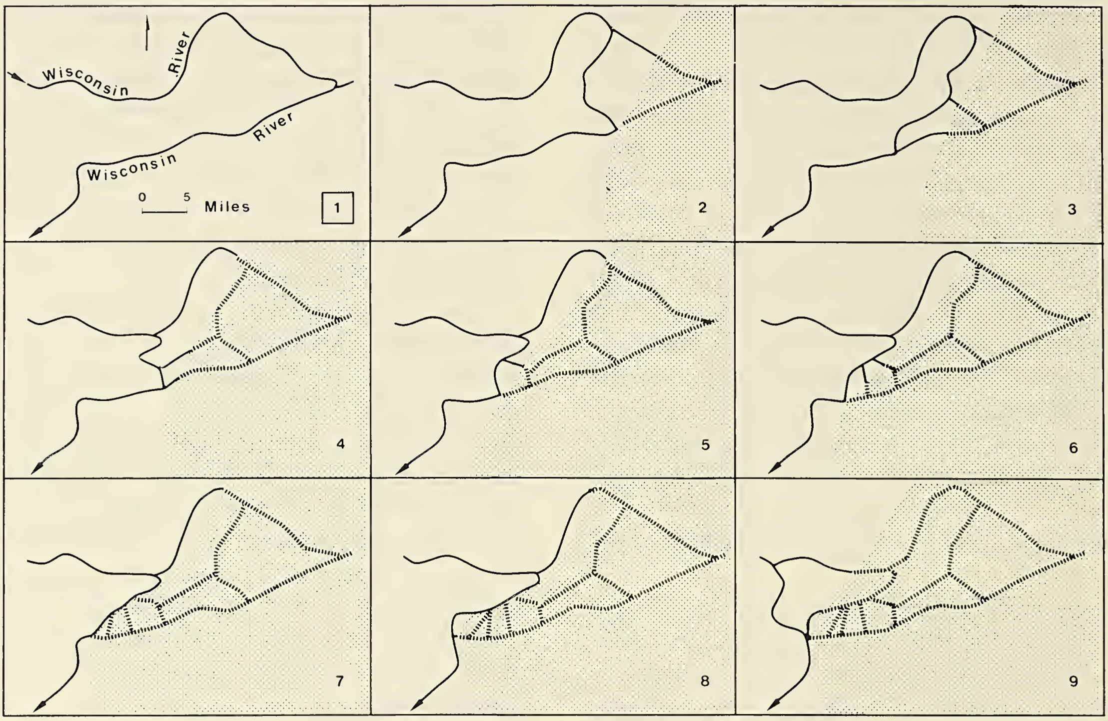


Fig. 4. Stages portraying the sequential damming of the ancient Wisconsin River by the advancing glacier. Stage 1 shows the course of the Wisconsin River before glaciation; it is the same course shown in Fig. 1. Stages 2 to 9 depict a possible association of each drainage channel with the terminus of the glacier. The glacier is shown by the dotted pattern. The dashed lines show the valleys buried under the ice. The area in this figure covers Marquette and Green Lake Counties.

cross section. The model cross section was defined by the following equations:

$$y_I = a(x-b)^2 + c \qquad b \leq x \leq x_2 \qquad (1)$$

$$y_{II} = p(x-e)^2 + q \qquad x_2 \leq x \leq s \qquad (2)$$

$$y_{III} = a(x-d)^2 + c \qquad s \leq x \leq d \qquad (3)$$

where $s = 2e\text{-}x_2$ and is based on the stipulation that the cross section be bilaterally symmetrical. The purpose for dwelling on the derivation of a mathematical model arises from the chance to exploit the information supplied by that special circumstance wherein a buried valley is spanned by three water wells (Fig. 5). In this particular situation, the wells happen to bracket the location of the bottom of a valley and the elevations of the bottoms of the wells indicate the degree of curvature of a valley wall.

As will be seen, there is not enough data available to obtain a complete mathematical description of a hypothetical valley cross section as proposed via equations (1), (2), and (3), unless some artificial constraint is imposed upon the model. There are many con-

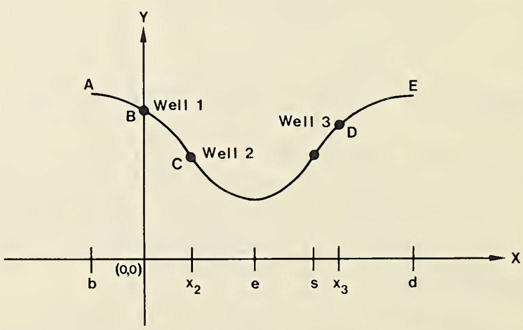


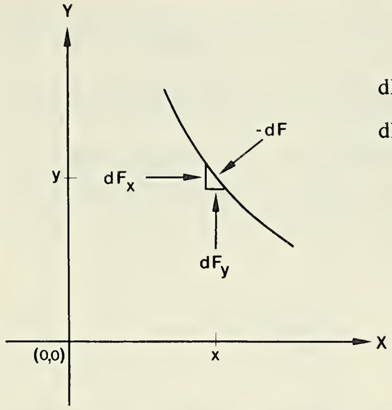
Fig. 5. Hypothetical valley cross section. The relative locations of the wells must be observed when using the equations found in the text.

ceivable constraints that could be used to make the model work, but the one given below by equation (7) worked very well.

The model so described by equations (1)–(3) requires the numerical solution of seven unknown parameters and hence the formulation of seven independent equations from which a unique solution may be obtained. From time to time, three water wells did line up to span a valley as illustrated in Fig. 5 and gave rise, thereby, to three equations. To obtain the necessary seven equations, four constraints were imposed on the model so as to complement the equations already provided by the three wells. The first two constraints that were chosen impose on the model the continuity from A to E (Fig. 5) which would naturally exist and the bilateral symmetry needed to make a simple second order model simpler. (The bilateral symmetry which was sought for the cross section warranted the condition, $e=(b+d)/2$). For the third constraint, parabolas I and II were appropriately joined at C to make the first derivative continuous all along the curve.

At this point, we have imposed three constraints on the model with one more to go. If, by good fortune, the buried river valleys were to have been spanned geographically by four wells lying in a straight line instead of the three, then all of the necessary information would be at hand. But, since the chance of having four wells drilled as such did not occur and because an arrangement of that kind frequently did occur with three water wells, a special constraint had to be found that would fulfill the requirement needed to arrive at seven independent equations and which would at the same time reasonably incorporate into the mathematical model some aspect of nature.

Recognizing that the forces acting on a valley wall must balance in order to preserve static equilibrium, the internal forces that bind the wall together were presumed to be equal and opposite to the outward forces that act to tear the wall apart. The outward forces acting on a valley wall are, in general:



$$dF_x = P(x,y)\,dy$$
$$dF_y = P(x,y)\,dx$$

where P(x,y) is the cumulative effect of the weathering and the pressure pushing outwardly at (x,y) due to the weight of the wall. The resultant force is $dF = P(x,y)\,dS$, where $dS = \sqrt{dx^2 + dy^2}$. Taking into account the assumption that the outward forces are equal and opposite to the internal binding forces, the resultant shearing force, dV, is:

$$dV = -P(x,y)\,dS$$

The function P(x,y) took the form of

$$P(x,y) = P_o \frac{(S_1 + S_3)^2}{4S_1S_3}$$

where P_o is a constant and S_1 is the length of arc AB and S_3 is the length of DE. For example.

$$S_1 = -\frac{b}{2}\sqrt{1+4a^2b^2} - \frac{\sinh^{-1}(2ab)}{4a}$$

It was reasoned that the nearer the points B and D lie to one of the valley's crests, the more pronounced the shape of the valley, and therefore the greater P(x,y) ought to be. In the other extreme case, it was reasoned that P(x,y) should approach some constant, P_o, when the valley becomes very shallow. Consequently,

$$dV = -P_o \frac{(S_1+S_3)^2}{4S_1S_3}\,dS$$

$$\text{or } V(x) = -P_o \frac{(S_1+S_3)^2}{4S_1S_3} S(x) \quad b \le x \le d \qquad (4)$$

where $S(x) = \int_b^x dS$ and is the length of the arc (Fig. 5) beginning with abscissa b and ending with x; $S(x) \cong x\text{-}b$.

Drawing upon the study of the strength of materials, the energy, U, associated with the deformation of the valley walls due to shearing is:

$$U = \frac{k}{A}\int_b^d V_y^2(x)\,dx \qquad (5)$$

where k is some constant, $V_y(x)$ is the vertical component of V(x), and A is the cross sectional area above the bottom of the valley;

$$V_y(x) \cong \frac{(c\text{-}q)}{(e\text{-}b)} V(x)$$

$$A \cong a(x_2\text{-}b)(e\text{-}b)^2 \qquad (6)$$

The final and fourth constraint that we want to impose on the model dictates that the energy, U, be a minimum.

In the course of the mathematical development, it was convenient to express the parameters of equations (1)–(3) in terms of e, the mid-point of the valley, as follows:

$$a = \frac{(y_3\text{-}y_1)x_2 + (y_2\text{-}y_1)(x_3\text{-}2e)}{x_2(x_3\text{-}2e)(x_2 + x_3\text{-}2e)}$$

$$b = ½\ \frac{(y_3\text{-}y_1)x_2^2 - (y_2\text{-}y_1)(x_3\text{-}2e)^2}{(y_3\text{-}y_1)x_2 + (y_2\text{-}y_1)(x_3\text{-}2e)}$$

$$c = y_1 - ab^2$$

$$d = 2e\text{-}b$$

$$p = a\ \frac{(x_2\text{-}b)}{(x_2\text{-}e)}$$

$$q = a(x_2\text{-}b)(e\text{-}b) + c$$

where y_1, y_2, and y_3 are the elevations above sea level of the bottoms of wells 1, 2, and 3 respectively. The relative locations of the water wells to e shown in Fig. 5 must be met in order to make the above expressions valid.

With the parameters expressed in terms of e, the task of obtaining the physical dimensions of a valley reduces to choosing e such that U, from equation (5), is minimized. In other words, the problem amounts to solving the equation

$$\frac{dU}{de} = 0 \qquad (7)$$

where, from equations (4)–(6),

$$U \cong \frac{kP_o(d\text{-}b\text{-}x_3)^4\ a(x_2\text{-}b)(e\text{-}b)}{6\ b^2(d\text{-}x_3)^2}$$

The solution of equation (7) which requires the use of numerical analysis pertains to that situation when, according to the model, the locations of three water wells are co-linear and they happen to span a buried valley.

To check whether or not the model adequately explains the data, a diagnostic plot of residuals versus predicted values generated by the model was made and is given in Fig. 7. The observed values are the elevations above sea level of the bottom of those wells that came into the path of a rotated cross section. The original cross sections were all rotated about their mid-points to make them perpendicular to a valley. Sometimes one of the nearby wells would intersect the rotated cross section and as a result would supply a data point with which to check the adequacy of the model. The funnel shaped pattern exhibited in Fig. 7 indicates a

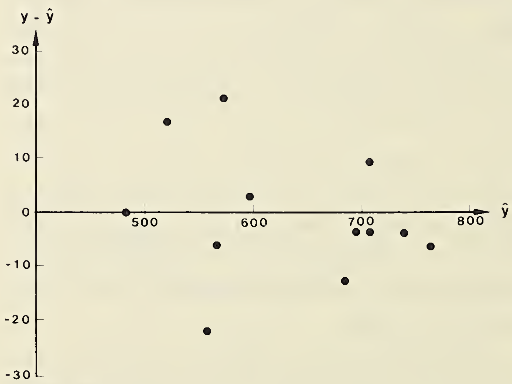


Fig. 7. Plot of the residuals versus predicted elevations above sea level from the model. An observed value is denoted by *y* and a predicted value by *ŷ*. Both coordinate axes are marked in units of feet. The funnel shaped pattern indicates a possible correlation between the expected elevation and variance.

TABLE 2. Parameters of Valley Cross Sections

Cross section[1]	a[2]	*Elevation of crests above* sea level	*Elevation of bottom above* sea level	*Width* at crests
1	−30.4 feet/mi²	760 feet	475 feet	6.3 miles
2	−64.3	699	515	4.2
3	−67.9	731	486	4.1
4	−183.0	788	447	3.0
5	−154.0	696	535	2.3
6	−125.0	721	485	3.5
7	−36.1	935	576	6.6
8	−77.0	807	469	4.3
9	−48.0	787	429	6.0
10	−86.7	654	491	2.8
11	−77.0	723	549	3.5
12	−47.3	687	552	3.5
13	−1152.0	991	477	1.4
14	−1140.0	681	442	1.0
15	−723.1	638	519	1.4
16	−267.0	805	577	1.9
17	−95.0	837	674	2.7
18	−241.0	831	492	2.5
19	−302.0	813	592	1.7
20	−90.3	767	538	3.6
21	−99.0	814	394	4.3
22	−130.0	788	389	4.1

1. Corresponds to cross sections labeled in Fig. 1.
2. Refers to the leading parameter of equations (1) and (3).

possible correlation between the expected elevation and variance. The standard deviation of the elevations based on the mean sum of square errors is ±12 feet.

The twenty two cross sections listed in Table 2 and labeled in Fig. 1 reflect the benefits of the mathematical analysis. For some of the buried valleys, cross sections could not be obtained because the wells did not lie in a straight line or there were not enough wells in the area. Using the available cross sections and certain wells, the slope of the ancient Wisconsin River was found to be 1.6 ± 0.1 feet/mile and that of the ancient Wolf River, 1.8 ± 0.8 feet/mile. Furthermore, the results listed in Table 2 show that the depths of the glacier induced channels are approximately 200 feet deep. In one case, for instance, cross sections 13 and 14 reveal the existence at Montello of a 520 foot deep, 1 mile wide channel which as it exists today drops 35 feet in 0.5 miles.

In addition to the results of the mathematical analysis, information from several wells proved to have been particularly important in locating the buried valleys and it is tabulated below (Table 3).

Techniques Used in Constructing the Maps

Information obtained from well constructor's reports provided most of the data used in constructing the map of the preglacial river valleys and the topographic map of the bedrock. The location, annotated with the depth of bedrock, of each well was plotted on graph paper at a scale of 1 mile to a half inch. Centered at the location of the deepest wells, a circle was inscribed having a radius such that the circumference equaled

TABLE 3. Important Wells

Location *T.N.-R.E.-Sec.*	*Owner*	*Material at bottom*	*Elevation of bottom above sea level*
14-8-25	Endeavor Farms	SS[1]	485 feet
14-9-21	Turner	SS	552
14-10-11[2]		SS	575
15-8-17[2]	Creamery	SS	610
15-9-21	Vanearn	Granite	488
15-9-34	Preuss	Sand	436
15-10-6	Quinn	SS	558
15-10-16	Hauserman	Granite	485
15-10-36	Lettuce Cooling Plant	Granite	490
15-11-22	Klawitter	SS	420
15-11-30	Tidd	SS	717
16-8-15[2]	L. Kruger	Granite	512
16-9-25	Shimpack	Granite	485
17-11-4	Doiro	SS	462
17-13-6	Berlin Conservation Club	SS	473
18-11-34	Bartol	Clay	486
18-13-22[2]		SS	475

1. SS = Sandstone
2. Obtained from Alden (1918), otherwise obtained from DNR well constructor's reports.

the contour level of 700 feet. In effect, each of these wells was placed at the bottom of an imaginary bowl whose rim stood at 700 feet above sea level and whose bottom equaled the depth of the well. The radius of the bowl was obtained from the mathematical model in the following way. In those special cases where three wells fell in a straight line while spanning a valley, the shape of that cross section was estimated according to the procedure described earlier. The parameter a and the parameter c of all the cross sections were averaged together and the result served to describe a typical cross section. Knowing the depth of a well and height of the rim, in this case 700 feet, the radius was found by using equations (1)–(3) with the averaged parameters. The radius found in this manner can not account for the variability from one valley to another, nonetheless, following the path of the overlapping circles traced out a rough picture of where the preglacial river valleys existed.

Wells lying in the vicinity of the valleys were used in a triangulation method to locate as accurately as possible the bottom of a valley. Before taking that step, however, it was necessary to estimate the slopes of the ancient Wisconsin and Wolf river beds. Employing the method of least squares, estimates of the slopes were obtained based on the cross sections and wells marked in Fig. 1. Knowing the elevation of the river bottom at any point along a valley and the elevation of the bottom of a well lying on a valley's fringe, the distance of a well from the bottom of a valley was found by again using the model this time with the parameters associated with the cross section nearest to the well. From these wells an arc was swung with a radius corresponding to that distance which the valley's bottom was supposed to lie from a given well. Three intersecting arcs give a fix for the location of the bottom of a valley. Two intersecting or almost intersecting arcs were also used, if they were on opposite sides of a valley. And as a final resort, usually to compensate for gaps that sometimes occurred in the mapping of the valleys especially in the towns of Neshkoro and

Seneca, a single arc was used to reckon a position of where the bottom of a valley ought to be. Based upon the fixes, the midpoints of the valley cross sections, and the locations of certain wells that happened to reach the bottom of a valley, the locations of the preglacial river valleys were ascertained. The result was translated to the pertinent section of the Wisconsin Department of Transportation 1984 District Highway Map.

The method of contouring could have been used to accomplish the same end instead of the triangulation method that was actually employed. The contouring that was done is shown in the topographic map of the bedrock (Fig. 2). The levels were drawn freehand so that the accuracy of the levels is only about ±100 feet, whereas the accuracy of the elevations based on the mathematical model is ±12 feet. Because of that greater degree of accuracy, the method of triangulation was adopted for use in making the map of the preglacial river valleys. Once the map was made, approximately half of the mapping was field checked as time permitted. The map was also checked against aerial photographs and USGS topographic maps. In general, it was found that the wetlands in these three counties lie in the remnants of the ancient valleys.

The technique used in constructing the map of the glacier's movement was already explained earlier in the section pertaining to the discussion of the data.

Influence of the Precambrian Bedrock

To what degree the Precambrian bedrock influenced the courses of the ancient rivers and the glacier's movement in this region is largely a matter of conjecture. The Precambrian bedrock that underlies the sandstone and limestone is composed of granite and rhyolite. These igneous rocks were formed 1.765 billion years ago during a period of volcanic activity occurring to the northwest of Marquette County (Smith, 1978b). In subsequent ages, the sedimentary rocks of sandstone and limestone were formed on top of the Precambrian rock as a result of successive cycles of sedimentation associated with advancing and retreating seas (USGS, 1976). In a few instances, the Precambrian bedrock protrudes to the surface and is exposed as granite at Montello and Red Granite and the rhyolite of Observatory Hill in Marquette County and at Endeavor. Whereas the rhyolite forms the Precambrian bedrock in southeastern Marquette and Green Lake Counties, granite constitutes the bedrock in the northwestern section of the counties. The boundary between the two types of rocks bears 50° east of north (Smith, 1978b), and is essentially perpendicular to the direction of flow of the molten rock. The dashed line labeled T in Fig. 8

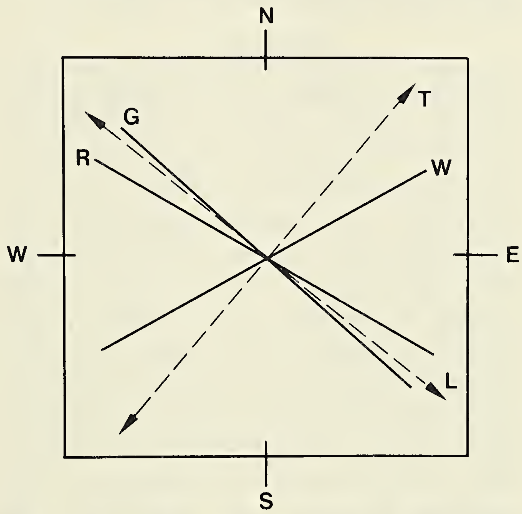


Fig. 8. Relation between aspects of the Precambrian bedrock and the direction of the glacier's movement and the courses of ancient rivers.

T = Axis of the contact between granite and rhyolite (Smith, 1978b).
L = Axis of the direction of flow of the molten igneous rock (Adopted from Smith, 1978b).
G = Direction of movement of the glacier in Marquette and most of Green Lake Counties.
R = Course of the ancient Grand River.
W = Course of the abandoned south branch of the ancient Wisconsin River.

The close associations of T and W and of L, G, and R suggest that the Precambrian bedrock influenced the courses of preglacial rivers and the glacier's direction of movement in Marquette and Green Lake Counties.

shows the direction of the contact between the granite and rhyolite, the granite being to the left and the rhyolite to the right. The dashed line labeled L in the same figure shows the direction of flow of the molten rock. The direction of the glacier's movement, G, and the course of the ancient Grand River, R, lie very close to L and appear to be correlated with the direction of flow of the molten rock. Also the course of the abandoned southern branch of the ancient Wisconsin River, W, seems to be correlated with the contact between the granite and rhyolite, T. Although the topography of the Precambrian bedrock is unknown, it appears from Fig. 8 that the bedrock affected the courses of preglacial rivers and the glacier's movement in this area.

Summary

Evidence suggests that the Precambrian bedrock played a role in determining the courses of the ancient rivers and the direction of the glacier's movement. Prior to glaciation, the physical geography was dominated in this region by the Wisconsin, Wolf, and Fox Rivers that had flowed through a country which would be unfamiliar to anyone living today. Glaciation radically altered the preglacial landscape. The thick layer of sand which is found in these counties came from the pulverizing action of the glacier on the sandstone. The lacustrine deposits left behind by the retreating glacier helped to create the many and extensive wetlands remarkable to this region. Marquette County, in 1938, had the greatest proportion, 29%, of wetlands to its size of any county in the state (WCD, 1963).

The eight drainage channels associated with the successive damming of the ancient Wisconsin River were created by the advance of the Green Bay Lobe through Green Lake and Marquette Counties during the Wisconsin stage of Pleistocene glaciations. The network of buried valleys was discovered primarily by means of well constructor's reports and mapped with the aid of a mathematical model that was designed to describe a hypothetical valley cross section. All of the preglacial river valleys in these counties are buried as a result of glaciation. What once were deep river valleys are now hidden. Only the muck farms and wetlands most visibly mark the locations of those valleys today.

Acknowledgements

Helpful comments for improving the quality of the manuscript were given to me by Lee Clayton of the Wisconsin Geological and Natural History Survey, Esta Lewin, David Mickelson of the University of Wisconsin–Madison Geology Department, and Mary Zellmer. I want to thank Christine Reinhard, Assistant Wisconsin State Cartographer, for her very helpful suggestions for making the illustrations.

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SPATIAL ATTRIBUTES OF UW UNDERGRADUATE ATTENDANCE PATTERNS

J. B. Foust
Department of Geography
University of Wisconsin-Eau Claire

Abstract

At first glance, the attendance pattern of undergraduates in the UW system appears to be very complex. It is often assumed that socioeconomic variables such as income and education are the major causal factors involved, but these do very little to "explain" UW undergraduate attendance patterns. A simple model based on distance (and variations thereof) yields much better results. Such a model can account for a very large percentage of the variation in undergraduate attendance patterns for individual campuses and most of the anomalies that remain are easily explained. This unconventional explanation of attendance patterns can be extended to consider the "locational efficiency" of campuses and programs.

Introduction

More than 100,000 residents of Wisconsin are enrolled as undergraduates at the thirteen four-year campuses of the UW System, but why does an undergraduate from a given county choose a specific campus? Many explanations could be offered. When individual undergraduates are polled, they cite the amount of financial aid available, the presence of specialized programs, family/friendship ties, the academic reputation of a campus or department, or reasons as trivial as the "party" reputation of a campus or the male/female ratio. Initial career decisions certainly play a role. A beginning undergraduate from Green Bay, for example, who wants to major in industrial arts, nursing, engineering, or agriculture has a more limited choice of potential campuses than one who intends to major in mathematics. On the other hand, most campuses offer "pre" programs (pre-engineering, pre-med, etc.) and many, if not most, undergraduates enter their college career undecided and often change their major more than once. Many select their field of study because a single course, taken to meet general education requirements, gets them interested in a major which may not be available on all campuses. These individuals did not choose a particular campus initially because it offered their eventual major. Had they begun their academic career at another campus, they might have selected another field of study.

We cannot predict with unerring accuracy the UW campus that will be chosen by a given Joe/Jane Freshman from a given place in the state. There may be as many reasons as there are individual undergraduates, but a consideration of student origins raises an interesting set of questions. Is there a general model which can predict attendance patterns at UW campuses with a high degree of accuracy? Is the location of UW campuses "equitable" or "efficient" given the population distribution of the state? Could a consideration of important variables and geographic patterns be used to make better decisions about the location of future facilities and programs or the termination of others? In this study, only undergraduates from Wisconsin enrolled in the Fall Semester of 1983 at the thirteen four-year campuses are considered.

Correlation with Population

Common sense suggests that the number of UW undergraduates from a given county

TABLE 1. Partial correlation results.

Campus	1980 Population[a]	Controlling for: Median Family Income[b]	Controlling for: Education Level[c]	Controlling for: Both[d]
UW-TOTAL	0.973	0.966	0.980	0.981
MSN	0.217	0.045	0.036	−0.007
MIL	0.796	0.736	0.764	0.744
EAU	−0.205	−0.028	−0.151	−0.056
GBY	−0.023	−0.039	0.046	0.004
LAC	−0.125	−0.056	−0.097	−0.062
OSH	−0.013	−0.095	0.032	−0.046
PKS	0.118	−0.010	0.121	0.034
PLT	−0.113	−0.076	−0.089	−0.075
RVF	−0.137	−0.103	−0.170	−0.130
SPT	−0.139	−0.076	−0.087	−0.067
STO	−0.020	−0.057	−0.176	−0.092
SUP	−0.101	0.007	−0.093	−0.024
WTW	−0.116	−0.085	0.064	−0.052

[a] r_{12}, where 1 = # of UW undergraduates at campus from each county and 2 = 1980 population.
[b] $r_{12.3}$, where 3 = 1980 median family income for each county.
[c] $r_{12.4}$, where 4 = per cent of county population with more than 16 years of education.
[d] $r_{12.34}$
Source (demographic data): 1980 Census of Population.

should be strongly correlated with the population of the county. The greater the population, the greater the number of undergraduates. Within this general trend, however, there might be other factors causing counties with similar populations to send different numbers of undergraduates to the UW System. Secondary variables which immediately come to mind are income and education. The assumption is that counties with higher incomes and educational levels will send a higher proportion of their population on to college. Simple and partial correlation coefficients were calculated to test this hypothesis and are given in Table 1.

For *total* UW undergraduates, the correlation between the number of undergraduates from a county and its population is very high ($r = 0.973$). The relationship is positive, i.e., as population increases, the number of undergraduates also increases. In partial correlation, one or more variables can be "held constant" to examine the relationship between variables without the intrusion of other factors. If income and education are important, the correlation with population should decline when they are considered, but the partial correlation coefficients in Table 1 show that controlling for income and educational levels (both individually and collectively) produces almost no change in the relationship between the total number of UW undergraduates from a county and its population. The individual campuses listed in Table 1, however, show very different results. *Positive* relationships are found only for the Madison, Milwaukee, and Parkside campuses. For the other campuses, the relationship is *negative* indicating that as population increases, the number of undergraduates from a county to that campus *decreases*. In addition, with the exception of Milwaukee, the correlation with population is rather weak and controlling for income and educational levels reduces it even more. There is a very high correlation in Wisconsin between population and income/education. The counties with the largest populations (urban counties) also have the highest incomes and the highest educational levels.

Madison, Milwaukee, and Parkside are located in the densest urban cluster of the state, hence the positive correlation with population (and education/income). The outstate campuses are distant from the concentration of population and controlling for education and income does little to overcome this distance handicap.

Campus Capture Areas

Within the context of the "Wisconsin Idea," campuses were established over the state to provide greater accessibility to higher education for all citizens. This suggests that each campus serves its "regional" market which could account for a large amount of the variation in the origin pattern of its undergraduates. Like other types of market areas, these should reflect the "attraction" or drawing power of individual campuses. The ability of a campus to attract students was assumed to be its "theoretical target capacity." These targets are given in a 1976 in-house UW System study which recommended potential enrollment limits for each campus (UW System, 1976). Target capacities were based on physical facilities and faculty/staff sizes and are directly proportional to enrollments which existed in the late 1970's. Enrollment itself, of course, could be used as a surrogate for "drawing power" because enrollments reflect physical capacities and availability of programs and majors. System targets, however, were assumed to reflect a more consistent estimate of drawing power. How can the boundary between two competing campuses be drawn? In this study, the "breaking point" between campus pairs was based on the following model:

$$BP_{xy} = \frac{D_{xy}}{1 + \sqrt{C_y/C_x}},$$

where: BP_{xy} = the "breaking point" between campus x and campus y.
D_{xy} = the distance between x and y.
C_xC_y = the target capacities of x and y.

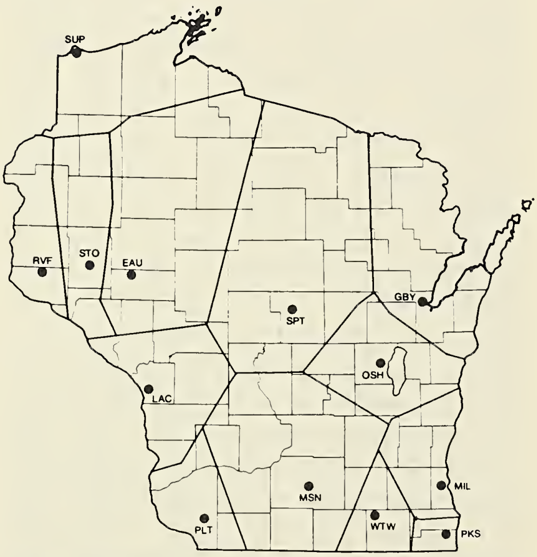

Fig. 1. Campus "capture areas" based on 1977 target capacities.

If two competing campuses have the same enrollment capacities, the "breaking point" will occur exactly half-way between them. A larger capacity, however, shifts the breaking point toward the smaller campus and expands the capture areas of larger campuses at the expense of their smaller competitors. The market areas in Figure 1 were derived by applying the above formula between each campus and its nearest competitors to determine breaking points. A straight line was drawn from a campus to its competitors and a perpendicular line was then extended from each breaking point. The connection of the perpendicular lines produces the "capture area" polygons.

How well do empirical attendance patterns match these theoretical capture areas? Actual capture patterns cannot be accurately mapped with the *raw number* of undergraduates from each county to each campus. A county with a large population like Milwaukee may send a greater number of undergraduates to a campus than a smaller county. The number from Milwaukee, however, can be a very small percentage of the total UW undergraduates from Milwaukee. The absolute number of undergraduates from Milwaukee at a campus is large, but the campus "captures" a relatively small percentage of the Milwaukee's undergraduate population. For example, Milwaukee sent 417 undergrtaduates to UW-Eau Claire in Fall 1983 and was the fourth leading county in terms of the raw number of undergraduates at Eau Claire. This total, however, represented less than two per cent of the total UW undergraduates from Milwaukee County. Using the *percentage of total UW System undergraduates* captured by a given campus from each county gives much more comparable estimates of capture rates. These percentages were used to derive the "actual" capture areas shown in Figure 2. The isopleths were based on the campus which "captured" the greatest percentage of total UW undergraduates from a county. Where capture rates in a county were almost the same for two campuses, the lines were interpolated based on the magnitudes of the competing capture rates.

Actual "capture areas" generally follow the theoretical patterns developed in Figure 1, but there are several exceptions. Stout's actual capture area is much smaller than its theoretical while Eau Claire's is larger. Madison's actual capture area extends into Sheboygan and Manitowoc counties at the expense of UW-Oshkosh. Madison is also the dominant campus in Marathon County and is the only example of an "enclave" within the capture area of another campus. This is not surprising given its size, status, and location, but in all three counties (Manitowoc, Sheboygan, and Marathon), UW-Center campuses capture almost twice as many UW undergraduates as any four-year campus. For most campuses, however, there is a remarkable similarity between actual and theoretical capture areas.

Capture percentages vary considerably among campuses. For example, UW-Parkside captures sixty-five per cent of all UW undergraduates from Kenosha County, but attracts zero undergraduates from many distant counties. Madison captures eighty-two per cent of all UW undergraduates from Dane County and some undergraduates from every county in the state. Capture rates in home counties varies from a high of eighty-six per cent for UW-Superior to a low of forty-seven for UW-Green Bay.

The Distance/Intervening Opportunities Model

The pattern presented in Figure 2 suggests two "hidden" explanations of UW attendance patterns. They are hidden in the sense that they are rarely (if ever) mentioned as explanatory variables yet are capable of predicting the capture pattern with high degree of accuracy. First, capture rates are an *inverse* function of distance: the greater the distance, the lower the capture rate for a given campus. Distances used in this study were measured between county centers. Secondly, the amount of competition or "intervening opportunity" in a specific direction plays a very important role. For example,

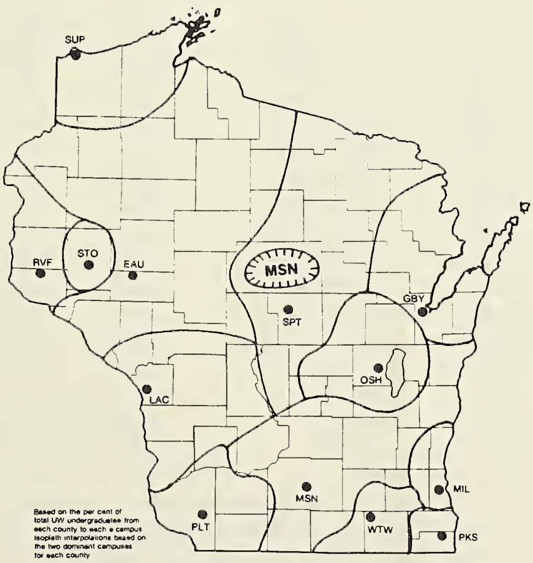

Fig. 2. Actual campus "capture areas."

Eau Claire's capture area extends a much greater distance to the northeast where there is little competition than due west where there is considerable competition from UW-Stout. The relationship between capture rates and intervening opportunity should also be inverse. For a given campus, intervening opportunity ("competition") was measured by:

$$IO_{xy} = (D_{xy} - D_{cy}) + D_{xy},$$

where: IO_{xy} = intervening opportunities between campus x and county y.
D_{xy} = distance between campus x and county y.
D_{cy} = distance to the UW campus *closest* to county y.

For the home county of each campus, of course, the value of IO equals zero [IO = (0-0) + 0]. The value of IO, however, between a given campus and a county which has another UW campus is *twice* the value of the distance between county centers. For example, if the distance between two counties is thirty miles and each has a UW campus, the value of intervening opportunities is sixty [IO = (30 − 0) + 30]. This effect is used as a surrogate for competition. Both hypotheses can be tested with simple correlation.

A visual inspection of distance (X) and capture percentages (Y) scattergrams indicated that the form of the relationship was not linear. Capture rates decreased with increases in both simple distance and intervening opportunities, but *at a decreasing rate.* This effect was adjusted for by using both the square root and common log of each. Correlation coefficients are shown in Table 2. Both distance and intervening opportunity values (unconverted) produce statistically significant (.0001 level) results. All signs are *negative* as hypothesized indicating that as distance (or intervening opportunity) increases, the rate of capture *decreases.* In all cases, converting the independent variables to square root and common logs yields higher correlations than raw values and, in most cases, the square root gives slightly better results than conversion to common logs. Coefficients of determination (squares of correlation coefficients) are a measure of the per cent of variation in the dependent variable (capture rates) which is "explained" by

TABLE 2. Simple correlation coefficients.*

	DIST	$\sqrt{DIST}$	*LOG (DIST)*	*IO*	$\sqrt{IO}$	*LOG (IO)*
MSN	−0.619	−0.734	−0.666	−0.650	−0.758	−0.730
MIL	−0.468	−0.621	−0.564	−0.465	−0.624	−0.635
EAU	−0.720	−0.803	−0.751	−0.734	−0.832	−0.825
GBY	−0.541	−0.654	−0.606	−0.537	−0.663	−0.674
LAC	−0.649	−0.778	−0.731	−0.658	−0.794	−0.797
OSH	−0.668	−0.790	−0.760	−0.668	−0.804	−0.823
PKS	−0.338**	−0.504	−0.479	−0.325	−0.494	−0.552
PLT	−0.577	−0.713	−0.835	−0.611	−0.749	−0.878
RVF	−0.567	−0.680	−0.812	−0.568	−0.682	−0.829
SPT	−0.622	−0.744	−0.629	−0.666	−0.748	−0.733
STO	−0.614	−0.732	−0.625	−0.616	−0.735	−0.698
SUP	−0.531	−0.698	−0.632	−0.503	−0.659	−0.660
WTW	−0.613	−0.720	−0.698	−0.625	−0.749	−0.788

DIST = distance (measured between centers of counties).
IO = intervening opportunities as defined in text.
* All coefficients significant at the 0.0001 level unless noted.
** Significant at 0.002 level.

variation in the dependent variable. The best predictor for each campus yields "explanation" rates which range from a low of about twenty-five per cent for Parkside (square root of distance) to a high of seventy-seven percent for Platteville (log of intervening opportunities). The statistical results indicate that distance (and its variation, intervening opportunities) is a very important variable in determing UW attendance patterns.

Once again, income and education levels were added to see if the predictive power of the model could be improved; if income and education are the important variables, the correlation with distance should decline when they are considered. Results are shown in Table 3. In general, correlations between student origins and distance remained remarkably constant when the effects of income and educational levels were added. The two exceptions to this generalization are Milwaukee and Parkside. For both, the correlation with distance drops appreciably when controlling for the effects of income and income and education combined. These two campuses are different from the other campuses in the System in that commuters are much more important than a residential student population. The daily driving distance limit of each "commuter shed" is very small and, beyond this limit, other factors take over. Parkside gets 92 per cent of its Wisconsin undergraduates from Racine and Kenosha Counties while Milwaukee gets 84 per cent from Milwaukee and Waukesha Counties. Only Green Bay and Superior come close to these levels from their home county (both 65%). Most of the other campuses hover around 25 per cent. The overwhelming importance of close student populations for these four campuses is supported by Table 3. The greater the importance of the "home" counties, the lower the simple correlation with distance. When variations in potential undergraduate populations are factored out by using percentage (of total

TABLE 3. Partial correlation results* undergraduates with distance.

		Controlling for		
Campus	*Distance*[a]	*Median Family Income*[b]	*Education Level*[c]	*Both*[d]
MSN	−0.619	−0.528	−0.591	−0.603
MIL	−0.468	−0.027[1]	−0.420	−0.238[2]
EAU	−0.720	−0.657	−0.711	−0.650
GBY	−0.541	−0.574	−0.544	−0.545
LAC	−0.648	−0.637	−0.646	−0.637
OSH	−0.668	−0.681	0.676	−0.652
PKS	−0.338[3]	−0.216[4]	−0.354[5]	−0.159[6]
PLT	−0.577	−0.624	−0.591	−0.624
RVF	−0.576	−0.613	−0.603	−0.609
SPT	−0.622	−0.644	−0.624	−0.651
STO	−0.614	−0.550	−0.609	−0.534
SUP	−0.531	−0.520	−0.538	−0.505
WTW	−0.613	−0.508	−0.604	−0.486

* All coefficients significant at the 0.0001 level unless noted.
Significance levels: [1]0.0043 [2]0.0024 [3]0.002 [4]0.036 [5]0.002 [6]0.096

[a] r_{12}, where 1 = per cent of UW undergraduates at a campus from each county and 2 = raw distance measured between county centers.

[b] $r_{12.3}$, where 3 = 1980 median family income.

[c] $r_{12.4}$, where 4 = per cent of county population with more than 16 years of education. (1980).

[d] $r_{12.34}$

Source: 1980 Census of Population.

UW undergraduates) capture rates, distance accounts for a very large proportion of the total variation in attendance patterns. Adjusting for income and educational levels (via partial correlation) does little to improve the accuracy of prediction. The distance/intervening opportunity model "explains" the UW undergraduate attendance pattern with a high degree of accuracy.

Residuals from Regression

What factors account for the variation not "explained" by distance and its variations? Some understanding can be gained by considering the residuals from regression which fall outside one standard error of estimate. When positive and negative residuals are mapped, it is immediately apparent that two different factors are involved. UW-Eau Claire is used as an example with residuals greater than one standard error of estmiate shown in Table 4. Competing campuses account for most of the counties for which the model *overpredicts* the capture rate by more than one standard error. For Eau Claire, the negative counties either contain a competing campus or are contiguous to one with the lone exception of Marquette County (equidistant between MSN and SPT). This explanation of negative residuals also holds true for all other UW campuses.

Three of the positive residuals (model *underpredicts* the capture rate) are in Eau Claire's capture area. This is also the general rule for all campuses. Two of the remaining positive residual counties (Burnett and Ashland) are fairly close. Only Door County is difficult to understand. The positive residual counties are also a mixed bag for other campuses as well. Some have high income levels and some low. Some have high educational levels while others are well below the state average. Some are rural and others urban. These anomaly counties seem to be the result of "random" factors. Friendship/kinship ties may very well play an important role. Certain high schools seem to be better represented at Eau Claire, for

Table 4. Residuals from regression.[1] UWEC capture rates and distance.[2]

Negative County Residuals		*Positive County Residuals*	
Counties with UW Campus		*In UW-Eau Claire "Capture" Area*	
Douglas	−1.0071	Chippewa	+2.5437
Dunn	−1.5890	Eau Claire	+2.7411
Grant	−1.0556	Rusk	+1.4386
La Crosse	−2.4686	Taylor	+1.6693
Pierce	−2.2689	*Other*	
Portage	−1.6156	Ashland	+1.3380
Counties Contiguous to UW Campus County		Burnett	+1.3901
Adams	−1.3380	Door	+1.0986
Crawford	−1.4282		
Richland	−1.1316		
St. Croix	−1.1334		
Wood	−1.0243		
Vernon	−1,1262		
Other			
Marquette	−1.2391		

[1] Greater than one standard error of estimate (8.76017).

[2] For $Y = a + bX$, where Y = UW-Eau Claire undergraduates from county as a per cent of total UW undergraduates from county.

X = square root of distance of county from Eau Claire (measured between county centers).

$a = 57.02226$, $b = 24.76499$, $r = 0.803$.

example, than others in the same distant county. Once a few undergraduates from a high school or small town go to a particular campus and have success there, the process may snowball so that the tradition of undergraduates from Place X attending Campus Y is carried on through time. Capture rates (per cent of total UW undergraduates) are so low in distant counties that only a few undergraduates one way or the other can throw a county outside the limits of one standard error of estimate. In distant counties, alumni who are high school guidance counselors or coaches or the experiences of siblings and parents may also be critical.

Locational Efficiency

The role that distance plays in determining UW enrollment patterns, raises the question of the "locational efficiency" of the respective campuses. One way to consider this is to map the centers of the undergraduate populations for each campus (Figure 3). The center of population for all UW undergraduates is remarkably close to the center of the total population of the state as would be expected from the simple correlation coefficient for this relationship. For individual campuses, however, undergraduate population centers are shifted away from the campus locations toward the total population center. The degree of displacement varies from campus to campus. Milwaukee, Parkside, Whitewater, and Madison are shifted the least, while Stout, Eau Claire, La Crosse, and River Falls are shifted the most. Generally, the closer a campus is to the major population concentration of the state, the less the shift of its undergraduate population center and vice versa. In Figure 3, the closeness of the center of total UW undergraduates to the population center of the state would seem to indicate that the campuses are well located to serve the population of the state, but this idea is less credible when individual campuses are considered. The amount of spatial displacement of the smaller UW campuses is somewhat a function of the degree of specialization. For example, UW-Stout, with its very specialized programs, is more displaced toward the center of state population than is UW-Eau Claire. The more specialized the campus, the more it should draw its undergraduates from the entire state as opposed to more "general" campuses. Stout has the "poorest"

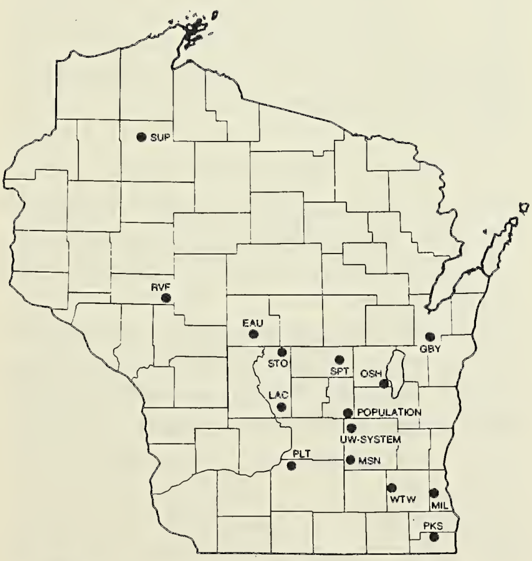

Fig. 3. Mean centers of campus populations.

Table 5. Theoretical and actual capture rates.

Campus	*Per Cent of State Population in Theoretical Capture Area*	*Per Cent of Total UW-System Undergraduate Enrollment*
MSN	13.80	23.67
MIL	33.04	18.86
EAU	5.60	8.27
GBY	7.58	3.69
LAC	4.16	6.36
OSH	9.05	8.06
PKS	4.45	4.08
PLT	1.93	4.21
RVF	2.16	2.62
SPT	8.97	6.67
STO	2.57	4.08
SUP	1.94	1.20
WTW	4.75	7.50

location of all campuses in this respect. Another simple way to consider locational efficiency is to compare the proportion of the state's population in the theoretical capture areas of Figure 1 with the proportion of the total UW undergraduate populations actually captured by each campus. This is done in Table 5. Madison captures a proportion of the total UW undergraduate student body which is almost twice the proportion of the state's population found in its theoretical capture area. This is to be expected from the "flagship" campus of the System. UW-Milwaukee, on the other hand, has an enrollment "capacity" which is half that of its tributary population. The creation of UW-Parkside seems to have been an "efficient" action in that it captures almost exactly its theoretical tributary area and "soaks up" an excess population that would otherwise seek to go to the already "saturated" campuses of Madison, Milwaukee, or Whitewater. The equitability of Parkside is also demonstrated by the small displacement of its mean student center from its actual location (Figure 3). Both Superior and River Falls face the stiff competition from nearby Minnesota campuses with reciprocal tuition rates (UM-Duluth and the University of Minnesota) and each just captures its expected share of the state's undergraduates as estimated by market areas.

Specialized programs should be located so as to serve their target populations best. To accomplish this, the target population must be carefully identified. For example, agricultural or veterinary science programs may serve agricultural concentrations rather than the general population. Agricultural programs are required at Madison of course because it is the land grant institution, but consider the "secondary" agricultural campus of River Falls. How well is it located with respect to the state's agriculture? The per cent of total county land in agriculture was used as a surrogate for agricultural activity in the state. This measure factors down the importance of counties with little agricultural activity such as Milwaukee or Forest. The mean center of this distribution is in southern Adams County, which suggests that Stevens Point would be a "better" location for such programs. Of course, other factors, such as economies of scale and existing facilities, must also play a role and are usually considered by decision makers.

Conclusions

In conclusion, the attendance pattern of the UW-System campuses is, at first glance, complex and would seem to require an intricate and complicated system of equations to unravel the puzzle. The simple geographic variable of distance, however, can be used to predict most of the variation in the pattern with a high degree of accuracy. This study highlights the utility of the geographic approach. Most of the data summarized in this study are usually considered only in tabular form by the gnomes of Van Hise Hall and it is very rare to see any policy statement from System Administration which contains a map or considers the geographical ramifications of decisions. Both the efficiency and equitability of such decisions might be improved by such considerations.

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LAND CHARACTERISTICS ASSOCIATED WITH DIVERSE HUMAN HEART AND DIGESTIVE SYSTEM CANCER DEATH RATES AMONG WISCONSIN COUNTIES

MARION L. JACKSON
University of Wisconsin-Madison

JI Z. ZHANG
Anhui Agricultural College, Hefei, P.R.C.

CHANG S. LI
Institute of Environmental Chemistry
Academia Sinica, Beijing, P.R.C.

Abstract

Among Wisconsin counties, the highly diverse land characteristics, such as northern and central sandy soils, silty and clayey soils, shallow glacial till depth to bedrock, and the industrialized areas are associated with diverse age-adjusted human heart death rates (HDR) and digestive system cancer death rates (CDR) per 100,000 persons per year, as reported by the Wisconsin Division of Health. For Wisconsin, the mean for HDR is 321 ± 33 and for CDR is 38.4 ± 4.5, an eight-fold difference. Maps of Wisconsin were prepared with HDR and CDR in each county on a whole-life basis. The 15 counties with the lowest HDR (less than 315) and CDR (less than 35) occur in the selenium-rich loessial silt along the Mississippi River (except where erosion has exposed bedrock sands). The 15 counties with the highest HDR (343 to 406) and CDR (42 to 52) are widely distributed among the land characteristics. Intermediate rates counties are similarly widely scattered. Recognition of the geographic diversity of HDR and CDR among Wisconsin counties may lead to hypotheses as to causation which will be helpful in further research.

INTRODUCTION

A commonly held view is that transportation of foodstuffs and migration of people should preclude, or obscure, any local effect of land characteristics on human nutrition or health differences among counties. Land variations such as soil sandiness, permeability, and other geographic land factors that affect food quality are, however, readily observable. Land low in selenium (Se) contents are indicated by low plant Se contents (below 50 ng g^{-1}) in many Wisconsin counties (Kubota et al., 1967). The need to supplement selenium (Se) in livestock feed to prevent cardiomyopathy ("white muscle disease") in Wisconsin is well-established (Hoekstra, 1974, 1975; Ullrey, 1974). Since crops do not need Se but take it up in the yield to the extent that is available, the Se deficiency in livestock is understandable. An inadequate remaining Se in the Wisconsin soil-plant-animal-human nutrition chain is possible (Jackson and Lim, 1982). Counties along north central Wisconsin and upper Michigan are shown in the "Atlas of Cancer Mortality of U.S. Counties, 1950-1969" (Mason et al., 1975) as having unusually high rates of stomach and other cancers. The land where this occurs in northern Wisconsin and upper Michigan is dominated by sandy soils developed in ancient quartzite rocks (Stose, 1960) and sandy till transported by several glaciations. The objective of this paper is to show that the age-adjusted

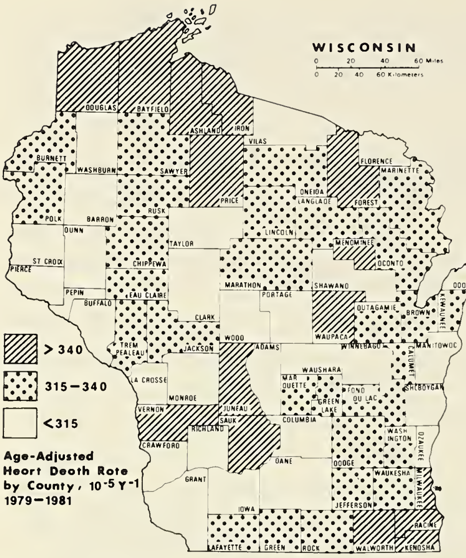

Fig. 1. Heart death rates in Wisconsin counties vary greatly, with a pattern related to land characteristics, being minimal in the deepest, loessial covered counties, but medium to high where erosion has exposed sandy strata in Trempealeau and Vernon counties, and in counties which are located in sandy glacial deposits.

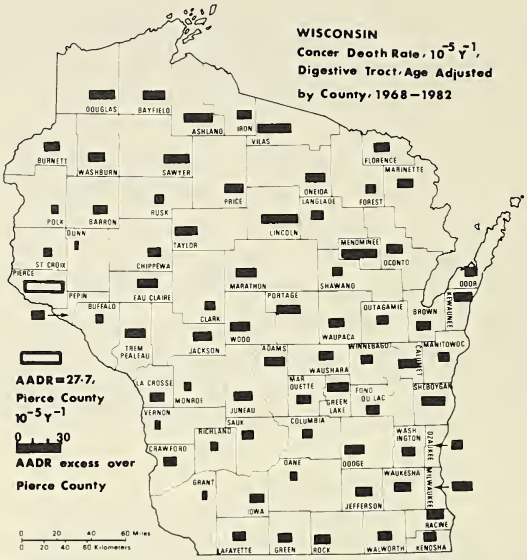

Fig. 2. Cancer death rates in Wisconsin counties vary greatly, with a pattern related to land characteristics, being minimal in highly loessial Pierce county and other deep-loess counties and up to twice as high in counties with sandy soils or intensively farmed silty land, eroded land, and land with shallow soils over bedrock.

TABLE 1. Mortality in Wisconsin counties from digestive tract cancers and from heart disease, age-adjusted per 100,000 persons per year.

County		*Cancer deaths, 1968-1982*			*Heart disease deaths 1979-1981*
	Stomach	*Colo-rectal*	*Pancreas*	*Total*	
Adams	6.1	28.2	7.9	42.2	295
Ashland	11.1	27.3	8.8	47.2	363
Barron	7.5	21.8	8.2	37.5	272
Bayfield	5.9	29.4	7.6	43.0	374
Brown	6.7	23.2	7.4	37.3	321
Buffalo	6.9	19.8	6.7	33.4	295
Burnett	8.6	18.6	10.6	37.9	318
Calumet	6.1	24.8	8.5	39.5	345
Chippewa	6.6	21.8	8.7	37.1	320
Clark	6.9	21.2	6.2	34.2	273
Columbia	4.3	22.8	7.1	34.2	311
Crawford	6.6	20.0	9.7	36.4	283
Dane	5.8	19.4	7.2	32.3	266
Dodge	5.9	26.0	9.7	41.7	324
Door	10.2	17.8	9.1	37.1	265
Douglas	10.8	23.6	11.1	45.5	406
Dunn	6.1	16.6	8.6	31.4	284
Eau Claire	8.6	26.3	6.6	41.4	317
Florence	15.2	18.2	4.4	37.8	234
Fond du Lac	5.1	24.7	7.0	36.8	350
Forest	7.5	19.4	8.1	35.0	386
Grant	4.5	21.2	5.8	31.5	284

TABLE 1. Mortality in Wisconsin counties from digestive tract cancers and from heart disease, age-adjusted per 100,000 persons per year. (Continued)

County	*Cancer deaths, 1968-1982*				*Heart disease deaths 1979-1981*
	Stomach	*Colo-rectal*	*Pancreas*	*Total*	
Green	7.7	22.6	6.6	36.8	326
Green Lake	6.6	28.6	7.3	42.4	316
Iowa	5.5	23.4	9.3	38.2	302
Iron	11.2	16.6	10.1	37.9	400
Jackson	7.6	23.5	9.2	40.3	318
Jefferson	5.8	24.2	8.2	38.2	317
Juneau	6.4	26.1	8.2	40.7	345
Kenosha	7.1	22.2	6.8	36.1	367
Kewaunee	8.6	24.6	7.1	40.4	336
La Crosse	5.9	23.2	8.4	37.5	286
Lafayette	7.2	21.6	8.2	37.0	326
Langlade	9.8	18.2	7.6	35.7	333
Lincoln	10.3	31.0	11.1	52.4	322
Manitowoc	5.3	22.9	7.7	35.9	309
Marathon	8.8	23.8	9.3	41.9	322
Marinette	7.8	22.8	8.0	38.6	333
Marquette	7.6	23.6	6.1	37.3	338
Menominee	8.2	33.5	10.0	51.8	399
Milwaukee	7.3	24.7	8.7	40.7	343
Monroe	6.4	19.1	7.5	33.0	312
Oconto	8.0	21.6	9.4	39.0	325
Oneida	5.8	25.2	11.1	42.1	323
Outagamie	6.2	21.3	8.2	35.8	324
Ozaukee	7.2	20.6	6.4	34.2	312
Pepin	7.1	22.7	6.3	36.1	313
Pierce	3.7	17.4	6.5	27.7	315
Polk	8.0	17.6	7.3	32.8	317
Portage	8.8	23.1	11.2	43.0	311
Price	8.1	24.6	7.6	40.3	362
Racine	7.6	20.9	10.0	38.5	344
Richland	6.3	19.1	7.3	32.7	274
Rock	6.6	23.3	8.9	38.7	330
Rusk	8.4	19.5	6.2	34.0	334
St. Croix	6.4	18.5	8.7	33.6	294
Sauk	6.1	20.5	10.0	36.6	370
Sawyer	8.6	25.6	10.7	45.0	319
Shawano	6.9	21.5	7.2	35.6	296
Sheboygan	7.8	25.9	9.1	42.7	259
Taylor	10.5	20.1	12.2	42.9	300
Trempealeau	7.8	26.6	7.8	42.2	317
Vernon	6.5	18.8	6.2	31.5	344
Vilas	9.5	29.7	10.3	49.5	297
Walworth	6.6	23.6	7.6	37.8	348
Washburn	8.6	22.0	8.2	38.7	298
Washington	7.5	22.0	7.2	36.7	316
Waukesha	7.8	22.9	8.3	36.7	325
Waupaca	5.9	23.7	8.8	39.0	381
Waushara	7.5	24.1	6.1	38.4	307
Winnebago	7.0	21.5	7.5	36.1	296
Wood	8.8	24.4	7.9	40.6	305
Wisconsin (State)	7.1	23.0	8.3	38.4 ± 4.5	321 ± 3

human heart death rate (HDR) and gastrointestinal cancer death rate (CDR), per 100,000 persons per year, varies among counties of Wisconsin, a cool temperature state. These studies were parallel to studies showing even wider variance of HDR and CDR in counties of the humid subtropical state of Florida (Jackson et al., 1985) and in regions of USA and China (China News Agency, 1985; Li and Jackson, 1985).

Methods

Because the human HDR and CDR are high in Wisconsin (as well as eastern USA, China, and elsewhere) the epidemiology for the years 1979 to 1981 for the HDR and 1968 to 1982 for CDR are presented on an age-adjusted rate per 100,000 persons per year in each Wisconsin county, as supplied by the Wisconsin Division of Health, Madison. The HDR rates were grouped into low, medium, and high rate groups and plotted. The CDR were considered as to increments over the rate in Pierce county (27.7 10^{-5} y^{-1}, the lowest rate in any Wisconsin county). Land characteristics, such as bedrock diversity, soil sandiness, erosion, fertility and suitability for intensive agriculture as mapped by the U.S. Geological Survey (Stose, 1960) and the Wisconsin Geological and Natural History Survey, Madison (Hole, 1976) were compared in an effort to interpret the great differences in HDR and CDR among Wisconsin counties.

Results

Land characteristics such as sandy soils, clay content, and glacial till depth to bedrock appear to be associated with different age-adjusted human whole-life heart death rates (HDR) and digestive system cancer death rates (CDR) per 100,000 persons per year (10^{-5} y^{-1}) among Wisconsin counties as mapped (Fig. 1 and 2). The annual age-adjusted HDR and CDR in Wisconsin are 321 ± 33 and 38.4 ± 4.5 10^{-5} y^{-1}, respectively (Table 1). The HDR varies from 234 in Florence county to 406 10^{-5} y^{-1} in Douglas county (173% greater in the latter) and the CDR range from 27.7 in Pierce county to 52.4 10^{-5} y^{-1} in Lincoln county (nearly a two-fold difference).

Heart death rate

To facilitate discussion of land characteristics in relation to human HDR, the age adjusted county rates were grouped as follows:

(1) Lowest rates, <315 . . . 29 counties,
(2) Intermediate rates, 315-340 . . . 28 counties,
(3) Highest rates, >340 . . . 15 counties.

The 29 counties which fall in the lowest HDR group are well-distributed throughout the state (Fig. 1). With the lowest county first: Florence, 234; Sheboygan, 259; Door, 265; Dane, 266; Barron, 272; and Richland, 274 10^{-5} y^{-1} are the six with the lowest HDR. Of these, only Sheboygan and Florence counties are in the high to medium CDR categories (Table 1, Fig. 2). The other four counties have silty and clayey soils which would be expected to be moderately well supplied with essential trace nutrient elements. The thick high-Se loess belt from Grant county north to St. Croix county has low HDR, except for those in which sandstone bedrock has been exposed by erosion. Vilas county with HDR 297 10^{-5} y^{-1} is noteworthy because the other northern acid, sand-rich counties are nearly all in the high HDR category. Infusion of trace elements has occurred by deep-seated mineralization of ore-bearing rocks (Mudrey et al., 1982), including copper, with which Se is associated. These rocks have been worked over by several glaciations.

Those 15 counties falling in the highest HDR group are, in decreasing order: Douglas, 406; Iron, 400; Menomenee, 399; Forest, 386; Waupaca, 381; Bayfield, 374; Sauk, 370; Kenosha, 367; Ashland, 363; Price, 362; Walworth, 348; Juneau, 345;

Racine, 344; Vernon, 344; and Milwaukee, 343 10^{-5} y^{-1}. Acid sandy land characterizes ten of these counties, including Juneau county. Kenosha, Racine, and Milwaukee are the most industrialized counties, with generally higher HDR risks. Vernon county has highly eroded land, induced by the erosiveness of the St. Peter sandstone caprock (Strose, 1960), even though it occurs in the deep loess belt. The land of Walworth county is high in glacial moraines and sandy outwash, and over half of it is intensively farmed.

Cancer death rates

To facilitate discussion of land characteristics in relation to variation in gastrointestinal cancer death rates (CDR) among Wisconsin counties, the counties were mapped (Fig. 2) in three age-adjusted CDR rates:

(1) Lowest CDR (28 to 35) . . . 15 counties,
(2) Intermediate CDR (36 to 41) . . . 42 counties,
(3) Highest CDR (42 to 52) . . . 15 counties.

Those 15 counties falling in the lowest CDR group are, in increasing order: Pierce, 27.7; Dunn, 31.4; Grant, 31.5; Vernon, 31.5; Dane, 32.3; Richland, 32.7; Polk, 32.8; Monroe, 33.0; Buffalo, 33.4; St. Croix, 33.6; Rusk, 34.0; Columbia, 34.2; Clark, 34.2; Ozaukee, 34.2; and Forest, 35.0 10^{-5} y^{-1}. The first ten counties occur in the portion of western Wisconsin in which loess (windblown silt) was deposited from the Mississippi flood plain during the Wisconsinan glacial age 14,000 to 16,000 years ago. This deposit came from the Cretaceous sea-bottom clays of Minnesota and South Dakota (U.S. National Research Council, 1952). Rusk, Columbia and Clark county soils received appreciable loess from various nearby glacial sources. Ozaukee county soils received shale clay pushed by glaciers from the Lake Michigan basin. Forest county soils received some glacial till from Ordovician dolomite and shales from the northeast and in addition lies near metal ore deposits intruded from below.

Those 15 Wisconsin counties falling in the highest CDR group are, in decreasing order: Lincoln, 52.4; Menominee, 51.8; Vilas, 49.5; Ashland, 47.2; Douglas, 45.5; Sawyer, 45.0; Bayfield, 43.0; Portage, 43.0; Taylor, 42.9; Sheboygan, 42.7; Green Lake, 42.4; Trempealeau, 42.2; Adams, 42.2; Oneida, 42.1; and Marathon 41.9. The agricultural lands of the 8 counties highest in CDR are predominantly covered by acid sandy soils developed in glacial outwash. Acid sandy soils predominate in the other counties of the group, except for Sheboygan and Marathon counties which have shallow silt over till and granite, respectively.

Medial heart and cancer death rate counties

The medium HDR and CDR counties are well-distributed throughout Wisconsin. The major fertilizer elements (phosphorus, potassium, and nitrogen) are routinely used to increase the yields of various crops. A rapid draw-down of trace elements in intensively cropped counties is inevitable, while acid sandy land is initially low in available trace elements. Zinc (Zn) is deficient in a majority of tests of sandy soils. For example, soil tests show 100% Zn deficiency for Lincoln county. Selenium (Se), which is not needed by plants, is taken up in the crop and the available supply drawn down in cropped land but not necessarily in forested counties.

A fairly low correlation ($r = 0.27$) between heart death rates (HDR) and digestive system cancer death rates (CDR) among the 72 Wisconsin counties suggests variation in causation. This situation contrasts greatly with that among the 67 Florida counties where a correlation, $r = 0.73$ ($p < 0.001$), occurs between HDR and CDR (Jackson et al., 1985). Because of the wide distribution in medial HDR and CDR counties in Wisconsin, the pattern of causation can only be fully explained by additional data on the geochemical and other locality characteristics of land and people.

Discussion

The soil-food-nutrition chain should carry adequate amounts of each of the 13 or so essential trace elements (Mertz, 1981). A well-established model is the role of iodine (I) supplementation in the prevention of human goiter in Wisconsin. An essential deoxidizing Se-enzyme (Hoekstra, 1974) helps prevent lipid oxidation in cell membranes and other cell-damaging oxidization reactions (Draper and Bird, 1984). Wisconsin is one of the high human HDR states (Li and Jackson, 1985). Few data have been gathered on human blood Se levels in various localities, even though heart deaths account for nearly half of all deaths (U.S. Department of Health and Human Services, 1974-1981).

Adequate Se is a chemopreventive anticarcinogen (Thompson, 1984). Active peroxides and epioxygen groups that promote cancer (Cerutti, 1985) are suppressed by Se enzymes and vitamin E (Hoekstra, 1975). Soils Se, as measured by plant uptake of Se, varied between localities within the states of Arizona, Arkansas, California, Missouri, Montana, and New Mexico; CDR varied inversely with the soil Se level within each state (Shamberger and Willis, 1971; Schrauzer et al., 1977). Ammonium molybdate application to soil lowered the incidence of human esophageal cancer in a low molybdenum area in China (Li et al., 1980). Cancer types have distinctive land distribution patterns among counties of China (Li et al., 1979), as found in Wisconsin. Trace element supplementation in human nutrition is available "over-the-counter," with expert dosage guidelines from the U.S. National Academy of Sciences (1980).

Conclusions

Diversity of land characteristics corresponds to a considerable extent with the wide HDR and CDR variations among Wisconsin counties. Status of essential trace elements such as Se and Mo show relationships to HDR and (or) CDR within regions of some states, between U.S. states, and between provinces of several countries. The diversity of human HDR and CDR among Wisconsin counties may come to be understood in terms of land (soil, water, and crops, dietary trace elements and toxic substances) with the accumulation of more data on localities.

Acknowledgments

This work was supported by the Academy of Sciences, P.R.C. and the College of Agricultural and Life Sciences, University of Wisconsin-Madison. Ji Z. Zhang and Chang S. Li are Honorary Fellows at the University of Wisconsin-Madison. Earlier, M. L. Jackson, The *Franklin Hiram King* Professor, was visiting scholar in China, sponsored by Academia Sinica. Special thanks are extended to Gregory Ruark for his assistance with the statistical analyses. Soil clay data were gathered with the assistance from the National Science Foundation grant EAR-8405422. Gratitude is expressed to Ms. Chrystie Jackson for her editorial and typing assistance.

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WISCONSIN'S ELECTRIC UTILITY INDUSTRY SINCE THE ENERGY CRISIS

Richard A. Walasek
University of Wisconsin-Parkside

In the ten years following the Arab oil embargo of 1973-74, much upheaval and change occurred in the nation's electric utility industry. Foremost among the changes were rapid increases in electric rates, which induced conservation and a dramatic drop in the historical annual rise in electricity consumption. Between 1950 and 1973, electricity use grew an average of 8.2 percent every year, but between 1973 and 1982 the annual growth averaged only 2.3 percent [14]. The decline in consumption growth combined with the long lead times required to plan and construct new generation capacity left many utilities with overly ambitious and expensive expansion plans. The many canceled nuclear power plants in recent years exemplify this situation. Rapid increases in electric rates caused much consumer unrest, but rate increases did not prevent substantial deterioration of the financial condition of many electric utilities across the United States. Fuel and construction costs exacerbated by inflation and high interest rates grew faster than the revenues generated by the higher electric rates. The high rates, overly ambitious plans, poor utility finances, and the need to conserve energy have induced a variety of efforts to tighten regulation of utilities, improve public relations, and use innovative rate designs like time-of-day rates. The changes in the electric utility industry since the "energy crisis" of 1973-74 have been major, but more fundamental change during the 1980s and 1990s is probable.

National trends and statistics often mask variations within the nation. The purpose of this paper is to examine the status of the electric utility industry in Wisconsin, and in particular, to assess the extent to which national conditions have affected the state. The assessment is accomplished by comparing Wisconsin to the nation and to several neighboring states which compete with Wisconsin economically. These states, like Wisconsin, also obtain a majority of their electricity from coal. Variables relating to prices, consumption, and financial health are compared using two years, 1972 and 1982. (It should be noted that 1982 was a year of recession which would be reflected in this data). To assess patterns within Wisconsin, individual utility companies are compared, but data constraints limit this analysis to the major privately-owned utilities. This is not a major drawback because the privately-owned utilities serve approximately 83 percent of the state.

The literature concerning electricity contains several studies which examine the status of the electric utility industry. A recent Department of Energy study finds that the electric utility industry has not performed as well financially as other major industries [15]. Browne concludes that utilities have faced a difficult period since 1973, but problems are likely to continue because of uncertainty in demand growth and economic conditions [2]. Lastly, an argument that utilities are not planning enough generating capacity to meet long range needs (i.e. 15-20 years hence) because of regulatory constraints is made by Navarro [11]. These studies along with most of the related literature share the characteristic of being national in scope, but with the homogeneity of the national electric utility industry diminishing, it is increasingly essential to focus on smaller areas. This paper focuses on a smaller area by concentrating on a single state.

Another aspect of this paper relates to the

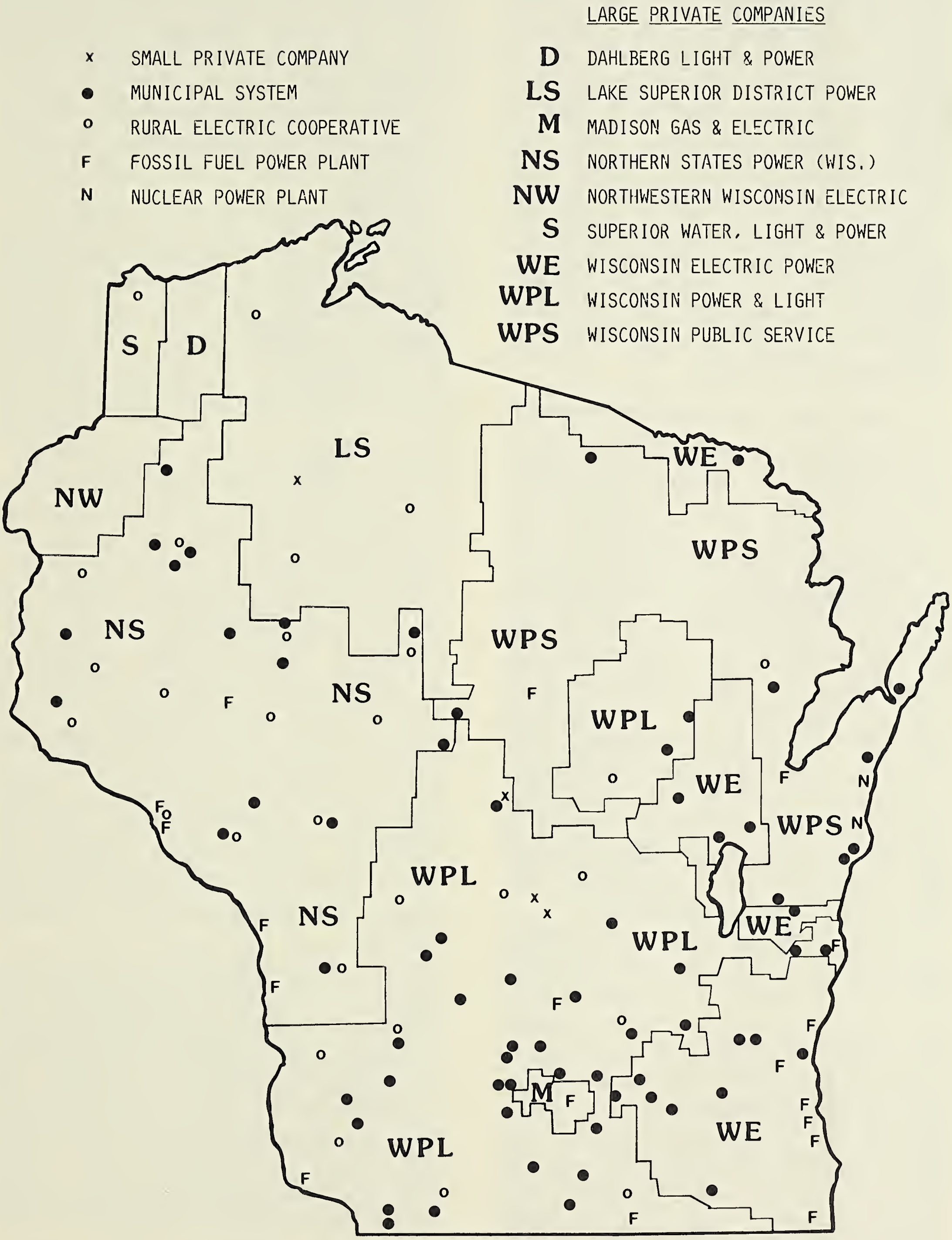

Fig. 1. Wisconsin's electric utility industry.

widely held perception that Wisconsin has a "poor business climate." Whether or not Wisconsin actually has a poor business climate can not be answered here, but it would seem that the quality of the utility industries in the state needs to be part of business climate evaluation. Since this paper's conclusions about the electric utility industry are positive, statements regarding Wisconsin's business climate should be upgraded to reflect this fact. Among other considerations sound electric utilities with relatively low prices should be a strong factor attractive to businesses considering Wisconsin as a place to locate.

Electric Utility Industry in Wisconsin

In Wisconsin, the electric utility industry is composed of 13 privately-owned companies, 83 systems owned by municipalities, and 30 rural electric cooperatives [4]. Except for municipal systems serving towns smaller than 1,000 population, Figure 1 indicates the locations of these utilities. Many of the municipal systems and cooperatives are found in the service areas of Northern States Power (Wisconsin) (NS) and Wisconsin Power and Light (WPL). Wisconsin Electric Power (WE), which is the state's largest utility with over 800,000 customers, dominates the more populous southeastern portion of the state. In contrast, the state's smallest utility, Footville Water and Electric Commission, serves only 340 customers.

Another aspect complicating the utility pattern is a North American Electric Reliability Council (NERC) boundary which divides the state between two NERC regions. NS, Lake Superior District Power (LS), and Superior Water, Light and Power (S) are part of the Mid-Continent Area Power Pool, while the rest of the major utilities in the state belong to the Mid-American Interpool Network. These two NERC regions are two of the nine regions in the United States which are multi-state groups of utilities having a purpose of enhancing the reliability and adequacy of electric power supplies [5]. Effects of this division include the lack of transmission line interconnections between utilities in the two regions and the absence of joint ventures that combine utilities from different NERC regions. Wisconsin's electric utility industry has had many joint ventures to construct power plants, but none, for example, have had NS and WPL working together.

Besides being divided by a NERC boundary, several additional characteristics impact operations of Wisconsin's utilities. First, several of the private utilities serve portions of adjacent states. Northwestern Wisconsin Electric (NW) serves a small part of Minnesota and LS, WE, and Wisconsin Public Service (WPS) each cover parts of Upper Michigan. WPL has a subsidiary company, South Beloit Water, Gas and Electric, operating in Illinois. Second, three of the utilities in Wisconsin are separate subsidiaries of companies based in Minnesota. Northern States (Minnesota) controls NS and LS, while Minnesota Power and Light controls S. These interstate relationships complicate utility operations, especially in terms of regulatory differences. Third, the service areas of WE and WPL are fragmented and most of the major utilities have tortuous inefficient boundaries. A fourth characteristic is the multi-product nature of Wisconsin's electric utilities; besides electricity, many of the utilities provide other products like natural gas, water, and steam heat.

As the above information indicates, Wisconsin's electric utility industry is quite complicated. This complexity occasionally leads to problems and suggests the desirability of simplifying the situation. For example, the cancellation of the NS Tyrone nuclear power plant created jurisdictional problems which led to several court battles [12]. The Tyrone plant, which was planned to provide power for the entire Northern States system (parts of Wisconsin, Minnesota, North Dakota, and South Dakota), was halted by the Wisconsin Public Service Commission

(WPSC) in 1979 after about $75 million had been spent. The problems and litigation developed over Northern States' efforts to recover the $75 million. The public service commissions in the three non-Wisconsin states, feeling that the plant and its abandonment costs were Wisconsin issues, balked at allowing higher electric rates to pay for any abandonment costs. Ultimately the courts ruled that the customers in the non-Wisconsin states would have to pay proportional shares of the $75 million because Tyrone was going to produce electricity for the entire Northern States system. The situation would have been much simpler if only the WPSC and a unaffiliated Wisconsin utility had been involved.

The locations of power plants with a capacity of 100,000 kilowatts or more are also indicated in Figure 1. The process of siting power plants involves the analysis of many factors like rail and water transportation possibilities, proximity to population centers, cooling water supplies, environmental impacts, and the existing transmission network. In Wisconsin, the distribution of power plants demonstrates the importance of closeness to population and cooling water. Almost all the power plants are in or near cities and areas associated with either the Mississippi River, Wisconsin River, or Lake Michigan. Fossil fuels are used by all the major power plants except for the Kewaunee and Point Beach nuclear stations. Among the fossil fuels, the overwhelmingly predominate fuel, representing 65.8 percent of total generation in 1982, is coal [14]. Comparable percentages for oil and natural gas are 0.3 and 0.6 percent, respectively. The remaining generation (33.3 percent) is nuclear with 27.5 percent of the total, and water power, where approximately eighty hydro plants scattered over central and northern Wisconsin contribute 5.8 percent.

Prices

Although electricity prices are determined by state regulatory commissions and are largely based on fuel costs, electricity prices still reflect utility management and operation. Relatively low prices commonly indicate sound planning including proper timing of construction projects and use of strategies to reduce costs. In addition, relatively low prices are sometimes the result of good fortune related to events beyond the utility's control. Conversely, bad planning and ill fortune contribute to relatively high prices.

While electricity prices throughout the nation grew rapidly between 1972 and 1982, Wisconsin's electricity prices increased relatively slowly and currently compare favorably with nearby states (Table 1). While national averages of residential and business prices grew 211 and 258 percent respectively, residential and business prices in Wisconsin increased by 156 and 166 percent respectively. The slower growth in Wisconsin is reflected in changes in national rankings. Especially noteworthy is the improvement in the business price ranking from 43 to 21. This improvement in relative electricity prices between 1972 and 1982 makes Wisconsin business prices much lower than business prices in Illinois, Michigan, and Ohio and competitive with the other nearby states except for Indiana. In the residential sector, Wisconsin has the lowest prices of the eight states. These relatively low electricity prices reduce the costs of living and doing business in Wisconsin, and even though electric bills are usually only a small portion of total expenses for a household or business, the low prices are beneficial to the state.

Table 1 also contains information for several individual companies as well as an average for the larger municipal systems. Considerable price variability exists within the state with the ratio of highest to lowest price ranging between 1.25 to 1.45 for the different sectors and years. In extreme instances, the locations of service area boundaries cause price variability to be much greater and to occur over short distances. For example, Kimberly and Little Chute are

TABLE 1. Interstate and Intrastate Comparisons of Electricity Prices—1972 and 1982 (Dollars)

	1972		*1982*	
Area	*Residential*[1]	*Business*[2]	*Residential*	*Business*
United States	16.55	4269	51.40	15286
Wisconsin	15.84	4408	40.54	11710
Wisconsin's Rank[3]	25	43	12	21
Illinois	17.15	4329	48.33	15748
Indiana	15.19	3818	45.03	9990
Iowa	18.38	4235	45.64	11697
Michigan	14.91	5023	40.93	14762
Minnesota	16.40	4275	43.09	10408
Missouri	16.79	4241	41.99	11137
Ohio	15.90	4083	53.54	14937
LS[4]	16.28	NA	43.91	NA
M	13.32	3301	35.56	13483
NS	14.72	3743	39.22	10034
S	14.95	NA	41.19	NA
WE	16.58	4641	42.41	11419
WPL	13.91	3799	41.19	12699
WPS	17.73	4189	40.56	12662
Municipal[5] Average	13.73	NA	34.55	NA

[1] Monthly residential bill for 750 kilowatt-hours.
[2] Monthly business bill for 200,000 kilowatt-hours and 1,000 kilowatts.
[3] 1 equals state with lowest price.
[4] Refer to Figure 1.
[5] Average of larger municipal systems.
Source: *Typical Electric Bills.* Washington, D.C.: U.S. Energy Information Administration, 1972, 1973, 1982, 1983.

Wisconsin towns of similar size located one mile apart, but Kimberly is served by WE and Little Chute by a municipal system. Thus, in 1982, households in Kimberly paid $15.62 more than households in Little Chute for the same monthly 750 kilowatt-hours of electricity.

Relatively low electricity prices for the state as a whole and for several of the individual utilities are the result of several interrelated factors which have evolved, especially since 1972. The more important of these factors include (1) increased use of less expensive Western coal, (2) no ongoing nuclear power construction projects, (3) slow growth in electricity demand related in part to slow population and economic growth but also in part to strong energy conservation campaigns, (4) widespread application of new rate schedule designs, (5) judicious regulation by the WPSC, and (6) consumer advocacy by the recently formed Citizens Utility Board.

Coal produced by surface mining in Montana, Wyoming, and other Western states usually has a lower delivered price and contains less sulfur than Eastern coal. These advantages have led utilities to use more Western coal. In 1973 (data are not available for 1972), utilities in the eight states in Table 1 obtained 10.3 percent of their coal from the West, but by 1982 this percentage had increased to 26.9 percent [3]. Wisconsin (5.4 percent in 1973 to 50.2 percent in 1982), along with Iowa (26.6 percent to 78.4 percent), exhibited the greatest relative shift to

Western coal among the eight states. In addition to heavy use of Western coal, electricity prices in Wisconsin are held down by the existence of two nuclear stations which were completed before nuclear power costs skyrocketed. The Point Beach station was completed in 1972 at a cost of $172 million and the Kewaunee station was finished in 1974 for $215 million. Costs of around $200 million are much less than the $1 to $6 billion range of costs for finishing, or in some cases, canceling current nuclear projects. While having Point Beach and Kewaunee lowers generating costs, decisions by Wisconsin utilities to not carry through with additional nuclear projects were crucial in keeping current and future prices relatively low. Wisconsin's utilities in the early 1970s, anticipating continued growth in demand, did plan to build more nuclear plants and three projects at Haven, Koshkonong, and Tyrone went beyond the early planning stages. These plants were eventually canceled because state mandated power plant planning along with WPSC urging caused the utilities to realize that demand growth was going to be much less than anticipated and that nuclear projects faced many economic and regulatory uncertainties.

Iowa and Minnesota have a situation like the one in Wisconsin. These two states each have at least one operating nuclear station and no current projects, while all the other nearby states are facing substantial costs related to nuclear projects. For example, the Marble Hill station in Indiana was canceled in early 1984 after $2.5 billion had been spent on the project.

The paucity of power plant construction of all types in Wisconsin helps the utilities keep electricity prices low. Since low levels of power plant construction are the result of projections of continued slow growth in electricity demand (peak demand), this means that slow demand growth contributes to lower prices. Economic problems and limited population increases, aspects largely beyond the utilities' control, are two reasons for slow growth in demand, but in addition, the utilities and the WPSC have made substantial efforts to reduce demand. Foremost among these efforts are time-of-day rates. Time-of-day rates employ higher prices during peak demand periods and lower prices during off-peak periods to encourage customers to shift consumption from peak periods during the day to off-peak periods during the night. In Wisconsin approximately 40 percent of the electricity sold in the state is billed under these rates, whereas a recent national study found that only a tiny percentage of customers chooses to use time-of-day rates [7]. Also, several Wisconsin utilities have extensive load management programs. For example, WE has a program in which residential customers receive a monthly credit of $4.50 on their electric bill in return for letting the utility install a remote control device which allows the utility to turn off the customer's water heater when peak demand conditions arise. This WE program covers approximately 65 percent (93,000) of the customers who possess electric water heaters. Overall, Wisconsin's efforts to shift demand away from peak periods are greater than those of other states and are large enough to lower the need for new power plants.

The WPSC and Citizens Utility Board (CUB) are the final two contributors to Wisconsin's relatively low prices. The WPSC is well regarded nationally and has already been cited for discouraging overly ambitious construction plans and for encouraging wide use of time-of-day rates. More will be said about the WPSC in the section on financial health.

CUB is a consumer group which grew out of the concern that residential customers were poorly represented in regulatory proceedings. The Wisconsin legislature established CUB in 1979 with a mandate to represent consumer interests on utility issues before the WPSC and the legislature [13]. CUB has a growing statewide membership of over 100,000 in 1984 and receives no state

Table 2. Interstate and Intrastate Comparisons of Electricity Consumption—1972 and 1982 (Kilowatt-hours)

	1972		*1982*	
Area	*Residential*[1]	*Business*[2]	*Residential*	*Business*
United States	641	10145	725	10521
Wisconsin	604	7977	657	9738
Wisconsin's Rank[3]	24	21	17	24
Illinois	529	11820	589	12940
Indiana	655	11594	808	12934
Iowa	606	6029	731	7746
Michigan	543	11992	533	10473
Minnesota	586	8381	696	10139
Missouri	565	7362	736	8214
Ohio	583	16083	664	13544
LS[4]	336	3262	476	5120
M	559	5982	508	6614
NS	654	5289	786	6492
S	387	12840	464	17490
WE	582	10140	601	11480
WPL	611	6417	666	7404
WPS	527	9100	589	10813

[1] Monthly residential consumption per customer.
[2] Monthly business consumption per customer.
[3] 1 equals state with lowest consumption.
[4] Refer to Figure 1.
Source: *Statistical Yearbook of the Electric Utility Industry*. Washington, D.C.: Edison Electric Institute, 1973, 1983.

funding. CUB's contributions to lower electricity prices are its continual and strong opposition to utility requests for rate increases and its efforts to change utility accounting and tax procedures to ones that are more favorable to consumers. CUB claims a number of cases where the WPSC reduced the amount of the rate request because of CUB intervention, but it is difficult to determine the accuracy of these claims. Critics of CUB argue that the group is too antagonistic toward utilities and does not always have the best interests of the consumer in mind because it tends to emphasize short term goals over long term benefits. Also, Wisconsin's CUB is somewhat experimental because it is a relatively young organization and it was the first state citizens utility board to be established in the country (by 1984, Illinois was the second state to form a CUB). In any event, CUB has withstood these problems to become a strong voice supporting lower electricity prices.

Consumption

Information concerning consumption of electricity is presented in Table 2. The business consumption data encompass commercial, industrial, governmental, and other non-residential uses of electricity. Wisconsin's relative consumption, in contrast to relative electricity prices, exhibits less dramatic change between 1972 and 1982 and more median positions among the nearby states. Looking at residential consumption, Wisconsin grew more slowly than the nation as a whole with its ranking changing to seventeenth. Minnesota, Missouri, and Ohio moved ahead of Wisconsin. Although there are many interrelated factors which influence electricity consumption, Wisconsin's relatively low but still higher residential electricity prices and demand reduction efforts as mentioned in the previous section are two reasons for Wisconsin's slow consumption growth. In addition, relative shifts among the states are influenced by income gains and by greater increase in use of air conditioners in the South and West.

Residential consumption within the state shows all of the utilities except for M increasing from 1972 to 1982 and much variability among the utilities. Colder weather (which reduces the use of air conditioning), somewhat higher electricity prices, and generally lower incomes are reasons for low residential consumption in areas served by LS and S. NS has the highest consumption even though its service area generally has lower incomes and less air conditioning than the service areas of M, WE, WPL, and WPS. The reason for this situation is that NS has proportionally more customers who use electricity instead of natural gas or fuel oil for water heating and home heating.

Examination of interstate variations in business consumption shows a different situation. Wisconsin's business consumption grew relatively rapidly, but its national rank did not change much and its relative position among the nearby states did not change at all. The results for Wisconsin and some of the other states are especially surprising because the economy was strong in 1972 and weak in 1982. Part of the explanation is related to Wisconsin having a weak 1982 economy, but not as weak as several of the major industrial states. Michigan and Ohio, two states with worse economic problems than Wisconsin, continue to have large amounts of business consumption in spite of recession-induced declines in per customer consumption. These states and others bring down the 1982 national value relative to the value for Wisconsin. Another reason for relatively rapid business consumption growth in Wisconsin is electricity price. In the residential sector, Wisconsin's 1982 prices, relatively low but still much higher than 1972, lead to conservation. In the business sector, where price increases can be passed on to the consumer, the same price situation does not slow consumption growth as much.

Discussion of business consumption in states or in utilities is complicated further by the effects of a few customers or a single industry. For example, S in 1982 has the largest number in Table 2 because this utility serves a small number of industrial customers which use very large amounts of electricity. Another city may have as much business activity as Superior, but its consumption per customer may be much less because its businesses are not as electricity-intensive. Also, if a large customer of S should happen to move or be hit by a strike, the figure for S could be much smaller. These aspects help explain why business consumption is much more variable than residential consumption.

A final point with respect to consumption is that it is difficult to judge the desirability of different levels of consumption. Wisconsin has low to medium levels of consumption, but one cannot make a strong argument either way that these levels are appropriate.

Financial Health

Given Wisconsin's combination of relatively low electricity prices and low to medium consumption, one might expect the financial health of the state's utility industry to be low, but it is not. In actuality, Wisconsin utilities are in excellent financial condition. Utility revenues are relatively modest, but operating and capital costs are relatively low, meaning that Wisconsin utilities possess strong cash flows and do not have to keep asking for rate increases to try to catch up with escalating costs. Also, the strong cash position allows the companies to use internal financing for capital projects and to avoid the more expensive credit markets.

Although measurement of electric utility financial health is complicated and sometimes controversial, the items presented in Tables 3 and 4 collectively provide an accurate picture of financial status. The results in Tables 3 and 4 are based on simple averages of values for the privately-owned utilities in a given area. The Moody's ratings of bonds and preferred stocks represent the financial community's opinion concerning the quality of a utility's offerings. Short and long term risk to the investor is the most important determinant in the ratings. In 1972, Wisconsin was among the top group of states, whereas by 1982 many states had suffered ratings declines leaving Wisconsin tied with Texas in the bond ratings and alone at the top in the preferred stock ratings. More recent information from early 1984 indicates that WE, WPL, and WPS are the highest rated electric utilities in the country. It is ironic that Wisconsin's superior ratings are partially the result of not having to borrow heavily for construction projects, while at the same time the superior ratings mean that the utilities could borrow funds more inexpensively.

For the next two measures in Tables 3 and 4, Wisconsin shows mixed results. Both rate of return on common equity (ROE) and interest coverage ratio before taxes (IC) are defined completely in Kanhouwa [9], but basically these statistics compare a utility's net earnings or income to: (1) the total value of the utility's common stock shares for ROE and (2) the utility's total interest expense for IC. Larger values of ROE and IC imply higher relative earnings and stronger financial condition. Even though WE in 1972 and 1982 along with WPL in 1982 have high ROE values, the other utilities bring the average down to a level below the national

Table 3. Interstate and Intrastate Comparisons of Electric Utility Financial Health—1972

Area	*Bond Rating*[1]	*Preferred Stock Rating*	*Rate of Return on Common Equity (%)*	*Interest Coverage Ratio Before Taxes*	*Regulatory Climate*
United States	A	NA	12.22	3.08	NA
Wisconsin	AA	NA	10.27	3.32	NA
Wisconsin's Rank[2]	1*	NA	40	16	NA
Illinois	AA	NA	13.18	2.97	NA
Indiana	AA	NA	15.00	3.60	NA
Iowa	AA	NA	12.32	3.74	NA
Michigan	A	NA	11.20	2.78	NA
Minnesota	A	NA	13.08	3.40	NA
Missouri	A	NA	10.61	2.65	NA
Ohio	AA	NA	14.06	3.05	NA
LS[3]	A	NA	11.20	3.91	NA
M	AA	NA	8.40	2.03	NA
NS	AA	NA	9.40	4.41	NA
S	NA	NA	9.50	3.77	NA
WE	AA	NA	11.90	3.94	NA
WPL	AA	NA	10.10	2.58	NA
WPS	A	NA	11.40	2.62	NA

[1] Ratings from high to low: AAA, AA, A, BAA, BA.
[2] For all variables, 1 equals highest rank.
[3] Refer to Figure 1.
* Wisconsin tied for first with 14 other states.
Sources: *Moody's Public Utility Manual.* 1973. *Statistics of Privately Owned Electric Utilities in the United States 1972.* Washington, D.C.: U.S. Federal Power Commission, 1973.

average. This is true for both 1972 and 1982. Wisconsin's ROE is low, but this does not mean that earnings are too low, since the low ROE results from having relatively large amounts of common equity and from the WPSC feeling that utility costs and finances warrant the granting of overall rates of return that are below the national average. Although ROE is low, earnings are more than sufficient to provide an ample margin of safety in covering interest expenses. Careful management of debt has allowed Wisconsin to move from sixteenth nationally to second in 1982 (Colorado was first).

Taken as a whole, the four measures discussed here demonstrate improved financial health for an already solid group of utilities. Wisconsin's electric utility industry was strong financially in 1972, but is even stronger in the 1980s. This is especially noteworthy because during the same period many states and utilities experienced increased financial problems. Among the nearby states, Illinois, Iowa, and Minnesota are above average and far better off than Michigan and Missouri, but do not rank as high as Wisconsin.

Part of the credit for the excellent financial health of Wisconsin's utilities belongs to the WPSC. The final item in Tables 3 and 4,

Table 4. Interstate and Intrastate Comparisons of Electric Utility Financial Health—1982

Area	*Bond Rating*[1]	*Preferred Stock Rating*[1]	*Rate of Return on Common Equity (%)*	*Interest Coverage Ratio Before Taxes*	*Regulatory*[2] *Climate*
United States	A2	A3	14.03	2.60	C
Wisconsin	AA2	AA1	13.44	3.73	B
Wisconsin's Rank[3]	1*	1	26	2	5**
Illinois	AA3	AA2	14.48	2.83	C+
Indiana	A2	A3	13.00	2.46	A
Iowa	AA3	A2	18.30	2.82	C−
Michigan	BAA3	BA1	9.66	1.85	C−
Minnesota	A1	AA3	14.18	2.86	C
Missouri	BAA1	BAA2	13.33	2.54	E
Ohio	A3	BAA1	13.16	2.15	B−
LS[4]	A3	NA	12.90	5.27	NA
M	AA2	NA	11.30	3.69	NA
NS	AA2	NA	9.80	2.93	NA
S	NA	NA	14.80	2.55	NA
WE	AA1	AA1	15.90	4.22	NA
WPL	AA1	AA1	15.80	3.88	NA
WPS	AA1	AA1	13.60	3.55	NA

[1] Ratings from high to low: AAA1, AAA2, AAA3, AA1, AA2, AA3, A1, A2, A3, BAA1, BAA2, BAA3, BA1, BA2, BA3.
[2] Climate rating: A (highest) to E (lowest).
[3] For all variables, 1 equals highest rank.
[4] Refer to Figure 1.
* Wisconsin tied for first with one other state.
** Wisconsin tied for fifth with one other state.

Sources: Luftig, Mark D. and Scott Sartorius. *Salomon Brothers Electric Utility Regulation—Semiannual Review.* February 1983, August 1983.
Moody's Public Utility Manual. 1983.
Financial Statistics of Selected Electric Utilities 1982. Washington, D.C.: U.S. Energy Information Administration, 1984.

labeled regulatory climate, is an assessment of how favorable the public service commission rulings are to the utilities and their stockholders. The WPSC, considered to be fairly favorable to the electric utilities, has at the same time closely monitored capital expenses (power plants), encouraged good utility management, and used sophisticated approaches to resolving utility issues [8]. The results of this regulatory environment provide Wisconsin with solid utilities that are able to sell electricity at below average prices. Among the other nearby states, there is surprisingly little correspondence between regulatory climate and electricity price levels. Missouri's public service commission does not grant large rate increases and is very unfavorable to utilities, but Missouri's electricity prices are similar to those in Wisconsin and Missouri's utilities have much poorer financial health. One explanation for this situation is that more favorable regulation allows the utilities borrow at lower interest rates and to be more flexible in controlling costs.

Another issue related to financial health is utility diversification. Utilities throughout the country, wanting to grow and expand in spite of slow growth in electricity demand, are increasingly interested in becoming involved in other businesses besides selling electricity. Some minor diversifying has occurred in Wisconsin, but the principal issue in the state revolves around legislation to allow the state's utilities to organize utility holding companies [1]. Utility holding companies, which would permit utility and non-utility activities to be kept separate, are desired by the utilities so that WPSC regulation would not cover the non-utility activities. The utilities argue that non-utility enterprises need to be free from regulation in order to be competitive. The utilities also emphasize strongly the possibility of creating new jobs when the non-utility businesses are established. Opponents of utility holding companies (like CUB) object to the increased potential for deterioration in the cost and quality of utility service and to the possibility of unfair competition adversely affecting small business. There have been instances in other parts of the nation, where utility holding companies have shed lackluster utility subsidiaries leaving the utility subsidiaries with financial problems. Also, occasionally the better managers migrate to the "more glamorous" non-utility businesses, and thereby, worsen utility management. These drawbacks reduce the attractiveness of utility holding companies so that it is difficult to decide whether they should be allowed in Wisconsin.

The Wisconsin legislature has not reached a final decision about utility holding companies. In 1983, the bill authorizing holding companies was tabled in the Senate by a close vote. During 1984, the bill has not been reintroduced primarily because the bill's complex language is being rewritten to try to satisfy some of the bill's opponents. Utility diversification in Wisconsin, at least in terms of holding companies, is presently at a standstill.

Conclusion

This paper examines the status of Wisconsin's electric utility industry by focusing on the state's major privately-owned electric utilities. The examination finds the utility industry to be spatially and jurisdictionally complex. Per customer consumption of electricity in the state is relatively modest. In addition, the industry along with the WPSC is able to combine relatively low electricity prices and financial strength. Wisconsin's situation is significant in terms of emphasizing time-of-day rates, developing the first citizens utility board, and showing the impact of having no expensive new nuclear projects under construction. Wisconsin's electric utilities represent a high quality portion of the state's infrastructure which should help to attract new businesses to the state. Efforts to promote economic growth in Wisconsin need to stress the character of its electric utility industry.

The future of Wisconsin's electric utility industry shows two possible causes of concern, but on the whole the future seems bright. One concern is the potential for utility diversification to be allowed without sufficient safeguards for utility customers. A second concern relates to acid rain [10]. Acid rain, caused in part by sulfur oxides emitted from coal power plants, is a major environmental issue. There is a strong likelihood that stricter air pollution regulations will be enacted, which would substantially increase pollution control costs for utilities and their customers. Wisconsin's utilities, using much coal, would be adversely affected by acid rain regulations, but at least much of the coal being used is low sulfur Western coal.

On the positive side for the future, Wisconsin's utilities expect to be able to avoid construction of new power plants until the middle 1990s and to maintain relatively low electricity prices. Evidence of the last point occurred in early 1984 when the WPSC lowered rates for WE. Another possible development which could lower costs is the importation of electricity from Canada [6]. Manitoba, in particular, has hydro power potential which could be developed for Midwestern markets including Wisconsin. These positive factors combined with continued careful management and regulation should outweigh any future concerns, thereby maintaining the state's strong electric utility industry.

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THE SOUTHERN SOCIAL ART OF ROBERT GWATHMEY

CHARLES K. PIEHL
Mankato State University
Mankato, Minnesota

"All serious creative work must be at bottom autobiographical," wrote the Southern-born novelist Thomas Wolfe in 1936.* "A man must use the material and experience of his own life if he is to create anything that has substantial value." Wolfe wrote these words in the middle of what has become known as the Southern Renaissance, a cultural movement that produced William Faulkner, Robert Penn Warren, Eudora Welty, Erskine Caldwell, and many other skilled and influential authors. Not only the quality of their writing but also the subject matter dealt with by Southern writers of this era has intrigued literary critics throughout the world. Southern writers struggled with the heritage of slavery, intense racial interaction, brutal poverty, and the Lost Cause of the Confederacy. The "sense of place" and the mixing of individual identity with social and geographic surroundings, have fascinated both Southerners and non-Southerners, with the former group developing an intense self-consciousness over the years. Thomas Wolfe's comments about the importance of autobiographical expression in literary work could have come just as readily from the pen or typewriter of many other Southern writers of this era.[1]

Recent work by literary and cultural historians has shed considerable light on writers during the Southern cultural awakening, but surprisingly little attention has been given to artists of the same period. The discussion of Southern art in *The Encyclopedia of Southern History* virtually ignores Southern painting in the middle third of the twentieth century. Even George B. Tindall's massive survey, *The Emergence of the New South, 1913-1945,* fails to discuss the visual arts even though he devotes two full chapters to literature. The cultural historian Henry Nash Smith recently questioned whether the term "Southern Renaissance" could accurately be used because "the record shows no outstanding Southern achievement in the graphic arts . . . during this period . . ." His conclusion reflects the current consensus on Southern art in the mid-twentieth century.[2]

"An artist is motivated by the fact that he sees something worthy of recording," Robert Gwathmey once observed. "However, in the final analysis, if it is not to a great extent autobiographical . . . it will lack conviction." The similarity between Gwathmey's observations and those of Thomas Wolfe is more than coincidental, for the two shared sentiments about the creative process. They differed because Gwathmey expressed his ideas most often with paint on canvas rather than with typewriter or pen. In doing so, Gwathmey exemplified the visual expression of Southern culture in the middle years of the twentieth century.[3]

As Gwathmey himself suggested, the keys to his art are his personal experiences as a white Southerner who encountered the stark contrasts of race and caste that characterized society in his region. The influence that this social context had on his art developed slowly and did not manifest itself until well into Gwathmey's adult years. He was born in Richmond, Virginia, in 1903, into a respected white family that traced its roots eight generations back into Virginia history.

*Previous versions of this paper were presented at the 11th Biennial History Conference on New Approaches to Social and Cultural History at Kutztown, Pa., on March 26, 1979, at the 85th Annual Meeting of the Michigan Academy of Science, Arts, and Letters at Ann Arbor, Mi., on March 20, 1981, and at the 5th Annual Meeting of the American Culture Association in Wichita, Ks., on April 26, 1983.

Although his home environment was comfortable during his early years, it was not affluent. His father, a railroad engineer, died in a train accident before Gwathmey was born and left only a small death benefit from the railroad. He was raised in an environment dominated by a mother and sisters who contributed to the maintenance of the family welfare and ultimately to Gwathmey's pursuit of a career as an artist. Despite their lack of wealth, the family maintained a veneer of gentility in what Gwathmey called a "middle class neighborhood." He found time to enjoy sports, reading, and fishing with friends and relatives.[4]

In this period of the early twentieth century, racial segregation was hardening in the South, and Gwathmey developed an awareness of class and racial distinctions that he later depicted in his art. "As a youth I was conscious of harsh inequalities in my community," he recalled of his high school years in Richmond, during which he worked in a lumberyard, a florist shop and a department store. The structure of Southern society intrigued but also disturbed him. He remembered hearing Norman Thomas speak when the Socialist leader stopped in Richmond during summer speaking tours. But Gwathmey's interest in social protest proved little more than curiosity during these years.[5]

The 1920s were a critical period for Gwathmey as he developed an interest in art and in the wider world outside the South. After graduating from high school he spent two years as a railway clerk. In 1924 he decided to enroll in a business course at North Carolina State in Raleigh, but after only a year he left and obtained a summer job on an American freighter that took him far from home for the first time. When his ship stopped at major European ports, Gwathmey occasionally took time to visit art galleries and museums. On board ship, he used his free hours to sketch fellow crew members at work. Clearly, this was an influential time in the development as an artist, for when the twenty-two year old returned to the United States he abandoned plans for a career in business and enrolled in the art program at the Maryland Institute in Baltimore.[6]

Whereas his visit to Europe had opened his eyes to a world of culture not widely available in the South, his experience in Baltimore provided him a different vantage point on society in his native region. He later described his arrival in the Maryland city: "When I went to Baltimore to study art, the first thing I saw was Negro policemen and statues of Yankee generals. It was my first trip North, the farthest North I'd ever been, and I was 22 years old." Returning to Richmond from Baltimore allowed him to look anew at his region. "When I got back home," he observed, "I was shocked by the poverty. The most shocking thing was the Negroes, the oppressed segment. If I had never gone back home, perhaps I would never have painted the Negro."[7]

Appropriately for an artist, he remembered his new perspective on Southern society in very visual terms: "I was shocked at the red clay. The green pine trees and red clay were everywhere. The Negro seemed to be everywhere, too. . . . But he was a thing apart, so segregated." While this new awareness of the racial and caste system of the South did not influence Gwathmey's art for at least another decade, it started him thinking about ways of portraying blacks that would avoid quaintness of the kind sometimes found in the works of the nineteenth-century painters Eastman Johnson and Winslow Homer. "The Negro never seems picturesque to me," he later observed.[8]

In 1926, after a year in Baltimore, Gwathmey went to Philadelphia to study at the Pennsylvania Academy of the Fine Arts, one of the most prestigious art schools in the nation. Part-time jobs he held while studying there, including one teaching art at a settlement house in an immigrant neighborhood, gave him a chance to work closely with people from cultural backgrounds different from his own. Summer fellowships in 1929 and 1930 allowed him to travel and to study art in Europe, where he also deepened his appreciation of issues of social class, especially as the effects of the Great Depression were being felt.[9]

Gwathmey's artistic stance at this time reflected the formal training he had received under Franklin Watkins, Daniel Garber, and George Harding at the Pennsylvania Academy. He had not yet settled on the subject matter nor on the distinctive style that he developed in his mature paintings. He remembered the Thirties as a time of economic problems and as a period when he worked to define his own art. "It takes about ten years to wash yourself of academic dogma," he later explained. In 1938 he made an artistic break with his past and destroyed virtually all of his previous work, leaving only those pieces consistent with the themes and techniques he was adopting as his own. One of his earliest surviving works, *The Hitchhiker,* reflects both his new interest in timely social subject matter of the Depression era but also some of the latent artistic influences of Watkins.[10]

From the late Thirties onward Gwathmey's art drew heavily on his life experience, focusing to a great degree on Southern subjects, particularly those revealing the lives of common people and their relationships to others in society. His frequent portrayal of blacks as a group and as individuals has sometimes caused him to be categorized incorrectly as a single-minded painter of racial scenes. In reality, Gwathmey's paintings were explorations of the nature of Southern life and community which often expressed his belief in the dignity of people so often taken for granted. His artistic expressions of the simple beauty of everyday life and labor of blacks and whites were sometimes made more effective by the use of juxtaposition and satire of the dominant class of the region.[11]

During the Thirties Gwathmey taught art at Beaver College near Philadelphia. While teaching did not pay very well and ended in a messy dispute with the college's administration, the position gave him more security and income than many artists had during the Depression and it required him to be in the classroom only two days each week. This schedule allowed him time to travel to New York City, where he absorbed the ideas of and became increasingly active in left wing artistic and political worlds. Although Gwathmey did not depend on government arts projects for his livelihood, he became friends with many artists who were desperate and depended on federal art programs in order to survive. He often traveled to Washington and New York on behalf of government support for cultural projects and became an active member of the Artists' Union movement in Philadelphia. These activities heightened his commitment to social change, particularly in race relations. In the Philadelphia Artists' Union "for the first time I met Negroes on an equal plane," he remembered.[12]

Despite the attraction of northern cities such as Philadelphia, Pittsburgh and New York, where Gwathmey eventually held teaching positions, he continued to be pulled back to and influenced by the South. During the Thirties, he made periodic trips back home to Virginia that caused him to maintain an interest in Southern social conditions that otherwise he might have lost. In 1935 he married Rosalie Hook, an art student from Charlotte, North Carolina, where he retreated after being fired from Beaver College. A Rosenwald Foundation fellowship in 1944 allowed him to spend a year living and working on a North Carolina tobacco farm, where he worked with three different sharecroppers three days a week. Although his schedule was clearly not as backbreaking as that of the men and women with whom he worked, his experience served as a symbolic link between his life as an artist and the world of the South from which he had emerged.[13]

Even though he lived in the North for

most of the rest of his life, he regularly visited the South until his later years to make working drawings or to put final details on canvases. Each trip renewed his interest in Southern social conditions as a focus for his art. In fact, a year spent in Paris during the late Forties proved artistically unproductive because he found it impossible to be motivated as he was when he experienced the Southern environment. "You go home," he later recalled. "You see things you had almost forgotten. It's always shocking." Most disturbing were what he called "the acute blind spots" of his "boyhood friends and associates."[14]

While Gwathmey's style evolved over the years, a remarkable consistency ran through his art for over forty years. Angular, elongated human figures are often found in his paintings; flat planes of color give many of his works from the Fifties onward a feeling of cubism. The major significance of Gwathmey's painting lies in his use of this style to treat social subjects, including the racial and caste system of the South. "When people ask me why I paint the Negro," he observed in 1946, "I ask 'Don't artists have eyes?'" His answer reveals not just a preference for art as social criticism but also a belief that an artist ought to devote himself to recording everyday reality as he sees it. Although his wife was an accomplished photographer, Gwathmey himself believed painting could more effectively convey reality and used photographs only to stimulate ideas he would later develop on canvas. For him, rural blacks were a part of Southern life as he had known it during his formative years. Paul Robeson speculated that "Gwathmey's identification with the South, brought him close to the culture of Africa and its classic sculpture. . . . He succeeded in adopting the elements of African sculpture and adding his own broader conception of social art." Indeed, many of Gwathmey's figures resemble African sculpture, with its accentuated height and angularity. *The Observer* (fig. 1), done in 1960 and one of his most famous works, could just as well be a scene from Africa as from the American South. The influence of black art is apparent. Gwathmey's strength as a painter comes not from photographic realism but from his being a critical observer of life in the rural South and a skillful portrayer of the emotional impact of the images he saw in society around him.[15]

His paintings include two major subject categories. In one group he used satire and caricature as a technique of social criticism. The painting called *Poll Tax Country* (fig. 2) depicts a white Southern orator haranguing from a bandstand. Below him, blacks ignore his speech and go about their work of hoeing. On the platform, lending unspoken support to the racist talk, are five figures: one black—an educator in academic garb—and four whites—a society woman, a clergyman, a hooded clansman, and a man who may be a sheriff or a representative of the poor class of whites who are asked to stand by the upper class racists. On the roof of the speaker's platform is a black crow, a frequent symbol in Gwathmey's art that may depict the pervasiveness and inevitable decay of the segregation system that Southerners called Jim Crow.

Another painting where Gwathmey uses satire and caricature focuses on a single white man. Titled *The Standard Bearer* (fig. 3), this work strikes even more clearly at what Gwathmey saw as the hypocrisy of the Southern political system. The rotund politician holds aloft symbols of justice and equality while at his feet lies a lynching rope, the instrument of the suppression of blacks. At the top of the standard rests the black crow of segregation. Other paintings contain striking uses of satire and caricature. In *Hoeing,* done in 1943, Gwathmey contrasts languid whites on one side of the painting with a young and powerful black laborer who dominates the center of the work.

The second category of Gwathmey's works may be called social documentaries. They occasionally contain an element of

Figure 1 *The Observer,* oil on canvas, 1960, 48-1/8″ × 34″ National Museum of American Art, Smithsonian Institution, Gift of S. C. Johnson and Son, Inc.

Figure 2 *Poll Tax Country,* oil on canvas, n.d., 41″ × 28″ Hirshhorn Museum and Sculpture Garden, Smithsonian Institution.

Figure 3 *Standard Bearer,* oil on canvas, 1946, 33¾″ × 24″ Museu de Arte Contemporânea da Universidade de São Paulo. Photograph by Gerson Zanini.

Figure 4 *Sun-Up,* oil on canvas, c. 1955, 16″ × 11″ Philadelphia Museum of Art, Louis E. Stern Collection.

Figure 5 *Playing,* oil on canvas, n.d., 15″ × 10″ Hirshhorn Museum and Sculpture Garden, Smithsonian Institution.

Figure 7 *Self Portrait,* lithograph, n.d., 26½″ × 23½″, Flint Institute of Arts, Gift of Jack B. Pierson in memory of Robert Martin Purcell.

Figure 6 *The Countryside,* post office mural at Eutaw, Alabama, 1941, 13′4″ × 4′8″, General Services Administration, Public Building Service.

social protest with graphic depiction of the starkness of the lives of Southern blacks. But more often his documentaries focus on the gentle theme of the dignity of Southern laborers and their families as they go about their daily tasks. Among his favorite subjects were men and women at work as individuals or in groups as in *Sun-Up* (fig. 4). The details of his paintings of tobacco and cotton field workers demonstrate a familiarity with the subject matter so that overalls, hoes, buckets, and even weeds in the fields are authentic. He described one painting as "part of a scene I know intimately."[16] His beautiful painting of *Queen Anne's Lace,* which contains no human figures, revealed his concern with carefully documenting the details of nature.

Gwathmey portrayed more than just the work experience. Among his best paintings are those that reveal other facets of Southern life. *Family Portrait* offers a strong statement about the strength of the black family. Music has frequently appeared as a subject of Gwathmey's paintings, as in *Playing* (fig. 5). Some of his most powerful images result from the juxtaposition of a single black figure with an arrangement of flowers. *Portrait of a Farmer's Wife* and *Field Flowers* speak elegantly of the value of natural beauty in the life of the common laborer.

During the late 1930s Gwathmey began to advance in the American art world. In 1938 he became an instructor at the Carnegie Institute of Technology in Pittsburgh and won a competition to hold a one-man exhibition at the American Contemporary Art Gallery in New York City. In 1939 he received a commission from the federal Section of Fine Arts to paint a mural in the post office at Eutaw, Alabama, in the heart of the black belt. Rejecting suggestions of the local postmaster that he depict scenes of the Confederacy and the greatness of Eutaw, Gwathmey toured surrounding Greene County and did a mural called *The Countryside* (fig. 6), which reflect the social reality of the region. It contained three white men, two black men, and focused on the rural laborers of the area.[17]

Gwathmey received his greatest acclaim during the Forties. Galleries and individuals acquired his works as soon as he painted them, and he exhibited at shows that highlighted the best of contemporary American painting, including one organized during World War II by Artists for Victory. In 1942 he moved to a position at the Cooper Union in New York City, where he remained on the faculty until 1968. He called it "the best place in the world to teach—just as New York is the best place in the world for a painter to live." By 1950, when Gwathmey was invited to teach for a summer at the experimental Black Mountain College in North Carolina, he was clearly one of the most influential American artists. Although he continued to exhibit and to win prizes, the increasing domination of Abstract Expressionism during the Fifties pushed Gwathmey's painting out of the mainstream of American art.[18]

Gwathmey's art continued to develop into the 1980s, when a return of critical interest in realism brought him new attention. Although he still exhibited the dual tendencies of social criticism and social documentation, he also occasionally recorded images of the mainstream of American life. Gwathmey did a sequence of paintings on the 1957 World Series in Milwaukee for *Sports Illustrated,* which said the artist "was impressed . . . that much of the crowd [at the games] was comprised of family units, often including grandparents and grandchildren." The sports magazine also described him as having "a positive attitude toward life." Nonetheless, he reflected bitterly in the 1974 social surrealistic painting *Late Twentieth Century* on real and potential violence in contemporary life.[19]

Even though Gwathmey's paintings still recalled his Southern origins, his life became more remote from them. He eventually became a moderately wealthy member of the New York artistic community. "It's fearful to think that today's times are so affluent for me," he told interviewer Studs Terkel in the late Sixties. "I live real well, real well." Today he resides and works at a home and studio in Amagansett, Long Island, designed by his son, the post-modernist architect Charles Gwathmey. Since retiring in 1968 from his position at Cooper Union, where he was an extremely influential and popular instructor, he has been a visiting professor at several universities and received many awards in art and design. He remains active in New York artists' and writers' groups and continues to devote himself to social and political protest; although he recently has been slowed by Parkinson's disease. Throughout his life, Gwathmey was attracted to the social function of art and the artist. His own activities during the Cold War and Vietnam eras demonstrated a willingness to defend unpopular causes. In the middle of the Abstract Expressionist vogue of the Fifties, he deplored what he believed was the meaninglessness of much abstract art. He preferred to portray living things in his art.[20]

Until very recently when Southerners talked about art in their region they most often meant literary art. This dominance of literature has convinced some of today's Southern visual artists that they have no forebears. "We are the first generation of Southern artists," one of them proudly declared. The Southern cultural Renaissance of the mid-twentieth century focused intensely on the decadence and hypocrisy that pervaded Southern society, but it also emphasized the power of the history that Southerners shared. Robert Gwathmey revealed that Southern social history could create remarkable visual as well as literary images. His use of paint and canvas to depict the Southern racial and social system now deserves some of the attention that has been given to Southern writers.[21]

Only once did Gwathmey do a self-portrait (fig. 7). It was a lithograph done for the opening of the gallery of his friend and dealer Terry Dintenfass. Gwathmey, the artist, is seated on the floor with brush or pen in hand. A partially complete canvas rests on its side in front of him. In the room with him is a Southern fieldworker similar to those who appeared frequently in his works. On the studio wall, along with other mysterious and intriguing symbols, he placed the figure of a crow of the kind that rested above the heads of white Southerners in some of his paintings. It is deformed but still recognizable, perhaps an acknowledgement that he, too, carried the heritage of his race and region.

Notes

[1] Thomas Wolfe, *The Story of a Novel* (New York, 1936), p. 21.

[2] David C. Roller and Robert W. Twyman, eds., *The Encyclopedia of Southern History* (Baton Rouge, La., 1979), pp. 80-81; George B. Tindall, *The Emergence of the New South, 1913-1945* (Baton Rouge, La., 1967), pp. 285-317; among the recent studies are Morton Sosna, *In Search of the Silent South: Southern Liberals and the Race Issue* (New York, 1977); Michael O'Brien, *The Idea of the American South, 1920-1941* (Baltimore, 1979); Richard H. King, *A Southern Renaissance; The Cultural Awakening of the American South, 1930-1955* (New York, 1980); Daniel Joseph Singal, *The War Within: From Victorian to Modernist Thought in the South, 1919-1945* (Chapel Hill, N.C., 1982); Fred Hobson, *Tell About the South; The Southern Rage to Explain* (Baton Rouge, La., 1983); Henry Nash Smith, "Fathers and Sons Southern-Style," *New York Times Book Review* (June 1, 1980), p. 12; also C. Vann Woodward, "Why the Southern Renaissance?" *Virginia Quarterly Review,* 51 (1975), 222-239.

[3] Gwathmey quoted in Roland F. Pease, Jr., "Gwathmey," in *Art USA Now,* ed. Lee Nordness, vol. 1 (New York, 1963), unpag. insert between pp. 122-123.

[4] Elizabeth McCausland, "Robert Gwathmey," *Magazine of Art* (April 1946), p. 149; Harry Salpeter, "Gwathmey's Editorial Art," *Esquire* (June 1944), p. 83.

[5] McCausland, "Robert Gwathmey," pp. 149-150; Pease, "Gwathmey," unpag.; Paul Robeson, Introduction to *Robert Gwathmey,* ACA Gallery exhibition catalog (New York, 1946), unpag.

[6] *Current biography: Who's News and Why, 1943,* ed. Maxine Block (New York, 1944), p. 261; Salpeter, "Gwathmey's Editorial Art," p. 83.

[7] Gwathmey quoted in McCausland, "Robert Gwathmey," p. 149.

[8] Gwathmey quoted in *Ibid.*, p. 149-150.

[9] *Ibid; Current Biography, 1943*, p. 261.

[10] Gwathmey quoted in *Current Biography, 1943,* p. 262; Salpeter, "Gwathmey's Editorial Art," p. 131.

[11] Daniel Grant, "Compassion Colored By a Lifetime," *Newsday Part II* (July 22, 1984), p. 4.

[12] Studs Terkel, *Hard Times: An Oral History of the Great Depression* (New York, 1970), p. 373; Gwathmey quoted in McCausland, "Robert Gwathmey," p. 149.

[13] Grant, "Compassion Colored By a Lifetime," p. 5; McCausland, "Robert Gwathmey," p. 150; Terkel, *Hard Times,* p. 374; Pease, "Gwathmey," unpag.

[14] Barbara Delatiner, "'He Paints What Is in His Heart,'" *New York Times* (July 22, 1984), Long Island Section, p. 13; Gwathmey quoted in McCausland, "Robert Gwathmey," p. 150.

[15] Delatiner, "'He Paints What Is in His Heart,'" p. 13; Robeson, Introduction to *Robert Gwathmey,* unpag.; McCausland, "Robert Gwathmey," p. 147.

[16] Gwathmey quoted in College of Fine and Applied Arts, *University of Illinois Exhibition of Contemporary American Painting* (Urbana, Ill., 1951), p. 184. The painting was *The Cotton Picker.*

[17] *Current Biography, 1943,* p. 262.

[18] Quoted in *Ibid.;* Gwathmey turned down the invitation to Black Mountain because of prior commitments. Martin Duberman, *Black Mountain: An Experiment in Community* (Garden City, N.Y., 1973), p. 347.

[19] "Fervor in Milwaukee," *Sports Illustrated* (April 14, 1958), pp. 102-106.

[20] Terkel, *Hard Times,* p. 375; John Hejduk, "Armadillos," *John Hejduk: 7 Houses,* ed. Kenneth Frampton (New York, 1980), p. 4; Grant, "Compassion Colored By a Lifetime," p. 5; Elaine Benson, "Robert Gwathmey, Artist, Gentleman, Political Activist, A Hamptons Favorite, *The Hamptons* (August 1984), p. 13; Robert Gwathmey, "Art for Art's Sake?" Paper delivered at the International Design Conference in Aspen on Design and Human Problems, 1958.

[21] For example, Donald Davidson, "A Mirror for Artists, "*I'll Take My Stand: The South and the Agrarian Tradition* (New York, 1930), pp. 28-60; Bill Dunlap quoted in Mary Lynn Kotz, "The Southern Muse," *ArtNews* (February 1983), p. 78.

PIONEERING WITH PLANS AND PLANTS: H.W.S. CLEVELAND BRINGS LANDSCAPE ARCHITECTURE TO WISCONSIN

WILLIAM H. TISHLER *and* VIRGINIA LUCKHARDT
Department of Landscape Architecture
University of Wisconsin-Madison

Horace William Shaler Cleveland was the first professional landscape architect to practice in Wisconsin. His work in this state preceded that of such better-known colleagues as Frederick Law Olmsted, who designed important parks in Milwaukee; Jens Jensen, who shaped landscapes throughout the Midwest and founded "The Clearing" in Door County; and John Nolan, who developed the proposal for Wisconsin's state park system and planned important public open space projects in Madison, Milwaukee, Janesville, Green Bay and LaCrosse.[1] Yet, relatively little is known of this visionary environmentalist, and he has not received the scholarly attention his accomplishments justify.

During his professional career spanning more than fifty years, Cleveland pioneered significant contributions to the planning, design and management of the land. Not only did he provide an important link between the American West and the fledgling field of landscape architecture beginning in the East; he also was perhaps the most persistent and articulate nineteenth century spokesman regarding the comprehensive scope of his new profession. This activity, as he perceived it, extended far beyond the ". . . adornment of professedly ornamental grounds . . . and the private estates of men of wealth,"[2] to encompass, as he so eloquently wrote, ". . . the art of arranging land so as to adapt it most conveniently, economically and gracefully, to any of the varied wants of civilization."[3]

The descendent of an early New England seafaring family, Horace William Shaler Cleveland was born in Lancaster, Massachusetts in 1814. His grandfather and father had prospered from an active maritime business and, as a young man, Cleveland received not only a formal education, but benefited from his father's broad literary interests and sailing experiences.

At the age of fourteen, Cleveland's family moved to Cuba, where his father became Vice-Counsel. Here, young Horace worked on a coffee plantation, where he learned native mulching techniques that he would later utilize on his own farm and in many aspects of his landscape architectural practice, particularly those concerned with forest management.

Two years later, Cleveland returned to Massachusetts where he took up the study of civil engineering. This training led to employment as a land surveyor in central Illinois and Maine. The Illinois work, starting in 1833, provided his first opportunity to visit the Midwest—at that time a wild, virtually undeveloped frontier.[4] This adventure undoubtedly left a lasting impression upon the twenty-one year old and the area's potential influenced his later decision to move west. After returning to New York on horseback, Cleveland turned to a career in agriculture and horticulture, buying a farm near Burlington, New Jersey, in 1841. During this period he also founded the New Jersey Horticultural Society and served as the organization's Corresponding Secretary.[5]

The combination of experience in civil engineering, agriculture and horticulture served as a springboard for Cleveland's long and productive career in landscape architecture, or landscape gardening as it was known in the 1840's. Returning to New England in 1854, he established an active landscape architectural practice with Robert Morris

Copeland. The two men set up an office in Boston and engaged in work to ". . . furnish plans for the laying out and improvement of Cemeteries, Public Squares, Pleasure Grounds, Farms and Gardens."[6] Seeking the prestigious commission to plan Central Park in New York, they submitted a design for the 1857 competition, but it was not chosen as the winning entry.

Little is known of Cleveland's work during the ensuing decade. However, in 1868, he went to work with Frederick Law Olmsted, the founder of landscape architecture in America, where he worked on plans for Prospect Park in Brooklyn.[7] During this time, the Olmsted office was actively engaged in preparing a new, innovative subdivision layout for Riverside, Illinois, only nine miles from Chicago. This project may have revived Cleveland's interest in the West, developed more than thirty years earlier. In 1869 he established his landscape architectural practice in Chicago. He could now become more intimately involved with new and exciting professional opportunities in this young and dynamic city and also with the rapid development occurring throughout the Midwest.

It was from Chicago that Cleveland, with missionary zeal, worked to extend the frontier of landscape architectural practice into America's heartland. A prolific writer and engaging speaker, he appealed for orderly development of the land and set forth his philosophies of land planning and design in a variety of pamphlets, articles, letters, and his remarkably perceptive book *Landscape Architecture as Applied to the Wants of the West.*[8]

In this publication, he eloquently stressed the landscape architect's social role and responsibility in the newly-developing region, where a surge in homesteading activity and the efforts of railroad companies and land speculators stamped, with mechanical regularity, the gridiron plan upon the land.

By 1871, he had formed a loose partnership with William M. R. French, a creative civil engineer who later became Director of the Chicago Art Institute. Cleveland's work now began to assume important new dimensions and encompassed the design of cemeteries, suburban residential developments, vacation resorts, parks, university grounds and other institutional projects, and the sites for several new state capitol buildings. Their active practice eventually extended throughout the region to include projects in Illinois and Wisconsin, as well as work in Iowa, Indiana, Kansas, Minnesota and Nebraska.

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Fig. 1. Title from a pamphlet advertising the professional services of Cleveland and his civil engineer partner William M. R. French, after they had established an office in Chicago in 1871. (Photo from the author's private collection.)

Cleveland's work in Wisconsin began in 1870—just one year after he opened his Chicago office. At this time, the Board of Public Works of the City of Milwaukee authorized Cleveland, whom the *Milwaukee Sentinel* called ". . . an eminent landscape gardener whose works are all over the country . . ."[9] to prepare plans for a new park in the Seventh Ward, on the city's east side.

His design for Juneau Park, named after Milwaukee's founder Solomon Juneau, was submitted on October 15, 1870, along with lengthy and thorough instructions explaining how the park was to be constructed. The entire communication was of such popular interest that several days later, it was printed in full in the *Milwaukee Sentinel.*[10] The article reflected Cleveland's expertise in implementing all aspects of the project.

The site for this important park consisted of a strip of narrow, steep terrain encompassing the bluff and shoreline along Lake Michigan. Cleveland's plan called for a simple, restrained design that respected the area's indigenous natural features. He noted that

". . . the position and character of the tract . . . confine the whole scope of its possible decoration . . . and yet its features are so peculiar, and comprise so much that is picturesque . . . that no artificial ornamentation was required, beyond the simple development of their natural character."[11]

His design provided for a roadway at the top of the slope flanked with rows of trees and a sidewalk paralleling the upper edge of the bank. At convenient points, informal meandering paths of varying grade and width descended the bluff. Where the slope was favorable, small level landings were to be constructed to accommodate rustic seats. The natural ridges and hollows on the face of the cliff would remain almost undisturbed except for the minor changes necessary in building the paths and planting the beds of shrubbery to be located on the ridges to increase their apparent height.

Along the base of the slope, at a distance of about 20′ from the water's edge, a 3′ high protective wall was to be constructed adjacent to a proposed meandering pedestrian promenade. At appropriate intervals, steps would lead down to the beach. Toward the south end of the park, two or three pools of water were proposed, fed by springs flowing from the sides of the bluff.

In arriving at this solution, Cleveland sought to avoid using a costly series of artificial terraces which would be expensive to maintain, would interupt natural drainage patterns and would not fit in with the surrounding natural scenery. As one study of Milwaukee's architectural history put it ". . . the concern for drainage and shoreline control revealed the advanced ability which Cleveland was able to offer his clients at a time when most landscape gardeners knew little of these issues."[12]

Two years later, in 1872, land for the park was acquired and construction began. However, early in 1900, the adjacent shoreline was filled extensively and the character of the park was greatly changed. Today the park is extremely popular, though with the passage of years, Cleveland's design for the site has been altered to provide for additional landfill, the introduction of the automobile, the construction of a rail corridor and other changes. Historically, it is significant for two reasons: it was Milwaukee's first real park, and it is the earliest example of the work of a professional landscape architect known to exist in Wisconsin.

So progressive and stimulating were Cleveland's planning ideas, that he was frequently sought out as a lecturer. In February of 1872, he was invited to address the Madison Horticultural Society in the Agriculture Room of the State Capitol.[13] The title of his talk "Landscape Gardening As Applied to the Wants of the West," was essentially the same highly-acclaimed address he had given the previous week in both Minneapolis and St. Paul, Minnesota.[14] In it, he emphasized that ". . . Landscape Gardening, or more properly, Landscape Architecture, is the art of arranging land so as to adapt it most conveniently, economically, and gracefully to any of the varied wants of civilization."[15] This may be the first time that the title "landscape architect" was used in Wisconsin by a member of this new profession. He went on to give special ". . . reference to the laying out and beautifying of cities, parks, . . . and other outdoor features, and decried the monotonous results of the widespread use of the gridiron street plan in city after city. He further emphasized the urgent need for setting aside more park areas to accommodate the extensive urban growth he predicted would occur in the emerging Midwestern cities. At the end of the lecture, the Secretary of the Society indicated his hope that Cleveland would come to Madison again ". . . in a professional capacity, for he knew of no city that nature had done so much for and man so little."[16]

A short time later, in the spring of 1872, the Governor of Wisconsin, Cadwallader C. Washburn, and members of his Park Board, called upon Cleveland to help design the grounds of the newly-constructed State Capitol. The Senate had passed an Act in March of that year which gave the Governor authority to appoint a three-member Park Board to see that the Capitol Park was "surveyed, asthetically designed, laid out and platted, and hereafter improved and beautified in accordance with some fixed plan."[17]

A city-wide controversy on the placement of a fence to surround the capitol grounds had begun before Cleveland was called into service, and he started his work in the midst of the turmoil. The squabble began when Governor Washburn proposed extending the fence surrounding the square out to the edge of the streets. A new sidewalk would then be built outside the fence in the space used for horse and wagon parking. This would narrow the streets, dispel the offensive presence of vehicles and provide a more serene pedestrian environment where citizens could ". . .

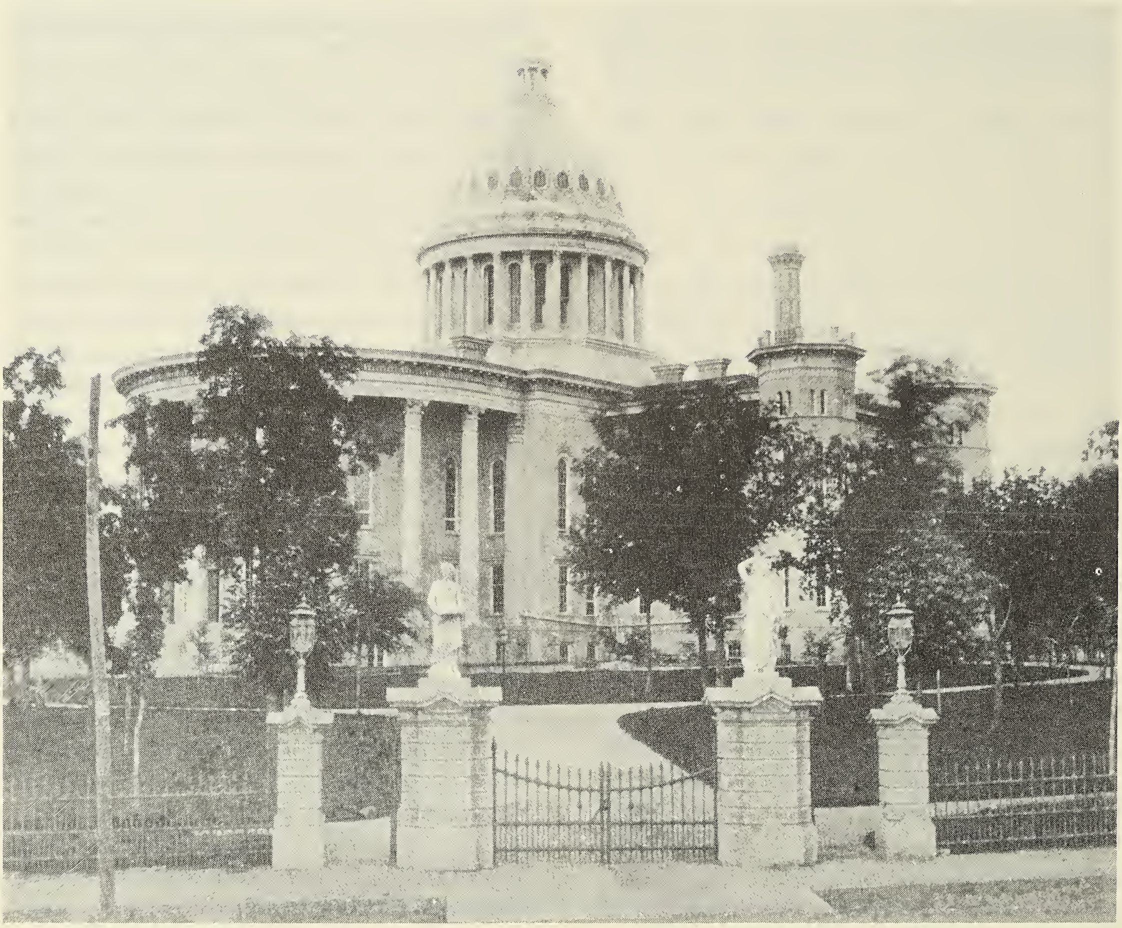

Fig. 2. View of the south-west side of the Wisconsin State Capitol about 1875. The fence and trees reflect the plans and recommendations Cleveland had prepared for the grounds several years earlier. (Photo courtesy Iconographic Division of the State Historical Society.)

escape from the din and turmoil of the streets."[18] After examining the area, Cleveland supported Washburn's proposal noting the ". . . incongruity of an ornamental park surrounded by a stable yard."[19] The following is Cleveland's description of the situation, contained in a letter dated May 1, 1872 to his partner, Wm. French:

"I took the cars for Madison at night and spent yesterday there with the Governor and the committee. The town is or was in a violent state of perturbation in regard to the position of the iron fence and I settled the question in a manner which may subject me to a coat of tar and feathers if I go there again. But I know I am right and they will think so when they see it done and the Governor and committee agreed with me. I have agreed also to furnish a plan of the capitol grounds (12 acres) at $20.00 per acre . . . My visit was a pleasant and gratifying one."[20]

True to his inherent egalitarian beliefs, Cleveland suggested that the capitol grounds become an enclosed park area to be enjoyed by all and separated from the hustle of commercial life on the surrounding square by a see-through Victorian iron fence. His plan showed serpentine walks, a music stand, a summer house, numerous fountains, statuary and urns of flowers and plants. Unfortunately, Cleveland's design was not completely executed. "Only one fountain was built, and the landscaping was confined mostly to trees. Some of the walkways were constructed, but not as many as Cleveland wanted."[21] The square remained essentially a rigidly geometrical setting for the handsome Capital building rather than a "more personalized public space."[22] Ironically, the recent redevelopment of the square captures some of the spirit for the place that Cleveland envisioned well over one-hundred years ago.

Four years later, in August of 1876, President John Bascom of the University of Wisconsin wrote to Frederick Law Olmsted asking him to come to Madison to advise on ". . . the proper position in which we should . . . place our (new) chapel," and ". . . give us suggestions on other points."[23] Regarding other planning for the campus, he went on to say that ". . . we are moving rapidly forward to a first class institution and your work will not be lost."[24] Unable to make the trip to Wisconsin, Olmsted recommended the services of his friend Cleveland ". . . in whose judgement and taste . . . (he had) learned by considerable experience to have much confidence."[25] Unfortunately no correspondence of the University of Wisconsin Presidents before 1886 nor records of the University of Wisconsin Board of Regents between 1867 and 1887 exists. Therefore, it is difficult to verify what became of the chapel building proposal mentioned by Bascom, or whether Cleveland actually worked on the Wisconsin campus. However, Music Hall, originally the Assembly Hall and Library building, was constructed three years later, in 1879, and the possibility of Cleveland's involvement with the site development of this building cannot be ruled out.

Nearly five years passed before Cleveland returned to Wisconsin for another professional commission. In a letter dated November 27, 1881, he stated: "I finished my work last week at Geneva Lake . . ."[26] Another source also briefly notes that he was active in Rice Lake.[27] Both of these commissions were probably for estate grounds.

Although he had as much work as he could handle out of his Chicago office, Cleveland decided to move to Minneapolis. When he left Chicago in the Spring of 1886, this seventy-two year old landscape architect was not moving into retirement, but into his major professional triumph. Here, he helped lay the foundations for the Minneapolis-St. Paul metropolitan park system—perhaps the finest urban open space network in America.

From his new office, Cleveland maintained an involvement with several projects in Wisconsin. In 1887, he was called to Waukesha by Mr. Alfred Miles Jones to lay out the grounds of Bethesda Spring Park—the famous source for medicinal spring water. Jones, a former politician and active entrepreneur, became manager of the area in 1885 and was eager to make improvements so that the Park might become a paying business venture.[28] According to an article in the July 25, 1889 issue of the *Waukesha Freeman:*

"Two years ago . . . (Bethesda Springs Park) was a shady place with good walks and drives, but utterly without system or real beauty. The first thing . . . (Jones) undertook was the better and more tasty arrangement of the park grounds. For this purpose he brought Mr. H. W. S. Cleveland here from Chicago, the gentleman who planned the famous South Park, and this resulted in a complete and systematic survey of the tract . . . (and) a more artistic plan of the shading, drives, walks, and especially of the miniature lake. Facilities were also provided for handsome croquet and lawn tennis courts etc., and right here we may say that the old-fashioned and healthful game of quoits is specially provided for with an apparatus that will no doubt entice many to take it up anew."[29]

After Bethesda Spring Park was rebuilt according to Cleveland's plan, Jones developed it into a popular and profitable recreational spa known widely for the healing qualities of its spring water.

Cleveland's last known work in the State of Wisconsin was in Menomonie in 1892. According to the Proceedings of the Dunn County Board of Supervisors for that year, H. W. S. Cleveland and Son were paid $376.50 for laying out the Dunn County Asylum grounds.[30] The site for this project was entirely barren and Cleveland's plan provided for driveways, footpaths and the planting of some 400 native trees, evergreens and shrubs. An unusual aspect of this project was the appeal he made to farmers in the timbered portion of the county to furnish at least 250 elm, basswood, white ash and box elders from three to five inches in diameter with roots from 15 to 30 inches in length.[31] Cleveland stated "that if farmers would respond to his appeal . . . the asylum grounds would have a selection of trees that could not be excelled."[32]

The most significant surviving feature of his work there is the sweeping entry turnaround in front of the main building. Many of the original trees donated by the local farmers also remain.

In the early 1890's, perhaps because of his advanced age or the beginning of the 1893 financial recession, Cleveland was experiencing a steady decline in work. Yet, he managed to travel to Chicago to see the fruits of his earlier activity in the South Parks and enjoy his friend Frederick Law Olmsted's work at the Columbian Exposition. He later moved back to Chicago, presumably to live with his son's family for his remaining years.

In 1898, his good friend Charles Loring, the distinguished former President of the Minneapolis Park Board, visited Cleveland in Chicago and "found him, in his eighty-sixth year, the same genial, pleasant, unselfish character that he had known for so many years."[33] Loring invited him to write a

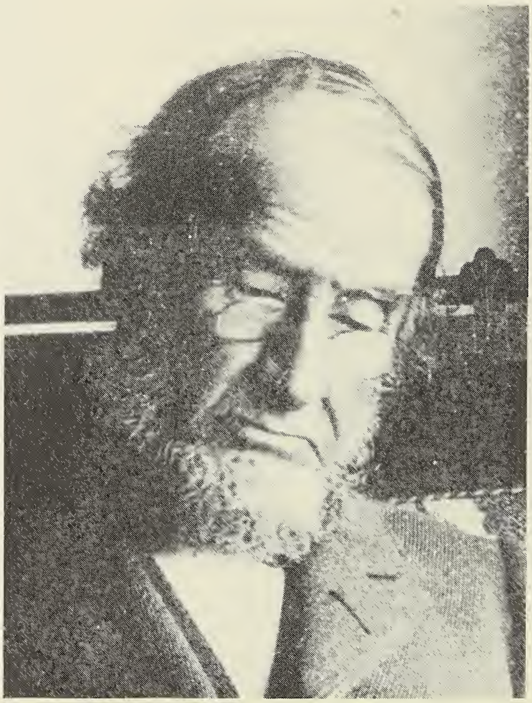

Fig. 3. H. W. S. Cleveland during a reflective moment late in his long and productive career. (Photo from the author's private collection.)

paper for the Park and Art Association convention to be held in Minneapolis. Although he at first declined, Cleveland quickly reconsidered and wrote his last article, "Influence of Parks on the Character of Children."[34]

Cleveland died in Hinsdale, Illinois, December 5, 1900, within a fortnight of his 86th birthday. He was buried in Minneapolis, the city he had grown to love.

H. W. S. Cleveland's long and productive professional life spanned almost the entire last half of the nineteenth century. This period, marked by unprecedented urban and industrial growth, produced great changes in the American environment. Perhaps Cleveland's greatest achievement was his ability to foresee this physical change and develop concepts and plans to deal with it in ways that would enrich the lives of countless Americans.

Notes

[1] Other pioneering landscape architects whose work can be found in Wisconsin include: Franz A. Aust, Annette Hoyt Flanders, Henry V. Hubbard, G. William Longenecker, Annette E. McCrea, Frederick Law Olmsted, Jr., Elbert Peets and Ossian Cole Simonds.

[2] H. W. S. Cleveland, *Landscape Architecture as Applied to the Wants of the West,* ed. Roy Lubove (Pittsburgh: University of Pittsburgh Press, 1965), pp. ix-x.

[3] Ibid. 5.

[4] H. W. S. Cleveland, *The Aesthetic Development of the United Cities of St. Paul and Minneapolis* (Minneapolis: A. C. Bauman, 1888), p. 10.

[5] Theodora Kimball Hubbard, "H. W. S. Cleveland: An American Pioneer in Landscape Architecture and City Planning," *Landscape Architecture,* 20 (January 1930), 94. This was the first comprehensive attempt to examine Cleveland's career and shed light on his many contributions to landscape architecture and city planning—professions that both were in their infancy at the time.

[6] Ibid. 94.

[7] Norman T. Newton, *Design on the Land* (Cambridge: Belknap Press of Harvard University Press, 1971), p. 310.

[8] Originally published as H. W. S. Cleveland, *Landscape Architecture as Applied to the Wants of the West; with an essay on Forest Planting on the Great Plains* (Chicago: Jansen, McClurg & Co., 1873).

[9] *Milwaukee Sentinel,* October 19, 1870.

[10] Ibid.

[11] Ibid.

[12] Landscape Research, *Built in Milwaukee* (Milwaukee: 1981), p. 119.

[13] *Madison Daily Democrat,* February 23, 1872.

[14] *Wisconsin State Journal,* February 24, 1872.

[15] Ibid.

[16] Ibid.

[17] John O. Holzhueter, "The Capital Fence of 1872," *Wisconsin Magazine of History,* 53 (1970), 245.

[18] H. W. S. Cleveland, *The Public Grounds of Chicago: How to Give them Character and Expression* (Chicago, 1869), pp. 15-16.

[19] H. W. S. Cleveland, Letter to Hon. C. C. Washburn, July 6, 1872, Olmsted Papers, The Library of Congress.

[20] H. W. S. Cleveland, Letter to W. M. R. French, May 1, 1872, Olmsted Papers, The Library of Congress.

[21] Holzhueter, p. 248.

[22] *The Capital Times,* June 7, 1977.

[23] John Bascom, Letter to F. L. Olmsted, August 24, 1876, Olmsted Papers, The Library of Congress.

[24] Ibid.

[25] Frederick Law Olmsted, Letter to John Bascom, August 31, 1876, Olmsted Papers, The Library of Congress. On the same day Olmsted also wrote to Cleveland informing him of this correspondence.

[26] H. W. S. Cleveland, Letter to W. W. Folwell, November 27, 1881, Olmsted Papers, The Library of Congress.

[27] *The National Cyclopaedia of American Biography,* ed. numerous authors, 63 vols. (New York: James T. White & Company, 1907), V, 540.

[28] *Waukesha Freeman,* October 20, 1898.

[29] *Waukesha Freeman,* July 25, 1889.

[30] *Proceedings of the Board of Supervisors of Dunn County, Wisconsin: Annual Session: November, 1892, and Special Sessions of 1891-2-3* (Menomonie: Flint and Weber, 1893) p. 11.

[31] *Dunn County News,* April 20, 1983. Original source, *Dunn County News,* April 29, 1892.

[32] Ibid.

[33] Board of Park Commissioners of the City of Minneapolis, *Thirteenth Annual Report* (Minneapolis: Harrison & Smith, Printers, 1896), pp. 25-26.

[34] H. W. S. Cleveland, "Influence of Parks on the Character of Children," Introduction by C. M. Loring, *Second Report of the American Park and Outdoor Art Association* (Minneapolis: 1898), pp. 105-106.

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Carroll College
Waukesha, Wisconsin

On the 8th of May, 1947, the Maharaja of Patiala visited the Viceroy at his palace in New Delhi and voiced the concerns of his people, the Sikhs, concerning the forthcoming partition of their homeland in the Punjab between the Hindus and Muslims. When the Viceroy informed him that there was no way of preventing the forthcoming partition the Maharaja replied:

> Patiala: In that case I greatly fear the Sikhs will fight.
>
> Viceroy: If they do . . . they will have to fight the Central Government; for I and my Government are determined to put down any communal war with a ruthless iron hand; they will be opposed not only by tanks and armored cars and artillery, but they will be bombed and machine-gunned from the air. You can tell your Sikhs that if they start a war they will not be fighting the Muslim League, but the whole might of the armed forces.[1]

So did the last Viceroy of India, Admiral the Right Honorable the Viscount Mountbatten of Burma and cousin to King George VI, promise a terrible response from the military forces under his command. Yet, three months later, as Hindus, Sikhs, and Muslims were killing each other in the Punjab, the group of infantry brigades which formed the Punjab Boundary Force could not fulfill Mountbatten's promise of retribution. Great Britain's failure to ensure a peaceful transition for India from a colony to an independent dominion paved the way for bloody events to come: three major conflicts between India and Pakistan; a bitter religious hatred which includes both Mohandas K. Gandhi (d. 1948) and Prime Minister Indira Gandhi (d. 1984) amongst its list of victims.

What happened? Why did Mountbatten's words count so little in stopping a civil war which left hundreds of thousands of dead and millions of refugees? Why could not the Punjab Boundary Force prevent or at the very least suppress the civil war which destroyed the prosperous Punjab?

The Punjab Boundary Force was the last remnant of the old Imperial Indian Army. The Indian Army in 1947 mustered over 500,000 troops and its existence as a unified force of Hindus, Sikhs, Muslims, and British personnel was threatened by independence and partition. The British element, over 60,000 strong in 1939 would be withdrawn. The British Officer Corp of over 10,000 officers would also leave. Finally, the Muslim contingent, representing 33.8% of the enlisted ranks and 23.7% of the officer corp would be extracted and organized into the new Pakistani Army.[2] Partition meant that a large portion of the army could not be used in any military action until the reorganization was complete. In a paper compiled on the division of the armed forces, the Commander-in-Chief in India, Field Marshal Claude Auchinleck, pointed out that while some infantry battalions and armored regiments were entirely Muslim or Hindu (Sikh included), most were mixed and in none of the formations were all of the officers Muslim or Hindu. All of the units would have to be broken down and gradually rebuilt. His concluding statement made this point: "During the process of division India will be virtually undefended."[3]

India would be "virtually undefended" from any external or internal threat. The only protection India would have consisted of a small reserve of mixed troops to be used in case of emergency. One of those units not communally divided was the 4th Indian (Infantry) Division. The commander was Major General T. W. Rees, and he had been in command for about two years. The division had seen major combat action in North Africa, Italy, and Greece. In late May of 1947, in response to the Governor of the Punjab's pleas for additional troops, the headquaters of the 4th Division and two infantry brigades were ordered to the north. The 4th Indian Division would become the nucleus of the Punjab Boundary Force.

"The whole might of the armed forces" was what Mountbatten had promised to use against the Sikhs should they start civil war. The 4th Division did not represent the "whole might" of the armed forces. However a full strength infantry division would be a powerful arm for the government to use against the violent Sikhs and Muslims. Unfortunately none of the brigades under its command were at full strength. Most of the battalions were at half strength and in the reorganization process the division had lost its British battalions; its artillery contingent had been withdrawn, and both the division's armored reconnaisance regiment and one of its infantry brigades (7th) were omitted from the division's marching orders.[4]

The order of battle, despite the low combat strengths appeared impressive. The Punjab Boundary Force mustered the Headquarters of the 4th Division, the 5th Infantry Brigade, 11th Infantry Brigade, 14th Parachute Brigade, 42nd Lorried Brigade, 114th Infantry Brigade, and the 18th Cavalry Regiment (a tank formation). The five infantry brigades deployed sixteen infantry battalions. They were to police the Punjab, an area with thirty administrative districts of which eleven required "special military measures." The eleven districts alone covered an area of 37,500 square miles with a population of over 14,500,000.[5]

Traditionally, the military was used to supplement, not replace, the civil administration during times of crisis. The massive rioting in Calcutta the previous year had had infantry battalions assisting the police in clearing the streets. The situation in the Punjab was very different from the violence that plagued Calcutta. The population was spread all across the province and while local police corps were responsible for vast areas they were usually understaffed. The police in Calcutta had been reinforced by Gurkha (Nepalese) Gendarmerie and were fairly reliable. The police in the Punjab, who in August numbered over 24,000 constables, began to lose their impartiality under the barrage of propaganda from the various religious communities. Over 74% of the police force was Muslim and as independence approached large bodies of constables began to desert.[6] On the 10th of August, in Jullundar district 7,000 constables fled their posts and demanded safe conduct to Pakistan.[7]

The loss of the police represented the physical disintegration of the civil administration in the Punjab. Troops could not replace police since very few of them were properly trained to arrest or search within the limits set by civil law. Within a week after the first mass desertions by the police (August 14th) the violence in the Punjab changed from peasant armies attacking military units to a campaign of mass terrorism. In the cities, people were being knifed or shot down in the streets or market places. In the countryside, whole villages were burned and scores of bodies littered the ground. The absence of the police meant that troops had to take over safeguarding refugees from attack. The elaborate plans for crushing resistance with the use of tanks and bombers were now irrelevant in stopping the violence.

However, the Viceroy had ordered the

Chief of the General Staff, Lieutenant General Sir Arthur Smith, to send mechanised units to the Punjab:

> ". . . I wished to have tanks, armoured cars, and aircraft used so that the poorly armed insurgent armies would feel that their resistance was futile since they were being mown down without a chance of killing any of the armed forces . . ."[8]

At first, Sikh and Muslim Jathas (battle groups of several hundred or more men) did attack mechanized army units and consequently suffered enormous casualties. In one encounter, an army detachment supported by a tank killed 69 Sikhs, wounded 10 and captured mortars, machine guns, submachine guns, and rifles from the enemy dead.[9] Once the Jathas realized the futility in attacking armored units they stopped, and instead began attacking trains or ambushing refugee columns.

Why were the Sikhs and Muslims killing each other? History reveals that the Punjab, while peaceful during the century of British rule, was a violent region before the British Army arrived in the 1840s. The Mogul Emperors in the sixteenth century oppressed the Sikhs to the extent that their 5th Guru (spiritual leader) led a revolt against the Muslim rulers. Upon his death in 1606, a period of constant war persisted as both faiths fought to achieve martial supremacy. When the Sikhs conquered the Muslims in 1767 their rule was so oppressive that the Muslims in turn rose in revolt. Despite the arrival of the British, religious tensions were exacerbated during the Sepoy Mutiny in 1857. While Muslims joined Hindus in the mutiny the Sikhs remained loyal to the British and had many opportunities to kill rebel Muslims.[10]

A century of peace did not dissipate communal fears as the populations of both faiths (Sikh-Hindu and Muslim) abandoned their homes rather than live under the rule of their new masters. Hindus and Sikhs abandoned over 6.7 million acres of land worth over 5 billion rupees in the West Punjab (Pakistan). Conversely, Muslims abandoned over 4.7 million acres of land worth over 1 billion rupees.[11] The number of refugees, by early October totalled over 8 million people. With the desertion of the police the Punjab Boundary Force had to protect these refugees from attack. Tanks and bombers can make up for any deficiency in numbers when it comes to suppressing poorly armed peasant Jathas. Now the crisis demanded large bodies of troops to protect these refugees. The Governor of the Punjab revealed how weak the P.B.F. had become.

> ". . . I estimated that we should need at least two divisions of full strength and on a War footing—i.e. a minimum of about 20,000 effective fighting men. The effective strength of the P.B.F. is at present about 7,500 or including static troops and training centres about 9,000. . . . Fire power is really less important than numbers."[12]

Sir Jenkins went on the say that neither the railways nor the main roads were safe and that it was impossible to control the village raiding without a great display of force.

Reinforcements were needed: the question was where they would come from. The General Officer Commanding of Eastern Command, Lieutenant General Sir Francis Tuker (and former commander of the 4th Division), sent as reinforcements the 123rd Infantry Brigade (3 infantry battalions), the 1st Mahar battalion, the Headquarters of the 161st Infantry Brigade, and an artillery regiment. Field Marshal Auchinleck also ordered the movement of another infantry brigade and a mixed (tanks and armoured cars) armored squadron to the Punjab but in his report to the Viceroy he stated that no amount of troops could stop the indiscriminate butchery nor could additional reinforcements be sent since the Army was stretched to its fullest extent and it would be difficult, if not impossible to find more troops.[13]

Sikh and Muslim Jathas inflicted considerable losses amongst the packed groups of refugees and every effort to protect them seemed beyond the capacity of the P.B.F. The Intelligence Officer (GSO 1) of the 4th Indian Division, Lieutenant Colonel P.S. Mitcheson, counted between 400 and 600 corpses along a fifty mile stretch of highway and witnessed an ambush against some refugees:

> "In a few minutes fifty men, women and children were slashed to pieces while thirty others came running back towards us with wounds streaming. We got up a tank of 18 Cavalry which killed six Sikh attackers . . ."[14]

Even in refugee columns escorted by troops, refugees (whether Muslim or Sikh-Hindu) were cut down by their attackers. General Rees, in his report described how the Jathas were deployed in ambushing Indian refugees:

> "As the crops were high it was simple to ambush marching columns of refugees. The attackers would remain concealed until the last moment and then pour in a stampeding volley, usually in North-West Frontier fashion . . . In spite of the best efforts of the escorts to hold them together the refugees would scatter in panic; whereupon the ambush parties would dash in with sword and spear. With attackers and attacked inextricably intermingled the escort usually was unable to protect its charges."[15]

It was no safer travelling by train. There were numerous incidents where mobs, as large as 3,000 in number, halted trains and butchered their passengers. Field Marshal Auchinleck reported that over 324 people had been killed in train attacks during the morning hours of the 15th of August. Train crews did not report to duty for fear of losing their lives. Despite the placement of escorts, the mobs would either overwhelm the guards, or worse, the guards would permit the mobs to enter the trains unopposed. On the 22nd of August, the military picket near Khalsa College, Amritsar, and the escort of a Muslim refugee train was overwhelmed by a Sikh-Hindu Jatha. The combined unit (2 officers, 2 NCOs, and 27 enlisted men) expended all of its ammunition before being overrun.[16] All of the refugees were either killed or injured. On the early morning of the 1st of September when a refugee train arrived in Ampala, the escort of 1 NCO and 14 enlisted men permitted a Hindu mob to attack the train. Over 183 people were killed. When the 2/1st Gurkhas[17] arrived, the escort was put under arrest.

A major fear was that communalism would affect the troops of the P.B.F. Apparently it did not occur to high ranking commanders that troops who might have originated from the Punjab were unlikely to remain impartial after seeing their homes burned or their families murdered. Of the troops in the twenty-three infantry battalions in the Punjab Boundary Force: 20% were Sikhs, 25% were Hindu, and Muslims the remaining 55%. Almost all of the Sikh personnel originated from the Punjab and a majority of the Muslim troops were Punjabi Muslims. An officer in a brigade headquarters noted that many Sikh troops had asked for help for their families marooned in Pakistan while many Muslim troops had families trapped on the Indian side of the province. In a telephone report from General Rees on the 11th of August, he reported (optimistically) that the troops were unaffected by the communal tension. Field Marshal Auchinleck did not share his optimism. He commented to Rees' statement, "troops are unaffected" with the question "How Long?"[18] Reports began to arrive at Supreme Headquarters that Hindu or Sikh officers and men were becoming unreliable. It required the direct intervention of British officers before the troops would open fire on mobs of their own faith. Muslim officers and men also become reluctant to shoot their own kind. Open mutiny was considered a serious possibility.[19]

When it became evident that the P.B.F. was no longer an effective military force the Partition Council decided to dissolve the force and allow the armies of both Dominions to accept responsibility for escorting refugees. On the 1st of September, 1947, the Punjab Boundary Force was officially disbanded. The last Indian Army units under British command came under Indian (Hindu) or Pakistani Army control.

The P.B.F. faced major difficulties that were not foreseen by the Supreme Command. Its problems included: Army battalions which were understrength; mechanised units unable to adapt to their new duties; communalism; lack of training to handle police duties. These were major problems that affected the Punjab Boundary Force. How could the Viceroy's Government have acted differently in preventing this disaster?

A larger military force would have eased some problems. The P.B.F. mustered seven infantry brigades, a tank regiment, air and artillery support. It is questionable whether the force reached 55,000 troops but it is likely the conclusion would have been the same. Thousands of troops were needed to pacify the Punjab. Had the P.B.F. and the police been at full strength, they would have mustered 79,000 men (55,000 troops, 24,000 police) to police an area (the eleven districts requiring "special military measures") covering over 37,500 square miles. That would be a ratio of two men per square mile. In comparison, the population of 14,500,000 would average 386 people per square mile. The actual number of troops and police deployed were 17,000 (9,000 troops, 8,000 police) or a ratio of two men per five square miles.

With the disintegration of the police and the collapse of the civil administration the number of troops needed to keep order were immense. To appreciate how understrength the P.B.F. was one can look to another British Colonial post that was plagued by civil war: Palestine. Palestine covered an area of over 8,000 square miles. There were 70,000 troops and 5,000 police guarding the Colonial administration in 1947 and the ratio was nine men per square mile.[20] Yet the Army was unable to suppress the Irgun, the Jewish terrorist army which harassed and bombed the British Government in Palestine. To equal the commitment in Palestine the Supreme Command needed to deploy over 300,000 troops to achieve an equal nine men per square mile ratio.

Did the Viceroy and his council really believe that seven brigades were sufficient to suppress the civil war? Was the Governor of the Punjab negligent in informing New Delhi of the serious situation in the province? On the contrary, Sir Evan Jenkins, the Governor of the Punjab, informed the Viceroy's Chief of staff, Field Marshall Lord Ismay of the need for more troops. Sir Jenkin's army advisor had told him that it would require four operational divisions (i.e. at wartime strength) with an army headquarters to deal with the civil war. The Punjab Boundary Force had seven weak brigades and a divisional headquarters to execute its duties. Lord Ismay felt he could speak for the Viceroy and concluded that the appeal for additional troops had no merit to be reviewed by the Viceroy and it never reached his desk. While Ismay had been Chief of the Imperial General Staff under Prime Minister Winston Churchill, it was the Viceroy and not he who had the last word in any major decision. Still, Mountbatten took no action to countermand Ismay's decision nor was there any record of a reprimand by the Viceroy either in Ismay's memoirs or in Mountbatten's personal log.

Ismay had turned down Sir Jenkin's request for more troops on the basis that there were none available. Great Britain was no longer at war. It is true that Great Britain was war weary and military garrisons were deployed in Palestine and Western Europe but reserves were available. 1947 was a year when troops were withdrawn from occupation duties and reserve battalions from the Territorial Army were demobilized. In Palestine alone, seven infantry battalions and an armoured regiment were withdrawn and returned to Great Britain. Five of those seven battalions were demobilized by October, 1947, after the War Office had ordered all line regiments to demobilize to battalion strength.[21] They were a potential pool of reserves that could have bolstered the understrength formations in India but neither the Viceroy nor his generals considered petitioning the War Office for reinforcements.

There was also the British Army in India. The Army in India was weakened due to peacetime demobilization and while many of the troops and officers were recent conscripts or newly commissioned they represented a formidable military force. According to the accords set by the British Government, the British contingent in India would after 15 August no longer be used in suppressing communal affairs. Thus these troops were available for other duties. The British contingent deployed six independent brigade groups, twelve independent infantry battalions, four armoured regiments, and other support units.[22] Four infantry divisions equal forty infantry battalions, four armoured regiments, and other support troops. The British Army in India plus the reserves from Palestine would have fielded a force of thirty-seven infantry battalions and five armoured regiments. However, the entire British contingent in India and the reserves from Palestine would still not have brought the Punjab Boundary Force to a force of 300,000 troops.

If there was no solution militarily, what other alternatives were available to the Viceroy's Government that could have averted the civil war?

The Sikhs of the Punjab had the most to lose from the partition of their native homeland. They are a small, religious, tribal people who, during the course of history produced disciplined warriors who fought off many invaders. After the British Army crushed the Sikh forces at the end of the 1840s the sons of those earlier warriors enlisted in the ranks of the Imperial Colonial Army to continue the tradition inherent in their religious-military society. With the end of British rule the Sikhs realized that the Viceroy's Government had made no provision to protect their interests in the Punjab. Partition would place over 50% of the province in Muslim hands. Many religious shrines and temples, including the birthplace of their first Guru (teacher) would be defiled by Muslim Pakistani control. The Sikhs responded to this potential blasphemy by waging total war against the Muslims. The Sikhs maintained a small but efficient army which evenly matched the larger but less disciplined Muslim League National Guards. In Amritsar district alone, by 25 August nearly 100 Muslim villages were attacked by Sikhs while only 7 Sikh villages had been attacked by Muslims. In one case a Muslim village of 350 people was attacked by a Sikh Jatha (battle group); there were only 40 survivors.[23] General T. W. Rees commented that the organization of the Sikhs was superior to the Muslim League National Guards and that:

> ". . . both during and after the war there had been heavy smuggling of modern arms into India . . . The Jathas therefore possessed hard cores of skilled fighters armed with rifles, grenades, tommy guns and machine guns. Although the Punjab Mussalmans (Muslims) also possessed firearms and trained men . . . they lacked the cohesiveness of the Sikhs."[24]

Had the Sikhs not been abandoned by the British and had a plan been conceived ensuring that some of the Sikhs' demands could be met the religious hatred might have been mitigated. Throughout the official papers of the Viceroy's Government and including Mountbatten's personal log there is not a single mention of an attempt to assist the Sikhs nor a plan to ease the agony over the partition of their homeland.

Why did not the Viceroy's Government commit the available British Army units in India to the Punjab? The transition of power on the 15th of August meant that British troops were no longer part of the Indian Army, but the Punjab Boundary Force was the last *Imperial* Indian Army force still under direct British control. The P.B.F. commander did not hand over his command to a native Indian (or Pakistani) Army General nor did lower ranking British Indian Army officers relinquish their commands to equivalent native Indian Army officers. The P.B.F. was under the supervision of the Commander-in-Chief in India, Field Marshal Auchinleck, who, in turn, reported directly to the Viceroy. Neither the Hindu Indian nor Muslim Pakistani civilian or military authorities had any jurisdiction over the Punjab Boundary Force. There would have been no problem in placing British troops under P.B.F. control. Why was it not done?

The Chief of the General Staff, Lieutenant General Sir Arthur Smith, issued a secret Army directive dated 29 July 1947 for all British Army officers in command from Battalion level to Army level. No more than sixty British officers ever saw this directive. It dictated that under no circumstances could British Army units be used in suppressing communal riots to save native Indian lives. The only exception was in situations where British lives were in danger.[25] All copies of his directive were to be destroyed and no native Indian Army officers were to gain access to the directive. Both Field Marshal Auchinleck and the Viceroy knew of its existence. Both could have overriden the "no circumstances" policy since they had the authority to commit British troops to the Punjab. While defendants of British policy could argue that it was not proper to shoot one's hosts, i.e. citizens of the new India and Pakistan, at the same time it also meant that the Viceory's Government would not sacrifice the lives of British troops to save the lives of thousands of their former crown subjects, i.e. the Indians.

The Punjab Boundary Force had to stop the civil war with its own limited resources and without reinforcements. The P.B.F. was sent to the Punjab to support the civilian government of Sir Evan Jenkins. When the government collapsed was it not the responsibility of the Army to assume control of the government and declare martial law? Was Sir Jenkins negligent in reporting the state of the government in the Punjab to the Viceroy?

The P.B.F. was a peacekeeping boundary force, not a group of heavily armed and mechanised police. Neither was it an army of judges, lawyers, or civil servants nor was it ever meant to be one. When the military declares an area to be under "Martial Law" the military judicial system integrates with the civilian judicial system. The reason is that the military judicial system deals with violations of Military Law, not civilian law. While certain rights and privileges under civilian law are suspended during martial law the civilian courts still try and convict civilian miscreants under the established procedures of civil law. Both Sir Jenkins and General Rees advised against the declaration of martial law. In his report of 4 August, 1947, Sir Jenkins wrote:

> "We are not at present dealing with a situation in which Troops can act decisively- . . . There is no short-cut by Civil or by military procedure; for neither a Civil Governor nor a General administering Martial Law can properly shoot innocent people merely because they . . . live near the scene of an outrage."[26]

Martial Law was useless since without an existing civilian court system there was no way for military officers to legally convict and sentence people for crimes that were not applicable under Military Law or nor to establish criteria for criminal convictions that met civilian requirements.

If martial law could not be declared then how could the Punjab Boundary Force deal with the civil war? Did not the Governor, Sir Evan Jenkins, inform the Viceroy of the impending collapse of the government? Indeed, he had informed the Viceroy that not only the civilian administration was collapsing but also that the police was becoming scandalously corrupt and negligent, and discipline was disintegrating. The courts were unable to convict felons since magistrates refused to sentence law breakers of their own faith. This report was sent to the Viceroy on the 25th of June, 1947. Mountbatten had five weeks to prepare for the upcoming state of chaos and yet nothing special in terms of orders or personnel was prepared to counter the collapse of the civilian government.

A prosperous province was laid waste and old religious hatreds were reawakened in a civil war which brought nothing but death and destruction to its inhabitants. While the victims were Indian, key Government leaders were British. The Viceroy, most of his staff officers, most of the provincial governors, and all of the Senior Army officers were British. With the withdrawal of British sovereignty these people no longer had a future in the new India or Pakistan. Mountbatten personified that feeling. Mountbatten had been anxious to set a time limit in his appointment since he feared that he would lose seniority by his appointment to India and that being the last Viceroy would not count favorably towards promotion.[27] Over 10,000 British Indian Army officers, 1,600 British Indian Civil Service officials, and 50,000 civilians faced a future in which Indians, not British, would be the rulers. Very few were willing to be part of the new India's future. Sir Evan Jenkins, in his report to the Viceroy dated 16 April, 1947 read:

> "Every British official in the I.C.S. and I.P. (Indian Police) in the Punjab including myself, would be very glad to leave it . . . no British official intends to remain in the Punjab after the transfer of power. Six months ago the position was quite different"[28]

The civil war had a major influence in the decisions of these men, but the feeling was similar in the British Officer Corp. Out of 11,400 officers in the pre-partition Army, 8,200 were still serving in the ranks by Independence. Yet fewer than 2,800 volunteered to remain with their units in the new Indian and Pakistani Armies. Many of these officers could not accept the lack of a British Indian Army.[29]

Mountbatten personified the withdrawing British by his lack of proper direction, organization, and preparation in the creation of the Punjab Boundary Force. Mountbatten's failure to deal with the Sikhs meant that there was no peaceful option to prevent the civil war. Mountbatten's failure to assert his privilege as Viceroy and countermand the secret Army directive forbiding British troops to save Indian lives crippled the P.B.F. in its attempt to find reinforcements. Defenders of the Viceroy may argue that the P.B.F. was no longer under British Army control but that argument is invalid since the evidence indicates the P.B.F. was still under British, not Indian or Pakistani, control.

The Punjab Boundary Force was not a special army that was sent to reinforce the formations already in the Punjab. Rather, it was a title conferred on formations already deployed in the Punjab. There was no consideration concerning the religious composition of the troops, the weak formation strengths, the imminent collapse of the Punjab Government, nor contemplation of an alternate plan in mustering army reinforcements for the Punjab (aside from mobilising the British Army units in India). Proponents defending the Viceroy could argue that Mountbatten did not know of the situation in the province nor have any control in the Boundary Force's mandate. However, the evidence suggests otherwise. Mountbatten was updated every week by the Governor and he personally visited the devastated areas. The intelligence was accurate, its analysis of the forthcoming violence precise, but the Viceroy's Government chose to ignore or reject it.

The civil war in the Punjab was perhaps unavoidable but the British Government did little to mitigate the consequences. Instead of preparing for the worst in the Punjab, Senior Government and Army officials were concerned about the unknown future that lay before them. It was understandable that to have one's career swept away by Independence was traumatic but these men forgot one important thing: their duty. Their negligence permitted 8,000,000 people to become refugees and over 200,000 (some estimates total 600,000) people to lose their lives. Perhaps no sizable body of troops could have suppressed the civil war, but the Viceroy and his generals did not attempt to find additional reinforcements (e.g. from Britain). Instead they did only what was absolutely necessary in crushing the civil war. Unfortunately it was not enough to mitigate the tragedy in the Punjab nor prevent the failure of the Punjab Boundary Force.

Notes

1 Nicholas Mansergh, *The Transfer of Power in India 1942-1947.* (Her Majesty's Stationary Office, London, 1981, Vol. X), 686.

[2] Lorne J. Kavic, *India's Quest for Security.* (University of California Press, Berkeley, 1967), 82.

[3] Nicholas Mansergh, *The Transfer of Power in India* 1942-1947. Vol. X, 1008.

[4] G. R. Stevens, *Fourth Indian Division.* (Mclaren and Son Ltd., Toronto, 1948), 403.

[5] Ibid., 405.

[6] S. Gurbachan Singh Talib, *Muslim League Attack on Sikhs and Hindus in the Punjab 1947.* (Shiromani Gurdwara Parbandhak Committee Amritsar, 1950), 73-74.

[7] G. R. Stevens, *Fourth Indian Division*, 408.

[8] Nicholas Mansergh, *The Transfer of Power in India* 1942-1947. Vol. X, 828.

[9] Ibid., Vol. XII, 704, 735.

[10] H. V. Hodson, *The Great Divide.* (Hutchinson of London, London, 1969), 18.

[11] Penderel Moon, *Divide and Quit.* (Chatto & Windus, London, 1961), 270.

[12] Nicholas Mansergh, *The Transfer of Power in India 1942-1947.* Vol XII, 702.

[13] Ibid., 737.

[14] G. R. Stevens, *Fourth Indian Division.* 408.

[15] Ibid., 406.

[16] Francis Tuker, *While Memory Serves.* (Cassell, London, 1950), 483.

[17] 2nd Battalion, 1st Gurkha Rifles (Regiment).

[18] Nicholas Mansergh, *The Transfer of Power in India, 1942-1947.* Vol. XII, 667.

[19] Francis Tuker, *While Memory Serves.* 448-449.

[20] Gregory Blaxland, *The Regiments Depart.* (William Kinger, London, 1971), 49.

[21] Ibid., 8.

[22] Ibid., 20.

[23] SIKHS' "JUST RIGHTS," *The Times* (London), (August 27, 1947), 4.

[24] G. R. Stevens, *Fourth Indian Division.* 406.

[25] Nicholas Mansergh, *The Transfer of Power in India 1942-1947.* Vol. XII, 625-626.

[26] Ibid., 526.

[27] Michael Edwardes, *The Last Years of British India.* (World Publishing Co., Cleveland/New York, 1963), 156.

[28] Nicholas Mansergh, *The Transfer of Power in India 1942-1947.* Vol. X, 283.

[29] H. V. Hodson, *The Great Divide.* 416.

THE GREEK DOCTRINE OF ETHOS MANIFESTED IN THE PYTHAGOREAN AND EQUAL TEMPERAMENT INTERVALS IN THE TERTIAN HARMONIC SYSTEM OF THE TWENTIETH CENTURY AND SOME SOCIAL IMPLICATIONS

PETER AYER
UW Center-Washington County
West Bend

Since music is an eternally present mode of human expression, it follows that certain factors which governed the human response to music over 2,000 years ago may still be operable today given the premise that both music and man are the result of particular natural phenomena with some common origins.

It is part of the theoretician's task to explain not only the conventions and practices inherent in music but to examine and explain the origin, logic and paideutic reasons for them. If the following ideas seem to develop into a tacit defense of the tertian system, it should also be borne in mind that there is no implicit rejection of any other system.

The fact that one can rarely turn on a radio randomly tuned at any time and hear anything but music consisting of melodic and harmonic material derived from the most traditional tonic and applied dominant tertian sonorities, seems to indicate that there may be some cosmic or at least terrestrial physical phenomenon governing this state of affairs. Notwithstanding the existence of a few stations specializing in the classics or the esoteric, the preponderant musical fare traveling the air waves is tonal and based on the system derived from Zarlino's "harmonia perfetta" further refined and codified by Rameau's fundamental bass and theory of invertibility and subsequent functional harmonic principles.

The Pythagorean ratios and consequent intervals were known long before the harmonic age, and it is a curious fact that it took so long, nearly 2,000 years for the tertian system to evolve and assert itself as the predominant organizing factor in harmonic structure.

A possible reason for the late emergence of harmonic polyphony was the fact that the ear of the ancient musician seemed to be much more perceptive of subtle melodic variations, variations consisting of all the possible combinations of melodic intervals within the Greek Greater Perfect System of a 15 tone-2 octive diatonic sequence. Some of these intervals may have been lost to modern usage. Other authorities on Greek music state that the tones within the tetrachord could be fixed by any one, two, or three of an infinite number of intervalic possibilities and while Pythagoras advocated the fixing of these intervals by mathematical proportion, Aristoxenus asserted that the *ear* should determine the proper placement. Nonetheless, with the infinite number of *melodic* possibilities available, perhaps the ancient ear was not seeking additional complexities of sound.

The Greek modes, while still not very well understood by contemporary musicologists, seem to have been constructed from sets of intervals which were not arbitarily determined but were derived from observable, or rather, experienced phenomena. It can be reasonably assumed that the interval encompassing the tetrachord of the Greek system was easily derived from and observed as the ratio 4:3 since this interval can easily be produced by damping a vibrating string at appropriate nodes i.e., the second and third which produce the third and fourth partials of the overtone series.

It is still not certain if the whole and half-tone intervals within the tetrachord were the 9:8 and 16:15 ratios we use today in the diatonic system. That the intervals used were probably derived from the upper partials seems reasonable.

Although the production of partials above the 9th, 10th, 12th and 16th are difficult to produce on a single string, it is probable that the smaller interval, the 16/15 ratio semi-tone, was accepted as a logical extension of the series. It also was needed to complete the sequence of proportions necessary to the perfect octave.

Much has been written about the supposedly vast differences between the harmonic conventions of western music and those of other cultures which do not share the use of the tonic-dominant tertian system. However, these differences are not so great as they seem when it is taken into account that many of the so-called microtones and intervals less than the 16:15 semi-tone are actually inflections, or a sort of musica ficta, as it were, and embellishments of a subtle nature too slight to lend themselves to precise notation. Certain oriental instrumental music while employing a rather diverse set of scale intervals at the same time uses drone string accompaniment of perfect 5ths and major thirds.

To think that the tonality of the tertian system has run its course and is ready to give way to a new atonality or new tonal system is to deny the cosmic nature of the harmonic series and man's natural response to it, whether he understands it or not.

The acceptance of the perfect 5th as the first harmonic interval (the octave not qualifying as an harmonic interval since it does not progress) appears to be the result of the universal nature of its occurrence in the harmonic series. The series will occur in a string set in motion in Siam, Bangkok, and Calcutta in precisely the same way it will in Madrid, Berlin, or Chicago. Its cosmic nature is as certain as that of the color spectrum which will result when light is passed through a prism in the orient or the occident.

Vocal music of primitive cultures employs intervals of the harmonic series through the sixth partial quite extensively and perhaps was doing so at a time when the polyphonic composers of the 13th and 14th centuries were still reluctant to allow the 5:4 major third to occur in a final cadence. Why were composers so long in accepting these consonances and why was tertian homophony so long in arriving? And since its arrival and full acceptance in the 16th century why was there such an active movement to reject it in the early 20th century?

There are in use throughout civilization intervals of the major and minor third for practical applications. Consider the train whistle and the auto and truck horn. These devices are usually tuned to a major or minor third, never a perfect 5th or 8th. The sound of the WW II CD warning siren was distinctive for its minor third interval. Why not an augmented 4th? Certainly the dissonance of this interval would have carried a note of alarm. However, the affinity of the human ear for the third interval seemed to give it a priority over the more dissonant interval even for such drastic uses.

Natural tonality needed some adjustment in the 17th and 18th centuries, not because there was anything inherently wrong with it, but because of the limitations of the keyboard in accommodating a circle of pure fifths. A vocal ensemble singing perfectly in tune starting in the key of A and modulating through the eleven remaining keys through a circle of absolutely perfect fifths will, upon returning to the key of A, be only 6 cps sharp (446/440). This translates to only ½ a cps per key and few pieces progress through more than 3, 4, or 5 in the standard repertoire. Many choral directors would be happy if their choruses, performing a lengthy work modulating through three keys ended up within 1½ cps of the starting pitch on page one. Given the differences between individual tone quality and vibrato of most voices in a mixed chorus, this discrepancy is hardly noticeable. (and, it might be added, preferable to *some* vibratos) Disregarding for the moment the practical discrepancies of the pure and tempered intervals, there is room for consideration of the harmonic series on the basis of its universal appeal to the human ear. The first eight partials of the series contain the essentials of the tertian system. The primary harmonic progression I-IV, V-I, IV-V, embody the logic contained in the return to the fundamental of the third and fourth partials, second and third partials, and the 7th and 8th, although the stepwise progression IV-V is not precisely the 8:7 ratio but rather the 9:8. However, it *is* possible that the tertian system is not as closely linked to the diatonic major scale as is customarily thought. The diatonic scale is derived and constructed from the series in a manner which suits its own melodic purposes. But, the triad 4:5:6—the harmonia perfetta, is inherently logical, being an integral and contiguous part of the series, and hence, its universal appeal.

The ethos of Greek music was exclusively related to melodic structures and never to the harmonic aspect since, to the best of our knowledge, all music of the period was monophonic. More specifically, melodies of Greek music supposedly each had their own peculiar ethos or power to act upon man's sensibilities in such a way as to affect his character or ethical behavior. To what *extent* a person was thought to be affected or simply emotionally responsive is not altogether clear, although the *manner* in which they were affected was carefully defined.

The ethos of a melody was dependent on three factors: mode, genus, and rhythm. In our time, it seems that another factor, harmony, enters the picture. One should probably not discount one other factor which has crept into the picture in the decades since WW II—electronically induced volume, a dimension which, in many instances, tends to obscure melody, harmony, and rhythm and may even have an ethos of its own.

Now if we are to ascribe ethos to any of the musical sounds of the contemporary scene we should isolate those musical sounds which seem to be most natural, or the result of natural phenomena rather than those which have been contrived, since Greek melodies were constructed from supposedly natural scales—or at least scales derived from natural proportions.

The scales of Didymus, Pythagoras and Ptolemy are all derived from certain proportions and ratios found in the harmonic series but none of them are from a sequence of *contiguous* tones in the series. Consequently, the ear seems not to perceive these as natural as the triad since the triad *does* occur in natural contiguous order.

The acceptance of harmonic intervals occurred chronologically in precisely the same order as their occurrence in the series. If this process continues, and there is no reason to believe it will not, intervals smaller than the minor 2nd may become accepted as harmonic as well as melodic intervals.

A composition in traditional tertian harmony is now thought of as in one or the other of the only two harmonic modes left to us in popular use; major and minor. Melodic structures are born of these two primary tonalities and the three forms of the minor mode available to us do little to effect the overall harmonic impact of minor sound. That is to say, the triads derived from the different modes are identical. The minor triad cannot be found in the series at *all* in *contiguous* form, only by omitting certain tones 10-(11)-12-(13-14)-15, etc. Therefore, it might be thought that the minor triad is more a child of a contrived scale than an integral part of the natural series.

Redfield, in "Music: a Science and an Art," says, "for purposes of melody alone, it is probable that one scale is as good as another—and the various scales that have arisen at different times the world over prove conclusively that the human ear can learn almost any kind of scale."

Consider the probability of a scale such as the one in figure 1 resulting from the experiments of a fictitious ancient musician.

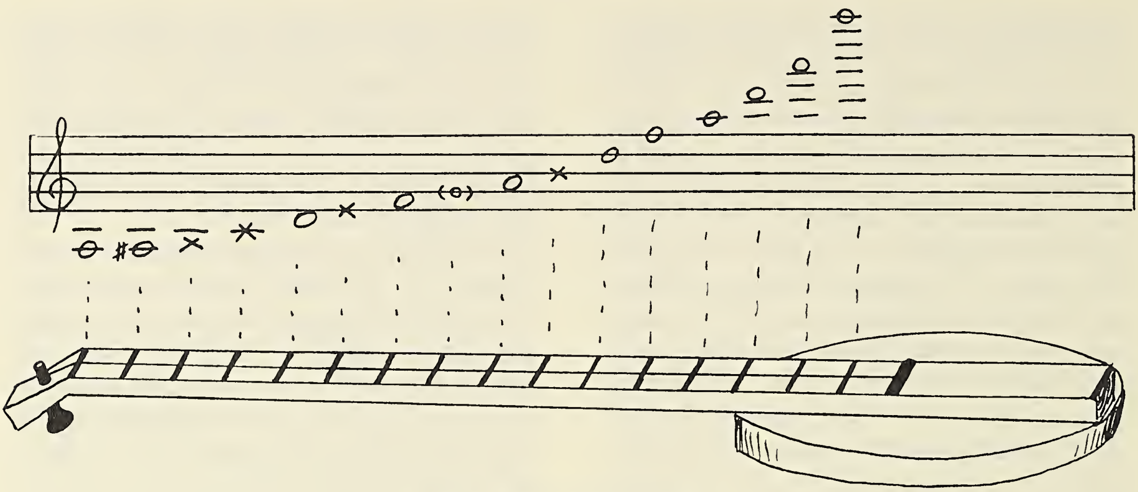

Fig. 1 The ancient thrmbl

Given man's predilection for symmetry in other art forms, it seems not improbable that someone at some time attempted constructing a scale or sequence of tones for melodic purposes by this method of equipartition.

Kathleen Schlesinger discussed scales of equipartite spacing in "The Greek Aulos," published in 1939. For the purposes of this discussion, a fretboard on a single stringed instrument serves as an example.

Stopping the string on frets spaced *equal* distances apart produces certain tones which can be used in our present diatonic system and some that cannot. It is also apparent that such a spacing produces a series which is *identical* to the *natural* series; but inverted! It is also apparent that the *minor* triad occurs here contiguously. Could not some theorist, a counter-part of Zarlino's, say, studying this series, have declared the *minor* triad the "harmonia perfetta" on the ground that it *does* occur in a natural sequence of tones in this inverted series? That someone did not is probably due to the fact that an equipartite spacing does *not* produce a *natural* series, a natural series always generating from the fundamental, and *only* occurring in a medium left to freely vibrate in a manner not affected by outside influences (such as arbitrarily placed frets.)

The question now arises: what can the discrepancies between equal temperament intervals and pure intervals have to do with ethos, if indeed there is any such thing, in this day and age?

In the first place, few people today are aware of the sensations of pure intervals. Nearly all popular and commercial music is heard in conjunction with keyboard harmonies and a great deal of the concert repertoire is associated with equal temperament. In fact, there are so few opportunities to hear purely tuned intervals that the listener must rely on other dimensions for the ethos experience.

Some of the discrepancies existing between equal temperament and true porportional tuning can be seen in figure 2. The 16/15 Pythagorean semi-tone cannot be used to construct a chromatic (12-tone) scale. Nor can the 9:8 whole tone.

There does not appear to be a name for the discrepancy between the octave derived from twelve 16/15 semi-tones and a pure 2/1 octave. Since the difference between four perfect fifths and two octaves plus a major third is distinguished by the name "comma of Didymus," perhaps this other difference could be called the "comma of La Crosse," or "West Bend," the discrepancy being greater than that of Didymus and therefore deserving of a name.

At any rate, singing an ascending chromatic scale starting at A220 and continuing through 12 pure 16/15 semi-tones will result in an octave nearly 1½ semi-tones sharp. We do much better with the 9/8 whole tone scale, the resulting octave in this case is identical to the octave derived from the circle of pure fifths, 6 cps sharper than A440.

It seems the closest we can come to a 12-tone chromatic scale within an octave using true natural proportions is to use the 18/17 semi-tone. This, however, gives us something short of a perfect octave. Curiosity compelled the investigation of a proportion which would come close enough to give a semi-tone accurate enough to produce a true octave—or at least one true enough to have practical use—the result was a highly impractical 180,000:169,897 giving a factor of 1.0594654 (23 ten millionths greater than $12\sqrt{2}$).

Certainly the tables in figure 2, with the exception of the last column, are familiar to everyone. The similarities and discrepancies between the other columns have been dealt with many times.

The point of these observations is that since ethos was manifest in modes and intervals of pure and natural origin, then it should *presently* be manifest in phenomena of natural origin. In spite of the fact that triads of the tempered system are no longer pure, they still originate from—that is—their tertian *essence*—originates from a purely natural phenomena.

If music is to merely *reflect* man's condition, then we need not be concerned with its ethos at all. On the other hand, if it is to exert some manner of influence, then should it not embody that essence most likely to result in an ethos to which man—listeners—might respond?

Hindemith felt that music should be *used* —that is—serve some purpose other than that of being performed in an esoteric vacuum—Gebrauchs musik.

This requirement necessitates the use of a recognizable harmonic vocabulary. He fur-

	16/15	17/16	18/17	$\sqrt[12]{2}$	9/8	7/6	6/5	5/4	3/2	Ptolemy	Didymus	Equipartite
A	220	220	220	220	220	220	220	220	220	220	220	220
A#	234.66	233.75	232.94	233.08					234.93	9/8	9/8	234.66
B	250.31	248.36	246.64	246.94	247.5				247.5	247.5	247.5	251.43
C	266.99	263.88	261.15	261.63		256.66	264		264.3	10/9	10/9	
C#	284.79	280.37	276.51	277.18	278.44			275	278.44	275	275	270.76
										16/15	16/15	
D	303.78	297.9	292.78	293.66					297.33	293.33	293.33	293.33
D#	324.04	316.52	310.00	311.13	313.24	299.44	316.8		313.24	9/8	9/8	320.00
E	345.64	336.30	328.23	329.63					330	330	330	
F	368.68	357.32	347.55	349.23	352.4			343.75	352.4	10/9	9/8	352.
F#	393.26	379.65	367.99	369.99		349.35	380.16		371.25	366.66	371.25	
G	419.48	403.38	389.64	392.00	396.45				396.45	9/8	10/9	391
G#	447.44	428.59	412.55	415.31					417.66	412.5	412.5	
A	477.27	455.37	436.82	439.99	446.003	407.57	456.19	429.68	446.003	440	440	440
A#				466.16								
B				493.88								502.8
C				523.25								
C#												
D												586.66
											F	704
											A	880
											D	1173
											A	1760
											A	3520

Fig. 2

ther asserted that *tonality* was as inevitable as the law of gravity.

Composer Lou Harrison's philosophy is in the motto "—the overtone series is the rule—world music is the font."

Robert Baksa, in the Musical Heritage Review makes several rather sensible statements: 1) as a language, the tonal system allows a *wide* range of expression; 2) some composers who would prefer to work with traditional materials and harmonic vocabulary, avoid doing so because they accept, as fact, statements that older traditional, conventional methods, systems and tonalities have been totally exhausted—and finally; 3) he is convinced that after 25 years of composing, only a *little* cleverness is needed to come up with a convincing experimental piece—but to write a memorable work within traditional means calls upon a much more intense level of creativity.

Composers who have at their disposal musicians of professional caliber to perform their works have a factor working for them which has little to do with the tonal system they may have chosen for an experimental piece. Certain instrumental and vocal tones can be of such inherent beauty that combinations of tones having nothing to do with natural proportion have an appeal based on the *quality* of the tones alone and not their tonal relationships.

Webber's recently televised "Requiem" received widely divergent reviews—some positive—others negative—but aside from the merits of the work itself, it seems to this listener that *any* composition would have seemed to have merit based simply on the quality of sounds produced by the assembled musicians of world-class caliber.

The infinite possibilities *outside* the tertian tonal system present the composer with such freedom that it requires considerable discipline to set some limitations and boundaries in order to know where one might intend to go. On the other hand, the very *limitations* of tonality help assign *some* boundaries and *challenge* the composer to say something profound in a language that more than a handful can understand—let alone enjoy. If the contemporary composer sincerely wishes to say something to a listening world—would it not be well to say it at least part of the time, in the mother tongue, so to speak.

Without a doubt, there are valid, naturally generated principles waiting to be discovered and upon which new tonalities and techniques will be built—and there still is a lot to be said which has remained unspoken—in the language we already know so well—and with an ethos—however misunderstood—all its own.

IS THERE A MORAL DIFFERENCE BETWEEN ACTIVE AND PASSIVE EUTHANASIA?

Tom Tomlinson, Ph.D.
Medical Humanities Program
Michigan State University
East Lansing, Michigan

The purpose of this paper is to answer the question whether there is a moral difference between active and passive euthanasia. So long as a competent, informed, adult patient has requested it, does it matter whether what he has requested is active euthanasia instead of passive euthanasia?

Certainly institutionalized, traditional medical ethics holds that there is a difference between active and passive euthanasia. For example, the American Medical Association's House of Delegates has issued the ruling that "The intentional termination of the life of one human being by another—mercy killing—is contrary to that for which the medical profession stands and is contrary to the policy of the AMA (House of Delegates, 1973). The opposition to active euthanasia in medical ethics goes back much further than the AMA. When the physician pledges the Hippocratic oath he promises that "I will neither give a deadly drug to anybody if asked for it nor will I make a suggestion to this effect."

It is interesting to note that these uncompromising stands against active euthanasia may be lagging somewhat behind important shifts in public opinion. A series of Gallup organization surveys between 1950 and 1973 asked the question "When a person has a disease that cannot be cured, do you think doctors should be allowed by law to end the patient's life by some painless means if the patient and his family request it?" In 1950 60% of respondents thought that the doctor should not be allowed to fulfill the patient's request whereas 40% thought that he should. Twenty-three years later the distribution of opinion had flip-flopped, so that in 1973 only 43% believed that physcians should not have that discretion, while 57% thought that the physician should be allowed to end the patient's life by painless means (Public Opinion, 1983). Within society as a whole there is clearly a sharp division of opinion about the relative acceptability of voluntary active euthanasia.

So is there "a moral difference" between active and passive euthanasia? First of all we have to be clear about what question we are asking. One way of getting clearer about that is to be clear about what kind of answer we may be looking for. There are two kinds of "NO" answers that might be given. The first kind of "NO" answer would say that active euthanasia and passive euthanasia are "morally equivalent." That is, in any situation in which passive euthanasia would be justified active euthanasia would be justified also, and vice-versa.

The other kind of "NO" answer that might be given to the question is to say that there is no moral difference between active euthanasia and passive euthanasia that can justify permitting the use of passive euthanasia, but absolutely prohibit the use of active euthanasia. In this second sense of the question we are asking a question about policy: whether the current policy absolutely prohibiting active euthanasia can be morally justified.

When I ask the question whether there is a moral difference between active euthanasia and passive euthanasia I will be asking it in the second of these two senses. I will be focusing on this second sense for two reasons. First of all the claim of moral equivalence of active and passive euthanasia is probably false, since we can readily think of circumstances under which passive euthanasia would be justified, but active euthanasia would not be. For example, we might imagine a patient who while competent made a clear request for some form of passive euthanasia. She subsequently lapses into unconsciousness from which she will not recover. Perhaps the patient asked that she not be put on a respirator under certain circumstances. Such a request might well justify a decision to withhold the respirator under the circumstances specified by the patient. But the administration of active euthanasia would not thereby also be justified. The patient might, for example, have strong religious objections against "mercy killing," in which case the administration of active euthanasia would be an affront to her values. The other problem with the first sense of the question is that it does not directly address the social policy that aims to allow some forms of passive euthanasia but absolutely prohibits active euthanasia. Certainly if it were true that active and passive euthanasia were morally equivalent, it would follow that we could not justify a policy that allows one but prohibits the other. But if active and passive euthanasia should turn out *not* to be morally equivalent in the sense that I have described, it does not follow that the policy of prohibiting one but allowing the other is morally or socially justifiable. For example, it might be argued that active and passive euthanasia are not "morally equivalent" because active euthanasia offers opportunities for abuse—only active euthanasia can be abused by killing healthy people who don't want to die (More on this argument later). But even if this is true, it doesn't follow that it is impossible to develop an acceptable policy permitting active euthanasia. All that follows is that it will have to address some additional concerns than those dealt with by the current policy permitting passive euthanasia.

In what follows I will want to argue that there is no systematic moral difference between active and passive euthanasia that will justify allowing some acts of passive euthanasia, but at the same time prohibit all acts of active euthanasia. To show that I intend to use the following strategy.

The first step in the strategy is to establish that if there is a moral difference between active and passive euthanasia, then acts of active euthanasia must meet two conditions: *Condition* 1. Acts of active euthanasia must have some characteristic not shared by acts of passive euthanasia. Clearly, if active and passive euthanasia were exactly alike in all respects there could be no justification for taking a different moral or social attitude toward active euthanasia. If we continued to have a different attitude, it would be a difference for which no reasons could be given. Our rejection of active euthanasia would then have the character of a superstition or taboo. *Condition* 2. Such a unique characteristic of active euthanasia must imply a significant moral difference between the two. The reason for this second condition is to rule out the use of morally irrelevant or insignificant differences. A hyperbolic example of this would be if someone were to claim that the difference rested on the fact that active euthanasia was abbreviated AE and passive euthanasia was abbreviated PE. This is a difference that satisfies the first condition, but it is not a morally significant difference that would justify a different social policy on one than on the other.

If these two conditions are accepted (I won't argue for them any further), then the second step in the strategy is to show that none of the reasons which have been given to justify the prohibition of active euthanasia meet both conditions. If this can be accomplished, then we will have all the steps of an argument which shows that there is no moral difference:

1. If there is a moral difference between active and passive euthanasia, then conditions 1 and 2 must be met.
2. Conditions 1 and 2 cannot be met

(none of the reasons put forward satisfy both conditions).

3. Therefore, there is no moral difference between active and passive euthanasia.

It should be noted that this is an "open-ended" form of argument, since not every possible difference can be canvassed. In the remainder of the paper, I intend to describe some of the arguments that have been offered for making the distinction between active and passive euthanasia and show why they fail the conditions that I have set forth.

Probably the argument that's offered most frequently points out that passive euthanasia is "letting die" whereas active euthanasia is active "killing." Since it is always wrong to kill an innocent human being, active euthanasia but not passive euthanasia must always be wrong.

I think that this argument meets condition 1 but not condition 2. This can be demonstrated using an example provided by James Rachels (Rachels, 1975). Rachels describes two evil uncles named Smith and Jones. Each of these uncles has a young cousin and each of the uncles stands to gain a considerable inheritance if the young boy suffers an unfortunate accident. Each of the evil uncles therefore forms the intention of drowning the child when he is taking his bath. And each of the evil uncles enters the boy's bathroom fully intending to hold his head under water until he drowns. The one evil uncle Smith goes into the bathroom and forces the child's head under water until the child dies from drowning. The second evil uncle Jones enters his cousin's bathroom with the same intention, but just as he walks in the door the young boy slips on a bar of soap and hits his head on the side of the tub so that he is knocked unconscious. Since this fits in very neatly with Jones' plans he just stands by, does nothing, and lets the boy drown.

As Rachels points out there is a difference between what Smith and Jones did. What Smith does is an active killing but what Jones does is a passive letting die. But Rachels asserts—and I agree—that that makes no difference to our moral evaluation of Smith and Jones. We think that what each of them did is equally reprehensible. The bare fact that one is a "killing" does not make it morally worse than the other and the bare fact that the other can be described as a "letting die" does not make it less morally objectionable.

The example is not an attempt to draw a direct analogy between what Smith or Jones did and what doctors do when they allow passive euthanasia. Doctor's intentions are almost always more benevolent. All that the example is intended to show is that the distinction between killing and letting die is by itself not a reliable guide to what's morally justifiable or defensible. If indeed the example shows that this distinction is not a morally reliable one, then we should not use it uncritically to try to mark a moral difference between active and passive euthanasia. There must be some other difference beyond the bare fact that one is a killing and one is a letting die if indeed we are to justify our different moral attitudes toward active euthanasia.

This leads me to a second argument which is sometimes brought forward to articulate a bit more what the difference is between killing and letting die in the medical context. When we let a patient die, it is said, it is the disease or the condition that is the cause of the patient's death and so the physician is not responsible for the death in the same way that he or she would be if death were caused by a lethal injection (as in active euthanasia).

This argument meets condition 1, but not condition 2: if this identifies a difference, it is not a morally relevant difference. Even if we admit that there is a difference in the "causes" of the patient's death this cannot show that passive euthanasia is permissible whereas active euthanasia is not. This conclusion would follow only if we equivocate with the word "responsible." The following argument is an example of how this equivocation works.

(a) When a patient is allowed to die it is the disease that is $responsible_1$ for his death.
(b) When the disease is $responsible_1$ for the death, then the physician is not $responsible_2$ for the death.
(c) Therefore when the patient is allowed to die (passive euthanasia), the physician is not $responsible_2$ for the death.

In the first premise of this argument the word "responsible" is being used as a synonym for "causes." This use of the word "responsible" is morally neutral, just as it's morally neutral in the sentence "spontaneous combustion was 'responsible' for last night's fire." However, when we get down to the conclusion of the argument, the word "responsible" is not being used in a morally neutral way and is not being used as merely a synonym for "causes." "Responsible" in the conclusion is a synonym for "blameworthy." The only way we can link these two distinct senses of "responsible" is by the use of a claim like premise (b). But such a claim is clearly false. Cases of gross negligence by physicians would be an example in which the disease or underlying lethal condition was the cause of the patient's death and yet in those cases the physician would remain blameworthy for that patient's death. The fact then that in passive euthanasia the disease rather than the physician is the immediate cause of the patient's death does not by itself provide us any grounds for relieving the physician of moral responsibility and certainly cannot provide any grounds for justifying a physician's decision to withhold a potentially life saving medical treatment. The physician's merely indirect causal role in passive euthanasia does not relieve him of moral responsibility. A physician who lets a patient die can be morally blameworthy for that action just as much as a physician who deliberately kills a patient.

A third argument that is often heard points out that in medicine one can never be sure of the diagnosis or prognosis for any particular patient. Medicine is not an exact science and physicians are the first to admit that they make mistakes. Every physician as well as every subscriber to *Reader's Digest* can report anecdotes describing cases of patients who miraculously recovered. The argument is then made that the moral difference between active and passive euthanasia is that in active euthanasia such a lucky break (the miraculous recovery) is denied the patient who has been killed by his doctor. The philosopher Tom Beauchamp presents a version of this argument when he points out that if we prohibit active euthanasia we will save those people who are wrongly diagnosed as hopeless, but who would have survived with a good outcome even if treatment had been stopped. (Beauchamp)

I think this alleged moral difference fails both conditions 1 and 2. It fails condition 1 if the significant difference is supposed to be the fact that there will be a greater number of unnecessary or tragic deaths if we permit active euthanasia than if we permit only passive euthanasia. If this is a real difference between active and passive euthanasia, it's also a real difference between passive euthanasia and aggressive treatment. That is, we can make exactly the same kind of comparison between permitting passive euthanasia and prohibiting passive euthanasia. Beauchamp admits that a policy that permits passive euthanasia runs the risk of allowing tragic deaths. If avoiding unnecessary or tragic deaths justifys a policy prohibiting active euthanasia, it would seem on exactly the same score to justify a policy of prohibiting passive euthanasia as well. This alleged difference marks no real difference between active and passive euthanasia.

It also fails condition 2, because even if we assume that the "tragic deaths" are connected only with active euthanasia, this would not be a morally significant difference that would justify prohibiting active euthanasia on request. The patient who is requesting active euthanasia can knowingly accept the risk of false diagnosis and prognosis, which is just what well-informed patients do when they are asked to make any kind of medical treatment or non-treatment decisions.

A third argument that is offered against permitting active euthanasia claims that active euthanasia offers a much greater likelihood of abuse than passive euthanasia, where abuse means killing patients who don't want to die. We can find this argument, for example, in a letter to the *New England Journal of Medicine* from Dr. Fernando Vescia, in response to James Rachel's article: "Central to the condemnation of active euthanasia is the lack of protection from when this choice would be motivated by other than charitable purposes." (Vescia, 1975)

This argument may meet condition number 2, because certainly the likelihood of abuse is a morally relevant consideration in deciding whether or not to permit a certain practice. If indeed active euthanasia offers a much greater likelihood of abuse than passive euthanasia, we would have reason not to allow active euthanasia even on request. At least this would be so if in addition there were no practical mechanisms for reducing the additional threat of abuse that active euthanasia might pose. But even if this argument meets condition 2, it does not meet condition 1, because the potential for abuse does not mark a real difference between active and passive euthanasia.

The worst abuse would be to cause the death of patients whose death was avoidable or forestallable, and who didn't want to die. But one can do this with passive euthanasia as well as with active euthanasia simply by withholding potentially life-prolonging treatments from people who want to continue to live. Indeed, you might argue that abuse of this kind would be easier with passive euthanasia since it would often be plausible in the circumstances to attribute the death to the patient's grave condition, rather than to a physician's decision not to act. I think there is indeed evidence of this kind of abuse of passive euthanasia.

There may, for example, be reason to believe that there is some abuse of passive euthanasia in the institutionalized elderly. In a study appearing in the *New England Journal of Medicine* by Brown and Thompson (1979) it was found that of a hundred and ninety patients in nine nursing homes who had suspected bacterial infections (probably pneumonia, in most cases) antibiotics which probably would have resolved the bacterial infection were withheld from 81 patients. Predictably, of those 81 who were not treated a much larger proportion subsequently died of that infection. In how many of these 81 cases had permission to withhold treatment been granted by the patient and/or the patient's family? Unfortunately Brown and Thompson don't ask the question directly but some of the other information they gather can provide some grounds for making an inference. Usually when permission to withhold a treatment has been explicitly sought by the physician and granted by the patient and/or the patient's family, that permission is noted in the patient's medical records as a very important form of legal protection. Brown & Thompson did determine the cases in which a notation had been made in the patient's medical records of the physician's intention to withhold the antibiotic treatment, which is still not quite the same as a documentation of *consent.* As it turned out in only 23 of the 81 cases was there such a notation. The proportion 23/81 probably represents a liberal estimate of the proportion of cases in which consent had explicitly been granted. That leaves a very large proportion of cases in which abuse of passive euthanasia should at least be strongly suspected.

Despite abuse such as this, the response has not been (and should not be) to call for the prohibition of voluntary passive euthanasia. The more defensible approach is to develop ways to prevent or lessen the abuse. Active euthanasia is just like passive euthanasia in that it, too, poses a threat of abuse. But if the real and present threat of abuse can't justify prohibiting passive euthanasia, then neither can it justify prohibiting active euthanasia.

The final argument that I wish to consider is one that I myself made a couple of years ago but have come to reject (Tomlinson, 1981). The argument points out that permitting voluntary passive euthanasia of competent adults is justified by the existence of a right to refuse treatment which physicians must recognize whether they agree with the decision of the patient or not. There is by contrast no analogous "right to be killed" that would justify active euthanasia because such a "right" would require that physicians actively participate in an action that they may deem immoral. The patient, however, can't have a "right" that the doctor violate his or her conscience. The upshot of the argument is that the moral difference between active and passive euthanasia is that patients have a right to passive euthanasia, which they can demand of physicians, but they don't have any such right to active euthanasia which entitles them to physician cooperation.

Although I once thought that this was a very significant difference between active and passive euthanasia, I no longer believe so. I think that the argument violates both conditions 1 and 2.

First of all I think it fails condition 1 because it does not mark a real difference between active and passive euthanasia. Notice that the argument proposes that the morally relevant distinction between active euthanasia and passive euthanasia is based on the degree of moral responsibility placed upon the physician. When the responsibility is solely the patient's (as in passive euthanasia) it is more defensible to permit it as a matter of policy than when responsibility is "shared" with the physician or thrust upon him (as in active euthanasia). But if this is a genuine distinction that justifies us in accepting one form of euthanasia but in rejecting another it seems to condemn most passive euthanasia as well. The only form of euthanasia that would involve no supporting activity or cooperation from the physician or the hospital is when the patient is permitted to haul himself out of bed and stagger to the elevator under his own power. As a matter of fact, however, we think that patients have a right to something more than this when we advocate a policy permitting passive euthanasia, even though anything more than this is going to require some supporting activity or cooperation from the physician. If the logic of this argument was acceptable, for example, the policy of the University of Southern California Burn Center would have to be rejected. There, burn victims who have burns so severe that their survival is unprecedented are fully counseled on the alternative of no treatment, and if they elect that option they are provided with a private room, unlimited visitation, and full pain relief. (Imbus and Zawacki, 1977)

I also think this argument fails condition 2. Even if there is a real distinction here between active and passive euthanasia so that all and only forms of passive euthanasia are protected by a right that obligates physicians to respect the patient's request, how can that show that only passive euthanasia should be permitted? It shows only that a patient can't justifiably demand that a physician kill him as he can demand to be left alone. But this doesn't show at all what would be objectionable about a *mutually agreed upon* active euthanasia. That is, the argument doesn't show why we shouldn't or couldn't have policies regarding active euthanasia which would be similar to those we now have governing abortions and sterilizations. With abortion and sterilization we can also point out that no patient has a right to demand of a particular physician that he or she perform an abortion or sterilization when that would violate that physician's conscience. But all this point justifies is policies permitting people to refuse to perform abortions or sterilizations. Conscientious refusals cannot justify the prohibition of abortions or sterilizations, any more than they could justify the prohibition against active euthanasia.

These are all the arguments I have space to review. I believe I have successfully shown that each of them fails one or both of the conditions I've set out. If the same is true of any other plausible arguments that might be offered, then I think we will have a well-grounded basis for changing our moral attitude regarding active euthanasia.

Notes

[1] House of Delegates of the American Medical Association, statement issued December 4, 1973.

[2] Rachels, James, "Active and Passive Euthanasia," 1975: *New England Journal of Medicine* 192, pp. 78–80.

[3] Beauchamp, Tom L., "A Reply to Rachels on Active and Passive Euthanasia," 1979: revised for *Medical Responsibility,* Wade L. Robison and Michael S. Pritchard, eds., Humana Press, pp. 181–194.

[4] Vescia, Fernando, correspondence, 1975: *New England Journal of Medicine* 292, p. 865.

[5] Brown, Norman K. and Donovan J. Thompson, "Nontreatment of Fever in Extended Care Facilities," 1979: *New England of Medicine* 300, pp. 1246–1250.

[6] *Public Opinion,* December/January 1983, p. 39.

[7] Ernle W. D. Young, correspondence, 1975: *New England Journal of Medicine* 292, pp. 864–865.

[8] Tomlinson, Tom, "The Moral Difference Between Active and Passive Euthanasia," 1981: Unpublished manuscript.

[9] Imbus, Sharon H. and Bruce E. Zawacki, "Autonomy for Burned Patients When Survival is Unprecedented," 1977: *New England Journal of Medicine* 297, pp. 308–311.

SOME DISTINCTIONS BETWEEN ACTIVE AND PASSIVE EUTHANASIA

Daniel A. Putman
Department of Philosophy
University of Wisconsin-Fox Valley

I wish to argue that there is a significant moral difference between passive euthanasia (PE) and active euthanasia (AE). In doing so I will deal in various ways with the issues of intentions, responsibility, uncertainty in prognosis, and the effects of actions on a person's overall character.

Two questions stand out regarding the issue of intentions. Are the intentions in AE and PE the same? And, even if they were the same, or very similar, does that fact make each of the means equal? In other words, does a good intention (wanting to help the patient die a peaceful death) imply that there is no moral difference in the actions used to achieve that goal? Let's look at the second question first. In the Smith-Jones example cited by Professor Tomlinson, "killing" and "letting die" have the same intention, the death of a boy.[1] The analogy is supposed to imply that the intention of a physician (in this case, a morally good one—the peaceful end of suffering) makes "killing" and "letting die" equal as means to achieve the goal. In the Smith-Jones case, it does seem clear that there is no moral difference between killing and letting die. Both Smith and Jones are equally culpable. But I would argue that a physician's situation is different. We can assume the physician wants to be ethical, and moral integrity means *both* means and ends must be examined. In the literature, analogies used to equate AE and PE are almost always blatantly *immoral* acts in which the end makes all means equal. This skews the discussion because if we assume moral integrity to begin with, the end does *not* automatically justify the means. If I want to deceive you, how I do it is simply a matter of how best to achieve my immoral goal. The means is already completely tainted by the end. But if I want to be honest with you, the means I use is *independently* very important because the means itself may have moral dimensions. For example, consider a physician telling a patient he or she is terminally ill. The goal, honesty and respect for a person's right to know, does not mean it is morally all right for the physician to use any means of telling the patient. The means itself could be very harmful and destructive. Compare this with a physician who wants to cover up negligence, and one can see how immorality links means and end as one unit while moral consciousness puts an obligation on the person to view each independently. The example of Smith and Jones killing a child in the bathroom by one of two means sheds very little light on a situation where an individual *with moral integrity* is trying to decide the most moral means to bring about a person's death. Examples of immorality tend to flatten out distinction in means.

What then are some of the differences in the means? The intention of the active euthanizer is expressed by a very clear end-in-view, the death of the individual at a time and place ultimately under the control of the physician. John Dewey pointed out perhaps better than anyone that ends-in-view express the character of the individual as well as form that character in the future.[2] If I choose to steal, I am expressing both the character I have and at the same time forming my character. Part of a reflective moral decision is to consider the effect on one's own moral integrity. There is a very selfish, narrow way of interpreting this—how can I best feel smug about myself or give a good impression? I do not mean that. What I mean is reflection at a very deep level about what kind of *person* you want to become. As Sartre said time and time again, we become our choices. I think one of the things that bothers many physicians about active euthanasia is the potentially formative effect on character and what it will do to their overall view of human life if AE somehow became an accepted, even standard part of their actions. Active euthanasia can be a genuine expression of the need to relieve suffering, but what will it do to the character of an individual whose moral ideal is dedicated to preserving human life if it becomes part of his or her intention to actively take life? What does a physician become when his or her empathy lies in caring for life and he or she becomes an active agent in taking it? Moral conservatism is justified when it comes to killing because of the formative effect of the means on the character of individuals. This is far more than a "public image" problem for the physician. Are they actually going to be morally better people by taking someone's life—regardless of the reason? (Does the social approval of the executioner's action make what he does irrelevant to his moral character?) Because of the effect on the agent of killing another person, our intuitions imply that, even in a tragic situation, such an act must be a last-ditch effort of desperation. My point here is that this intuition is justified.

The effect on an individual can be directly tied to the moral tradition of the West. It is useful here to borrow W. D. Ross's distinction between *prima facie* and actual moral duties.[3] A *prima facie* moral duty is one that, all other things being equal, ought to be followed. For example, all other things being equal, lying is morally wrong and ought not be done. The moral tradition of the West has as one of its basic principles the sanctity and preservation of human life. The *prima facie* rule against taking life ranks higher than probably all other such principles and is countermanded only in certain specified situations such as self-defense. Even in self-defense it is generally agreed that killing the aggressor should be a last resort and that, if killing is not necessary, other forms of self-protection are clearly morally superior. The end, though it may be morally good—protection of self or family—does not make all means equal. In a situation such as physicians face in which the moral agent is forced to choose between actively taking life and letting someone die and these are the only two options to achieve the same goal (a peaceful "good death"), other factors being equal, not doing anything is the morally superior act. There may be times when AE is the only genuine moral alternative. But this does not make killing and letting die morally the same any more than killing someone as a last resort to protect the lives of one's children makes killing as a principle morally equal with other ways of protecting one's family. Where AE and PE are both options, PE recognizes the moral principle of the sanctity of life in the only way available to the person in that situation and, based on that principle, does not actively violate the integrity of the self. Respect for the moral principle of preserving life translates in concrete circumstances into a *prima facie* rule against AE whenever life cannot be maintained and PE is a viable alternative.

The intention of the active euthanizer ties into the causal nature of the act. We normally see the causal feature of moral agency as critical. Degrees of responsibility have always had important ethical implications. Active euthanasia makes the doctor the sufficient condition for the death of the other person. The intention serves to pull together and put under the control of the physician all the conditions necessary for bringing about death. On the other hand, the role of the physician in passive euthanasia is as a necessary condition only. The patient's death requires that the physician not do anything and that act of omission is only one (and frequently it is not even certain it is one) of the necessary conditions. Passive euthanasia puts the physician in the role of being one of a number of necessary conditions for the death of the other; active euthanasia requires the physician to be the sufficient condition.

The difference between being a necessary or a sufficient condition and the link between intention and sufficiency in an act is at the heart of many of the objections to AE. In a situation involving moral uncertainty, active euthanasia usurps all options. Professor Tomlinson's claim that both PE and AE foreclose an indefinite number of options for the patient deliberately blurs the meaning of "indefinite." In AE all options are closed. In PE *almost* all options close for the patient. When one is talking about ending someone's life, that distinction is crucial. Decisions involving PE are frequently clouded by a number of factors. Physicians have told me that in many cases of PE length of life and quality of remaining life are not at all certain. Moreover, cases of people who were "allowed to die" but recovered are known to most physicians and the rare but actual possibility of this occurring makes for an enormous difference in the moral texture of a large number of cases. The lack of infallibility is real for physicians. To be the sufficient condition for the loss of someone's future is more than enough to rule out AE in which possibilities are never even allowed.

Are the intentions in AE & PE really the same? I have implied above that they may not be. I think the strongest case for the difference in intentions has been made by Philippa Foot.[4] Pulling the plug on a respirator will allow a patient to die but if the patient lives we do not sense that we have failed. Because the individual did not die we do not subsequently feel an obligation to kill the person; the original intention was to *allow* to die. On the other hand, the failure of an injection to kill someone is a failure to produce the result directly intended by the agent. Being what it is, the moral intention would oblige us to try again. Foot's point is that having a role in the apparent inevitability of someone else's death varies significantly from directly intended causal agency.[5] Foreseeing death, allowing it to happen, is a fundamentally different intention from being the sufficient condition for death. It is simplistic to equate *in principle* the intentions in active and passive euthanasia and completely unjust to attribute a failure of moral nerve to someone opting for passivity rather than action. Examples such as the Smith-Jones case or those that equate the responsibility involved in negligence to that of PE assume the intentions in AE and PE are the same. My point is that they are not identical and that the difference between them has critical moral connotations. My further point is that, even in cases where the actual intentions are clearly synonymous (and clearly good), that does not make all means morally equal.

Finally, what should be the physician's role if a patient requests active euthanasia? The situation is essentially the same as any other request of a morally complex and difficult act. Since it is a request for a second party to counter a basic moral principle and since the request involves the integrity of the agent's moral self, patients should assume no prior claim on physicians' cooperation. The cooperation of a physician or loved one in helping a person die would depend on the agent evaluating a number of factors, including the request to die as an expression of the patient's autonomy. Autonomy alone may be sufficient for having someone not do anything to your body but autonomy alone is not sufficient to require another person to actively perform an action, especially when the action may countermand a long-standing moral principle. Contrary to Professor Tomlinson, the difference in causal responsibility between AE and PE makes this issue a real one in cases of voluntary euthanasia. Because of this difference and the implications cited earlier in the paper, passive euthanasia is much more easily justifiable by request than active euthanasia. Put another way, in the physician-patient relationship, just as the patient cannot assume on the physician to actively take life, the physician cannot force on the patient full medical treatment against his or her wishes. Both physician and patient have prior claims to say "no" for the same reason—the integrity of the self. In practice passive euthanasia is frequently a compromise between the physician and patient as distinct autonomous agents.

I have tried to show that there are significant moral distinctions to be made between AE & PE and that, if correct, these distinctions are relevant in cases of voluntary requests for AE. While it's possible that AE may be the most necessary and humane act at times (just as lying may be), I think it critical that the moral distinctions be made manifest before any action is taken in a particular situation.

Notes

[1] James Rachels, "Active and Passive Euthanasia," in Thomas Mappes and Jane Zembaty, *Biomedical Ethics* (New York: McGraw-Hill, 1981), pp. 349–50.

[2] See John Dewey, *Theory of the Moral Life* (New York: Irvington Press, 1980), especially chapter 1, sections 4 & 5, and chapter 6.

[3] W. D. Ross, *The Right and the Good* (Oxford: Oxford University Press, 1930), pp. 18–33.

[4] Philippa Foot, "The Problem of Abortion and the Doctrine of Double Effect" and "Euthanasia" in Philippa Foot, *Virtues and Vices* (Berkeley: University of California Press, 1978), pp. 19–32 and 33–61.

[5] See Foot's example of the driver of a runaway tram in "The Problem of Abortion . . . ," pp. 23–24.

FAINT SCREAMS:
SWIFT'S "A BEAUTIFUL YOUNG NYMPH" AND THE CRITICS

William R. Drennan
English Department
University of Wisconsin Center—Baraboo/Sauk County

The proposal behind this essay is modest enough: I hope to demonstrate, by means of a close look at the strategies of the text itself, that the appropriate affective response to Swift's "A Beautiful Young Nymph Going to Bed" is one of revulsion toward the poem's central character, rather than empathetic and sentimental compassion for her. Of course, this is not to deny the possibility of other readings. Good poetry is sufficiently ambiguous to evoke a variety of significant responses, some of which may have been quite unforeseen by the poet; the text outlives the writer and thereby becomes subject to critical attitudes which may vary widely from those of the age in which it was produced. But my purpose *is* to uncover that reading of the poem which Swift himself most likely intended us to have, so that when we deviate from that reading, we have at least some idea of the primal Swiftian tenets we are manipulating.

"A Beautiful Young Nymph" is commonly linked to three other so-called "excremental" poems—"The Lady's Dressing Room," "Strephon and Chloe," and "Cassinus and Peter"—all produced by the poet during 1730 and 1731.[1] It seems to me that this connection is a tenuous one, although the ways in which the poems are thematically similar do deserve some comment.

Swift's mad persona in *A Tale of a Tub* observes that happiness resides in "a perpetual Possession of being well Deceived." But it is always and everywhere the role of the satirist to force us to look beyond those comfortable constructs by which we seek to delude ourselves into a facile happiness. These four poems are allied in aiming at a stripping away of such obfuscation. They are similar as well as in their overt physicality, in their insistence upon rubbing the reader's nose in the most vile (and fundamental) aspects of the human body, and in their common horror at the rank grossness of human flesh when it is divested of all ornament and is operating in its natural state.

But there are important differences among the poems as well. "The Lady's Dressing Room," "Strephon and Chloe," and "Cassinus and Peter" all have as their "heroes" sentimentally-inclined poetasters who derive ultimately from the romantic Petrarchan tradition. They are characters who so deceive themselves about the supposedly angelic natures of their lovers that they leave themselves open to being psychologically shattered by the contravening evidence of the ladies' stark physicality. Excrement in these poems serves the purpose of what we might call rhetorical gravitation. By means of substituting parodic images of physicality and elimination for the anticipated romantic description, Swift undercuts these swains' delusive notions—notions which were supported by the sentimental literary conventions of the day. Women here are not so much castigated for defecating, as are their lovers for supposing them incapable of it.

Excrement in these three poems therefore helps to fulfill the traditional corrective aims of satire. When, at the close of "The Lady's Dressing Room," we see Strephon "blind/ To all the charms of Female kind" (11. 129-30), we understand that he is a satiric victim who parallels the condition of Lemuel Gulliver at the end of his *Travels.* Both characters are ridiculed for having posited a vision of mankind which is finally suprahuman and which belies the essential nature of the race. A recent article tries to deny this thematic kinship between Strephon and Gulliver by arguing that "Gulliver entertains no illusions about the beastly Yahoos while Strephon has been misled by romantic love."[2] But this misses the point entirely. Just as the discovery of Celia's excremental aspects leads to Strephon's misogyny, so Gulliver's discovery of his own kinship with the Yahoos—most clearly expressed in the swimming hole incident of Book IV—leads to an unreasonable misanthropy. Gulliver's world-view is so blighted by this stripping away of illusion that he is blind to the merits of a thoroughly good man, Don Pedro; similarly, Strephon can finally approach even the most beautiful women only by stopping his nose. Denied the numbing lies of romantic idealism, Strephon takes to woman-hating with the alacrity that Gulliver takes to the stables.

The movement from the romantic to the satiric world-vision, therefore, is seen to be fraught with danger. As Nora Crow Jaffe notes, the satiric writer "makes a bargain with the devil" when he seeks to blast comfortable illusions and uncover the damnable facts;[3] an eye, once jaundiced, may come to view everything as being irreversibly tainted, as Swift himself warns in "Strephon and Chloe":

> But, e'er you sell yourself to laughter,
> Consider well what may come after,
> For fine ideas vanish fast,
> While all the gross and filthy last. (11. 231-4)

Therefore the satirist buys the accuracy of his vision at a frightful price; for that reason, perhaps, he intends to rock the complacent and to disrupt the *status quo* by hitting at us precisely where we are most vulnerable and most repressed. Where is that? "The history of Swiftian criticism," replies Norman O. Brown, ". . . shows that repression weighs more heavily on anality than on genitality."[4] The violence of the reaction prompted by these poems only substantiates their point of view; when we lose our critical perspective and attack Swift for informing us of Celia's defecation, we merely recapitulate the error of Strephon and reveal the depths of our own illusions.

"A Beautiful Young Nymph," then, shares with these other poems the informing theme of sham *versus* reality and romantic delusion *versus* satiric accuracy. But there the similarities end. The poem, while grossly physical, contains no mention of excrement *per se* (save that of a cat). Nor is the poem much concerned with deriding or parodying romantic literary conventions, although the title and Corinna's name do make allusions in that direction, and a parodic similarity between this poem and Donne's elegy, "To His Mistris Going to Bed," has been argued by several scholars.[5]

Unlike "Strephon and Chloe," for example, "A Beautiful Young Nymph" depends very little on its narrative content. Rather, what we get is a sort of Hogarthian engraving—or a series of them—which portrays a Drury Lane prostitute in the privacy of her bedchamber. Swift etches three separate portraits: the lady's preparations for bed (11. 1-38), her fitful dreams (39-59), and her waking to disaster (58-64). The "I" of a persona—Swift himself?—then intrudes (65-74) to provide a sort of moral coda (to mix the metaphor) to the whole composition.

The long passage which relates Corinna's getting ready for bed has elicited some predictible squeals from what Jaffe calls the "shocked school of criticism." John Middletown Murry, for example, refers to the "horror" and "nausea evoked by the hideous detail" of the passage, and he chides Swift for his "total lack of charity, his cold brutality, towards the wretched woman who is anatomized. . . . It is utterly inhuman."[6]

Perhaps. But what happens in this section of the poem must strike the general reader, unless he is either saint (and therefore in no need of Swift's corrective satire) or prude (and therefore beyond its help), as being genuinely hilarious. The prostitute's ills are so calamitous and her prosthetic efforts after beauty are so patently absurd that she calls forth much more laughter than empathy; and this is as it should be. While any of us might respond with the milk of human kindness toward a "beautiful nymph" with, say, a glass eye, that milk becomes distinctly clabbered when we learn that the same woman is bald, has eyebrows made from the skin of mice, has no teeth, props up her breasts with rags, and wears a steel-ribbed corset and artificial hips. The whole sketch is so purposefully and grotesquely overdone as effectively to block any empathetic response on our part. For Corinna is not *real:* she is neither drawn realistically nor is her body so much flesh and blood as it is steel, ivory, glass and wire. Real people may be tragic; Corinna, a character out of a bizarre Saturday matinee cartoon or a slapstick farce, can never be either real *or* tragic. And when Murry refers to this preposterous stick figure, this uproarious demi-machine, as a "wretched woman"—that is, as if she were someone we might actually *know*—we find ourselves laughing at him, too.[7]

The second section of the poem does provide some problems, and one assumes that it is this passage which especially prompts protective urges within the manly breasts of certain critics. Corinna is now in bed, and she

> With Pains of love tormented lies;
> Or if she chance to close her Eyes,
> Of Bridewell and the Compter dreams
> And feels the lash, and faintly screams. (39-42)

But it is likely that Corinna's "pains of love" are less the pangs of unrequited passion than the surely-requited symptoms of venereal disease, one of her many occupational hazards. Further, if she screams "faintly," it is because she is, after all, asleep; the adverb should not provoke us into unwarranted pathos. It has been noted that dreams, in Swift, are consistently in accord with the character of the dreamer, so that the lurid nature of Corinna's phantasms only underscores her own moral wretchedness.[8] Her slumber does call up scenes of deportation, abandonment, and constables, but she also

> . . . seems to watch on lye
> And snap some Cully passing by. (49-50)

The imagery of this couplet is decidedly predatory, and we should recall that even gentle Gay, Swift's friend, used a similar trope in his *Trivia* to warn against contact with the ladies of Drury Lane:[9]

> She leads the willing victime to his doom,
> Through winding alleys to her cobweb room.
> (*Trivia,* 3, 11. 291-2)

The most palpable result of such contact is, of course, the "pox" with its "cancers, issues, [and] running sores"—symptoms which Corinna herself helps to disseminate. Further, we learn at the end of this part of Swift's poem that she numbers among her clients those clergymen

> Whose favor she is sure to find,
> Because she pays 'em all in kind. (55-6)

So Corinna actively corrupts the representatives of established religion. To be sure, she is as much sinned against as sinning in these unholy relationships, and Swift's principal satiric target here is probably the clergy, not the bawd. It is clear, however, that the intimacy is corrosive on both sides. Downtrodden and oppressed in most aspects of her life, Corinna nonetheless has the power to contribute to the undoing of the priests of God's Church. Therefore she must not be viewed sympathetically: as Swift emphasizes at the poem's end, Corinna represents an outright social menace.

Lest we be lulled into empathy by social or moral ambiguity, Swift abruptly returns us in the poem's third section to the disjointed world of Max Sennett farce. Corinna wakens to find her glass eye stolen by a rat, her wig infested with her dog's fleas, and her "plumpers" soiled by her incontinent cat. The reader needs only to visualize this scene to capture its overt hilarity. Further, the insistent animal imagery of the passage should serve to warn us against taking Corinna's "mangled plight" too much to heart.

The fourth and final section at last introduces the narrator, the "I" who presumably has told the story thus far. He is at the point of giving up the task:

> But how shall I describe her Arts
> To Recollect the scattered Parts?
> Or show the Anguish, Toil, and Pain. . . .

Like Humpty-Dumpty, Corinna here becomes a literal embodiment of the fragmented personality: her "self" is veritably strewn all over the floor, appropriately soiled by rats, fleas, and animal excrement. The "anguish, toil and pain" she must undergo to restore her mechanical, factitious body is, we must remember, effort aimed at moral and physical corruption:[10]

> Corinna in the morning dizen'd
> Who sees, will spew; who smells, be poison'd.
> (73-4)

This closing couplet recalls that other Corinna—Pope's in the *Dunciad*—who "chanced that morn to make" the puddle of urine in which Curll falls. (In fact the name Corinna was used by Dryden, Pope and Swift to refer variously to Mrs. Manley, Mrs. Eliza Haywood, Mrs. Elizabeth Thomas and Martha Fowke; in all cases the name is attached to a woman who is subjected to savage Juvenalian satire.)[11] Further, the couplet re-emphasizes the point that Corinna is a sort of walking contagion at loose in the city. Whoever approaches her is indelibly blighted. Pope's Sappho at least offers one an alternative between libel and infection; Swift's Corinna imparts only the latter.

In summary, Swift in this poem presents us with what Maurice Johnson has called a picture of "the wages of sin . . . [like] a preacher shouting hell-fire and brimestone, or the photographs in a medical treastise."[12] There is little in what we know of Swift the man or Swift the satirist to persuade us that this poem is other than the "pure invective against vice" that Jaffe takes it to be.[13] I have sought to demonstrate that neither does the poem itself, as an artistic entity, contain evidence to convince us that Corinna is any more like Moll Flanders than Swift's sensibilities are like Defoe's.

Notes

[1] This grouping is found in Jaffe (see citations below), who adds "The Progress of Beauty" to the list. Brown includes only three of these poems under the "excremental" heading: "The Lady's Dressing Room," "Strephon and Chloe," and "Cassinus and Peter." Johnson groups the poems similarly. Murry conforms to Jaffe, but omits "The Progress of Beauty" from his discussion.

[2] Rev. of "Swift's 'The Lady's Dressing Room,'" by Douglas Calhoun, *Scriblerian,* 3.2 (Spring 1970), 56.

[3] Nora Crow Jaffe, *The Poet Swift* (Hanover, NH: Univ. Presses of New England, 1977), p. 112.

[4] Norman O. Brown, *Life Against Death* (Middletown, Conn.: Wesleyan Univ. Press, 1959), p. 180.

[5] For example, see Irwin Ehrenpreis, *The Personality of Jonathan Swift* (London: Methuen, 1958), p. 42; and Robert Hunting, *Jonathan Swift* (New York: Twayne, 1967), p. 48.

[6] John Middleton Murry, *Jonathan Swift* (London: Jonathan Cape, 1954), p. 439. See Ehrenpreis, p. 33. (Lady Pilkington reportedly vomited upon reading the poem and saw it as "all the dirty ideas in the world in one piece"; see Ehrenpreis, p. 37, and Hunting, p. 74.)

[7] "Corinna," writes Denis Donoghue, "is a machine, her bedroom a factory; when she goes to bed, the factory is shut down"; see Donoghue's *Jonathan Swift: A Critical Introduction* (Cambridge: Cambridge Univ. Press, 1969), p. 207. As Ehrenpreis (p. 46) notes, the depiction of such mechanical women is a "staple motif in American humorous literature." Hunting (p. 48) objects that the whore is "not funny" and is "horrible to contemplate"; he accuses (p. 77) Swift of exaggeration: "Surely no such 'heroine' as Corinna ever lived." This, of course, is exactly my point in the present study.

[8] Donoghue, p. 199.

[9] It seems likely to me that Swift, in his couplet, makes a scriptural allusion: *cf.* Proverbs 7.

[10] Donoghue (p. 207) rightly refers to Corinna, in her efforts to reassemble her personhood, as "a resourceful mechanic."

[11] Marcia Heinemann, "Swift's 'Corinna' Again," *Notes and Queries,* 19 (June 1972), 218-21.

[12] Maurice Johnson, *The Sin of Wit* (Syracuse: Syracuse Univ. Press, 1950), p. 115.

[13] Jaffe, p. 105.

EMOTION AND PHILOSOPHY OF MIND: D. H. LAWRENCE'S NARRATIVE TECHNIQUE

Raymond J. Wilson III
Department of English
Loras College
Dubuque, Iowa

D. H. Lawrence reveals emotion through at least six narrative methods, three drawn from Philosophy of Mind and three transcending it. Considerations drawn from Philosophy of Mind provide titles for three of Lawrence's methods: (1) descriptions of bodily feeling; (2) descriptions of behavior which directly reveals emotion; (3) descriptions of states of consciousness. In addition, Lawrence relies upon three "literary" narrative techniques which transcend those identified through Philosophy of Mind; the literary methods for revealing emotion are: (4) the loading of a scene with overtones of emotion felt but not recognized by the characters; (5) descriptions of external objects and other people which actually reveal emotion in character; (6) symbolic action—behavior of characters which reveals emotion indirectly by reference to a system of ideas established elsewhere in the work.

Controversies in Philosophy of Mind provide the context for these categories. Philosophy of Mind contains the study of emotions; and in this pursuit, Jean-Paul Sartre identifies three categories that we can apply to Lawrence: bodily reaction, behavior, and states of consciousness. Philosophers of Mind split into two groups depending on whether they consider these categories as sources for facts or as directly intuited phenomena. Philosophers seeking to study emotion through isolating facts as in any other scientific investigation fall into the psychological school of Philosophy of Mind; those seeing emotions as self-significant phenomena fall into the category of the Phenomenologists. In seeking to establish relationships among the three basic categories, the psychological school splits: theorists of the intellectualist persuasion hold that there is "a constant and irreversible succession between the inner state considered as antecedent and the physiological disturbance considered as consequents."[1] In contrast, the second psychological theory, called the peripheric theory, which holds that "a mother is sad because she weeps," reverses the order of the factors, claiming that bodily disturbances cause the mental states which we recognize as emotions. The reliance of both branches of the psychological school upon facts, which have no significance in themselves, says Sartre, led to the reaction known as Phenomenology. Its founder Hussrl (and also Heidegger and Kierkegaard) directed attention toward emotion as phenomena the significance of which can be directly and intuitively known.

In arguing against the position of the Phenomenologists, Moreland Perkins relates the theme to literature and specifically to Lawrence's narrative techniques. Perkins's argument appears in an article in *The Philosophical Review* (1966); while not holding with William James the extreme peripheric position that emotion is *merely* our awareness of bodily feeling, Perkins does argue that "bodily feeling occupies a central place in emotional experience."[2] To support his claim, Perkins contends that novelists who are noted for "their power to convey to us the emotions felt by their 'characters,' " gain their power by including mention of the characters' bodily feelings. Perkins's first example comes from Lawrence's *The Rainbow* in the scene where Tom Brangwen proposes to Lydia Lensky: "She quivered, feeling herself created, will-less, lapsing into him, into a common will with him."[3] Perkins points out that the sentence is about emotion although there is no emotion word in it or near it in the text. "The emotion has no common name and it needs none," says Perkins (p. 156). In Sartre's terminology, "quivered" refers to a bodily reaction while "feeling herself lapse . . ." indicates a state of consciousness. However, according to Perkins, "the participle 'feeling' modifies the verb 'quivered,' follows fast upon 'quivered,' and depends upon 'quivered.' " Perkins says that the word "quivered" is needed to "convince the reader that at this very moment this woman *felt* what the rest of the sentence explains" (p. 157). On such examples rests Perkins's argument that emotion is best conveyed through bodily feeling.

However, a wider examination of Lawrence's technique for revealing emotion indicates that Perkins overemphasizes bodily feeling as Lawrence's narrative technique. For example, in the opening pages of *Women in Love* we see elements of exterior behavior used alone and in combination with states of consciousness. In such combinations they form an exterior/interior counterpoint that multiplies, rather than merely adds their effects. In the novel's opening scene, two sisters, Ursula and Gudrun, discuss marriage, especially the unhappy situation by which a woman must marry in order to be "in a better position."[4] Gudrun, who is sketching, picked up her eraser "almost angrily," according to the author. Here, Lawrence puts the reader into the position of someone in the room, observing the conversation; he implies that we at times detect emotions by observing simple bodily gestures such as Ursula's picking up the eraser. This assumption, underlying the narrative technique, continues as Lawrence says that "Gudrun flushed dark." Here we are to draw whatever conclusions about her emotions that we might draw if we were present in the room and saw her blush. In these examples Lawrence primarily relies on describing behavior which is assumed to directly reveal emotion. However, Lawrence does not limit himself to external signs. When Ursula says that she has turned down a marriage offer that would have meant "a thousand a year, and an awfully nice man," she says she was not tempted; "I'm only tempted *not* to," she says, and we then find the following sequence:

> The faces of both sisters suddenly lit up with amusement. "Isn't it an amazing thing," cried Gudrun, "how strong the temptation is, not to!" They both laughed, looking at each other. In their hearts they were frightened. (*Women in Love,* p. 2)

Lawrence describes emotion through behavior in the passage: the faces "lit up" and the sisters laughed. As a person present in the room, one could only assume that the women felt delight and amusement. But in the last sentence Lawrence introduces the counterpoint, claiming that both also felt fear, and Lawrence uses what Sartre called state-of-consciousness terminology to introduce this contrasting, tension-producing fact of secret fear. Bodily feeling, which Perkins stresses, is absent, yet the passage gains strength through the tension between outward amusement and inward fear.

An amplifying example comes later in the novel. In describing the complex relationship between Gerald Crich and Rupert Birkin in *Women in Love,* Lawrence resorts to externals of behavior and to bodily feeling in the well-known "Gladiatorial" chapter in which the two men strip and wrestle "swiftly, rapturously, intent and mindless at last, two essential white figures working into a tighter, closer oneness of struggle" (*Women in Love,* p. 263). But Lawrence has no reservation about also having his character Birkin later explain in state-of-consciousness terminology that "to make it complete, really happy, I wanted eternal union with a man too: another kind of love" (*Women in Love,* pp. 472–73). In such subtle interaction of behavior and state-of-consciousness, Lawrence's narrative technique serves him well. Birkin's expression, "another kind of love," would communicate little if Lawrence had not preceded it with active depictions of both behavior and bodily feeling which give flesh to the skeleton provided by the concept word, "love."

Perkins's contention is that Lawrence relies on bodily feeling because this narrative technique is intrinsically the best way to present emotion. This is not the case; complex literary considerations dictate Lawrence's choice. Furthermore, Lawrence could not rely exclusively on state-of-consciousness techniques for narrative presentation of emotion because one of Lawrence's central situations is that in which the character denies or refuses to become conscious of an emotion. In his story, "The Prussian Officer," for example, Lawrence describes an officer's "passion" for his enlisted man. The officer, according to Lawrence, "was a gentleman, with long, fine hands and cultivated movements, and was not going to allow such a thing as the stirring of his innate self. He was a man of passionate temper, who had always kept himself suppressed."[5] Although Lawrence does not specify the emotion as homosexual passion, he does stress the officer's barren emotional sex life with women and his bachelorhood at age forty. "He *would* not know that his feeling for his orderly was anything but that of a man incensed by his stupid, and perverse servant," says Lawrence. "So, keeping quite justified and conventional in his consciousness, he let the other thing run on" (p. 100, my emphasis).

Lawrence readily uses state-of-consciousness words such as "anger" and "hate" in this story. But, writing in the early twentieth century, Lawrence may have been reticent to openly broach the topic of homosexuality; thus, in addition to the problem of depicting an emotion being internally censored by the character, Lawrence was himself contending with external forces of censorship. In such a situation, Lawrence turns to Sartre's first category, bodily sensation, to reveal emotion. The young soldier's presence "was like a warm flame upon the older man's tense, rigid body," (p. 97) and later: "The officer's heart was plunging" (p. 101). The situation is even more subtle than we have so far explained. It is not that the captain felt homosexual desire and covered it with feigned anger, but that, in blocking himself from awareness of the nature of his passion, the officer really did feel anger instead. Furthermore, the officer's primary defense against recognizing his emotion has apparently been to withdraw from the animal instincts, to become abstract and intellectual. And it is with state-of-consciousness "emotion words" like "hate" that Lawrence reveals how the soldier's presence unintentionally weakened the captain's defense: "To see the soldier's young, brown, shapely peasant's hand grasp the loaf or the wine bottle sent a flash of hate or of anger through the elder man's blood (p. 97). Later in the story it is the youth's unconscious animality in putting that same arm around the soldier's girlfriend that incenses the officer. That Lawrence describes the young soldier's reciprocal hatred and anger in terms of intense bodily feeling may be because Lawrence has introduced the youth as a person who "seemed never to have thought, only to have received life direct through his senses, and acted straight from instinct" (p. 97). The use of bodily feeling is thus not dictated by the absolute notion that this is the "best" way of depicting emotion as Perkins suggests, but by the requirements of a complex narrative situation.

Lawrence resorts to a more purely literary technique in solving a similar problem when he describes the beginning of sexual attraction between Paul and Miriam in *Sons and Lovers*. The education of both children has been so restrictive that neither would recognize a sexual feeling in him or herself. Therefore neither could think of the emotion in what Sartre called state-of-consciousness terminology. One solution to this problem is revealed by a study of the swing scene in the chapter entitled "Lad and Girl Love" in *Sons and Lovers.* The external behavior is nothing beyond an innocent exchange of swinging on a rope and pushing each other; there is no state-of-consciousness language in either Lawrence's words or the characters' minds to indicate sexuality; and, although the bodily-feeling language is much more intense than one would expect for a mere swing ride, this language standing alone does not necessarily indicate sexual emotion. Lawrence, therefore, resorts to having the conversation and description carry overtones of sexuality that are unintended by the characters though almost certainly intended by Lawrence. Consider the following sequence:

> . . . the youth and girl went forward for the great thick rope . . . then immediately he rose . . . she made the swing comfortable for him. That gave her pleasure. . . . Almost for the first time in her life she had the pleasure of giving up to a man . . . in a moment [he] was flying . . . she could feel him falling and lifting through the air . . . "Now I'll die," he said, in a detached, dreamy voice . . .[6]

The youth and girl are completely unprepared to think in concepts about sexual emotions and know only that they are feeling something.

Lawrence's narrative method of loading the scene with sexual overtones becomes even more evident when Miriam takes her turn:

> "It's so ripping!" he said, setting her in motion. "Keep your heels up, or they'll bang the manger wall."
>
> She felt the accuracy with which he caught her, exactly at the right moment, and the exactly proportionate strength of his thrust, and she was afraid. Down to her bowels went the hot wave of fear. She was in his hands. Again, firm and inevitable came the thrust at the right moment. She gripped the rope, almost swooning. (*Sons and Lovers,* p. 151)

When Paul "mounted again," the sexual parallel continues although this time from the perspective of Miriam as she watches Paul:

> Away he went. There was something fascinating to her in him. For a moment he was nothing but a piece of swinging stuff; not a particle of him that did not swing. She could never lose herself so, nor could her brothers. It roused a warmth in her. It were almost as if he were a flame that had lit a warmth in her whilst he swung in middle air. (*Sons and Lovers,* p. 151)

In the swing scene Lawrence avoids state-of-consciousness language where sexuality is concerned but does not hesitate to name states-of-consciousness when speaking of fear or fascination. There is also no overtly sexual behavior, yet sexual attraction in an innocent "Lad-and-Girl Love" is surely the topic. Bodily feeling depicted by the "hot wave" and "flame" images, though excessive for a mere swing ride, would not be enough in themselves to communicate sexual attraction, so Lawrence sprinkles the passage with words and phrases that would be appropriate for the description of adults making love: "pleasure . . . giving up to a man . . . flying . . . falling and lifting . . . 'Now I'll die' . . . 'Keep your heels up' . . . firm and inevitable came his thrust . . . mounted again . . . he was nothing but a piece of swinging stuff." Thus we see, not a Lawrence favoring bodily feeling over the other two categories, but an author choosing his narrative strategies among the three Philosophy of Mind alternatives, combining them in various ways according to the situation and adding purely literary techniques that go beyond Sartre's three categories.

The relationship between Gertrude and Walter Morel in *Sons and Lovers* is another such complex interaction of emotions where Lawrence uses a purely literary technique—the description of an external object to reveal emotion. Lawrence certainly does not shrink from depicting emotion through bodily feeling in this book; after one argument, the pregnant Gertrude Morel "walked down the garden path, trembling in every limb, while the child boiled within her" (*Sons and Lovers,* p. 23); however, in this novel we also see Lawrence using external objects to correlate with internal emotion. At the very moment Gertrude is having the baby, Walter works in the mine on a rock "that was in the way of the next day's work. As he sat on his heels, or kneeled, giving hard blows with his pick, 'Uszza—uszza!' he went," says Lawrence. Walter's workmate advises him to avoid "hackin' thy guts out," but Morel insists on overworking himself into a frenzy (*Sons and Lovers,* pp. 30–31). He is the last to quit the mine and when he arrives home he finds to his surprise that Gertrude has given birth to his son, Paul. Lawrence does not comment on the physical parallel between the birth struggle and the effort to dislodge the rock from the coal seam, but the parallel works subtly to inform the reader that both of these people are besieged by frustrating emotional conflicts.

A similar, but even more revealing use of an external object occurs in *Women in Love* as Ursula walks through the woods:

> She started, noticing something on her right hand, between the tree-trunks. It was like a great presence, watching her, dodging her. She started violently. It was only the moon, risen through the thin trees. But it seemed so mysterious, with its white and deathly smile. And there was no avoiding it. Night or day, one could not escape the sinister face, triumphant and radiant like this moon, with high smile. (*Women in Love,* p. 237)

While Lawrence ostensibly describes the moon as an external object, he is really opening the reader to depths of Ursula's emotion. In Ursula's violent start, Lawrence does give us a behavioral component of her emotion but this would be far less meaningful if it were not combined with attributing to the moon a deathly smile, a sinister and triumphant face, and a desire to watch Ursula. These are obviously not realistic attributes of the moon but projections of the woman's emotion.

A similar concept of projection helps provide the rationale for explaining several profoundly emotional scenes in *The Rainbow.* Two kissing scenes—involving Anna Brangwen and, after the span of a generation, her daughter Ursula—reveal the subtle effect of projection when the projection is applied not to an object but to another person. Lawrence narrates both scenes in third person from the point of view of the male partner of the encounter. In the first, Lawrence employs bodily feeling to reveal the young man's emotion; the scene thus parallels the one explicated by Professor Perkins. The second contains projection in contrast to the earlier scene between Tom and Anna Brangwen. In the scene with Anna and Tom:

> "My love," she said, her voice growing rapturous. And they kissed on the mouth, in rapture and surprise, long, real kisses. The kiss lasted, there among the moonlight. He kissed her again, and she kissed him. And again they were kissing together. Till something happened in him, he was strange. He wanted her. He wanted her exceedingly. She was something now. They stood there folded, suspended in the night. And his whole being quivered with surprise, as from a blow. He wanted her, and he wanted to tell her so. But the shock was too great to him. He had never realized before. He trembled with irritation and unusedness, he did not know what to do. (*The Rainbow,* p. 120)

The passage continues mostly with repetition for effect and with Lawrence's depiction of Tom's gradual return to awareness of their surroundings in a moonlit field. Although the opening sentences could be interpreted as a neutral third-person narrative from outside the actors, the latter part makes clear that Lawrence is telling us what Tom feels, the words "quivered" and "trembled" providing a component of bodily feeling.

The following similar passage contains a decisive difference; here Lawrence describes the kiss of Anton and Ursula, Anna's daughter:

> Then there in the great flare of light, she clinched hold of him hard, as if suddenly she had the strength of destruction, she fastened her arms round him and tightened him in her . . . increasing kiss, till his body was powerless in her grip, his heart melted in fear from the fierce, beaked, harpy's kiss. The water washed again over their feet, but she took no notice. She seemed unaware, she seemed to be pressing in her beaked mouth till she had the heart of him. (*The Rainbow,* p. 479)

This passage expresses Anton's fear of Ursula's passion. Using a state-of-consciousness term, Lawrence clearly states that the man was in "fear." This fear becomes evident to the reader, however, more through attributes ostensibly attributed to Ursula: her "strength of destruction," for example, and her harpy's beak. Like the grinning moon of the earlier quoted passage, these supposed attributes of Ursula tell us more of Anton's emotion than they do about Ursula. Anton may notice the lapping of the wave about their feet but she "seemed unaware," terminology which indicates that Lawrence is narrating the passage from outside of her mind. And, since they are not realistic descriptions, the best assumption is that such depictions reveal the emotion that Anton felt toward Ursula.

After this kiss, Ursula initiates a sexual encounter with Anton Skrebensky, and then she breaks off with him, finding the experience utterly unfulfilling. Subsequently discovering herself with child, Ursula thinks she might write to Skrebensky in India where he has been posted and, unbeknownst to her, been married to his colonel's daughter. Ursula tries to convince herself that "Only the living from day to day mattered," that she "had been wrong, she had been arrogant and wicked, wanting that other thing, that fantastic freedom, that illusory, conceited fulfillment which she had imagined she could not have with Skrebensky" (*The Rainbow,* pp. 483–84). She asks whether it is not enough that she be satisfied with "her man, her children, her place of shelter under the sun" (*The Rainbow,* p. 484). Ursula has tried through her part of the novel to break the bounds of such conventionality, and been thwarted at every turn; she now considers giving in to the pressure to be a conventional wife: "Was it not enough for her, as it had been enough for her mother?" she asks (p. 484). This would run totally contrary to Ursula's emotional needs. Lawrence has thus set himself the task of revealing the emotion of a character who is, herself, denying those emotions.

Behavior and state-of-consciousness are inappropriate narrative methods for this situation; and, since the character is steadfastly deceiving herself about her bodily feelings there is little chance that the reader will correctly understand the emotional implications of Ursula's bodily feeling.

To solve this problem Lawrence again goes beyond the three basic tactics laid down by Sartre and employs a literary tactic unrelated to Philosophy of Mind: symbolic action. In a depressed state, Ursula wanders into a field. It is raining, and thunder and lightning begin. Suddenly she hears horses' hoofs beating on the path ahead of her; she turns but the riderless horses head her off. Each way she turns they are waiting for her, blocking her back. The horses roar very close, terrorizing her; "in a flame of agony, she darted, seized the rugged knots of the oak tree and began to climb" (*The Rainbow,* p. 489). We do not need to evoke Lawrence's frequent use of trees as male sex symbols to see the episode as a microcosmic recapitulation of Ursula's emotional development in the novel; both in the scene and in the novel at large she has made determined efforts and been brought to bay. But she uses the branches of the oak to reach the hedge and to fall in a heap on the other side. The horses were stopped by the hedge: "They were almost pathetic now. Her will alone carried her" across the bare field, "till, trembling, she climbed the fence" (*The Rainbow,* p. 489).

After this experience, Ursula "was very ill for a fortnight" (*The Rainbow,* p. 490). She experiences the illness as a compression, finally realizing that the "compression was Anton and Anton's world . . . She fought and fought and fought all through her illness to be free of him and his world" and at last succeeded (p. 491). Thus Lawrence continues the parallel, and the episode in the field with the horses serves not only to recapitulate but to forecast Ursula's assertion of her will over the forces that are trying to block her into a conventional existence. Not only does the scene reveal Ursula's emotion subtly and intensely, it also serves, along with the ensuing illness, as the catalyst for her decision not to marry Anton. The child is lost through miscarriage but she knows "it would have made little difference" to her decision (p. 493). Anton's telegram revealing the fact that he is married comes only as a relief to Ursula.

Symbolic action forms a literary strategy in the "Moony" chapter of *Women in Love,* where Ursula watches from hiding as Birkin moves near the mill pond. She first hears him address the Near-Eastern moon goddess: "Cybele—curse her!" He thus evokes an entire mythology of the Virgin goddess of the moon, as well as centuries of associated commentary and philosophy. Birkin then collects rocks and begins stoning the image of the moon in the mill pond. When Birkin finally relents from his temporary state that Lawrence says is like "a madness," Ursula reveals herself from her hiding place and asks Birkin, "Why should you hate the moon? It hasn't done you any harm, has it" (*Women in Love,* pp. 238–241). But Birkin answers with his own question, "Was it hate?" Neither can answer and they lapse into silence. The mythological allusion and Birkin's symbolic action evoke in the reader a complex reaction to an extremely intricate set of emotions. Birkin's question points out that our existing "emotion" terminology is inadequate to handle such a situation through abstract concepts.

Moreland Perkins's thesis that Lawrence derives his power in communicating emotion primarily from his use of the bodily-feeling component of the emotion is thus not an accurate description of Lawrence's practice. As we have seen in this paper, Lawrence uses the bodily-feeling component when that is the most appropriate, but he also uses the other two categories laid out by Sartre—state-of-consciousness and behavior—when they are most appropriate. Lawrence not only uses these three categories in various combinations, but he also goes beyond the categories taken from Philosophy of Mind to create more purely literary methods of narration, such as loading a scene with overtones, the description of objects and even of other characters to reveal emotion, and the working out of elaborate symbolic actions such as the horses in *The Rainbow* and the stoning of the moon in *Women in Love.*

A scene from *Sons and Lovers* perhaps provides an insight into Lawrence's operating principle. Miriam looks at one of Paul's paintings and asks, "Why do I like this so?" Paul answers:

> It's because—it's because there is scarcely any shadow in it; it's more shimmery, as if I'd painted the shimmering protoplasm in the leaves and everywhere, and not the stiffness of the shape. That seems dead to me. Only this shimmeriness is the real living. The shape is a dead crust. The shimmer is inside really. (*Sons and Lovers,* p. 152)

These are the relatively inarticulate words of the young Paul Morel, but if expanded they could perhaps be considered somewhat of a creed for Lawrence in his narrative method. Human emotion, revealed and projected outward, stands at the center, at times giving meaning, "shimmeriness," to the landscape, the rocks in Walter Morel's mine, and the remote moon.

Notes

[1] Jean-Paul Sartre, *The Emotions: Outline of a Theory,* tr. Bernard Fechtman (New York: Philosophical Library, 1948), p. 7–8.

[2] Moreland Perkins, "Emotion and Feeling," *The Philosophical Review,* 75, 2 (April 1966), p. 155.

[3] D. H. Lawrence, *The Rainbow* (1915; rpt. New York: Viking, 1961), p. 40. Further references to *The Rainbow* are to this text.

[4] D. H. Lawrence, *Women in Love* (1920; rpt. New York: Viking, 1960), p. 1. Further references to *Women in Love* are to this text.

[5] D. H. Lawrence, "The Prussian Officer," *The Complete Short Stories of D. H. Lawrence,* Vol. 1 (New York: Viking, 1961), p. 98. Further references to "The Prussian Officer" are to this text.

[6] D. H. Lawrence, *Sons and Lovers* (1913; rpt. New York: Viking, 1968), p. 150. Further references to *Sons and Lovers* are to this text.

SAMUEL MILLER: A TARGET FOR WASHINGTON IRVING

Henry J. Lindborg
Marian College of Fond du Lac

Knickerbocker's History of New York (1809), Washington Irving's first book, secured fame for its twenty-six-year-old author and created the enduring persona of Diedrich Knickerbocker, whose account of the Dutch settlement has remained vivid while the works of more sober historians fade. Though critics have counted the *History* among Irving's most effective creations, even firm admirers have been impatient with its Book One; written in collaboration with Washington's brother Peter, it recounts competing theories of creation while tracing New York's history back to the origins of the world. Richard Henry Dana, for example, thought it "laborious and up hill,"[1] and Edwin W. Bowen described the first chapters as "somewhat stilted, pompous and pedantic," and felt that they made "the unhappy impression that the authors were feeling their way and were not yet sure of their footing."[2] This view is lent support by literary historians' failure to find clear targets for the satire of Book One; for the vigor of the *History*, as Henry S. Canby remarked, depends upon Irving's "own observation, his own prejudice and rooted dislike, to add to the documents he drew upon."[3]

How the learned affectation of Book One might reflect anything more than some general Swiftian pretensions at first seems baffling. The 1809 edition announced that Book One was, "like all introductions to American histories, very learned, sagacious, and nothing at all to the purpose."[4] All American histories are rather an amorphous target, though in his 1848 "Author's Apology," Washington suggests a slightly narrower aim:

> "To Burlesque the pedantic lore displayed in certain American works, our historical sketch was to commence with the creation of the world; and we laid all kinds of works under contribution for trite citations, relevant or irrelevant, to give it the proper air of learned research."[5]

However, Irving editors Stanley T. Williams and Tremaine McDowell were puzzled, asking, "Who were these writers with their pompous rhetoric and their learned notes? No book can be named with certainty."[6]

For a work "above all . . . written with a home town audience in mind"[7] to resort to such scholarly display without a clear local target suggests indeed that the authors had not yet found their footing, and that at best they were diminishing their subject, employing the manner of a mock chronicle to place their little society at the end of cosmic processes. A more sophisticated view might add that the Irvings were also positing that their history's prelude does not rest on the rock of shared myth but upon the shifting sands of 18th century cosmological speculations. Though this interpretation fits nicely William Hedges' claim that the "*History of New York* consistently ridicules the possibility of acquiring certain or reliable knowledge," finally "reducing history almost to blank enigma," it does not address that nagging historical question.[8] The Irvings claimed to have histories in mind. If they did not, why did they make the claim, and why did Washington repeat it when he revised the book almost forty years later?

Is there no author in the Irving neighborhood whose pedantic display might have provoked that satire-producing admixture of "prejudice and rooted dislike"? Since the *History* is dedicated to the New York Historical Society, that venerable institution is a good place to look for someone addicted to amassing scholarly references. Samuel L.

Mitchell may be a candidate, since he was an eccentric historian with broad academic interests; however, while he may have represented the pedantic mental cast of the establishment to the Irvings, his *The Picture of New York,* which is cited in the *History,* does not contain the sort of notation used in Book One. While Mary W. Bowden may be correct in asserting that there is significant "satire in Knickerbocker's *History* of the type of men who founded the New York Historical Society, if not the founders themselves,"[9] the Irvings specified works rather than types; therefore, further search for one whose scholarly practices in a published volume approximate those attacked in the *History* is necessary.

Besides Mitchell, another prominent member of the New York Historical Society was the Rev. Samuel Miller (1769-1850), an important Presbyterian clergyman. In 1797 he began to collect materials for a history of New York, and he was given permission to make copies of documents without fee by an act of the legislature in 1798. According to his son, he "labored long in a desultory way" on the project and only gave it up in 1813 when he departed for Princeton, where he had a distinguished career as professor of church history.[10] This research interested him in founding the New York Historical Society (1804), for which he was Corresponding Secretary at the time of Washington Irving's appointment to membership. One of his discourses was the first historical article published by the Society.[11] Since Miller never finished his history, Michael Black has advanced a cogent argument that "Irving . . . was competing historically with an official historian, and when he won, or realized he was going to win, he laughed at the loser and those who supported him."[12] Thus Miller may be seen as a target, not on the basis of what he wrote, but because of what he didn't write: a definitive history of New York, for which he had collected masses of information.

An additional reason for Miller to have been attacked may have been his loyalty as "a warm partisan of Mr. Jefferson's politics and administration as President," a point of view likely to spark "rooted dislike" in the Irvings.[13] But more significantly, he did produce a major work which contains all of the scholarly apparatus mocked in the *History:* the two-volume *A Brief Retrospect of the Eighteenth Century* (1803), which gave its author a local and international reputation and a legitimate claim to the title of America's first intellectual historian.[14]

Originally the *Retrospect,* which was conceived as a sermon on the turn of the century, was to have covered all aspects of the eighteenth century, including theology, morals, and politics; though this design was never completed, the two volumes encompass twenty-four areas, including such subjects as physiognomy and Oriental literature. It was necessarily a patchwork job, an encyclopedic compilation which compensated for lack of depth with extensive notes, which the Irvings may be parodying in Book One. In applying the methods of the intellectual historian Miller comments that science in the eighteenth century "led to the erection and successive demolition of more ingenious and splendid fabrics" (*Retrospect,* I, 417). The Irvings make an interestingly similar remark that "philosophers demolish the works of their predecessors, and elevate more splendid fantasies in their stead, which are in turn demolished and replaced by the air castles of a succeeding generation" (*History,* p. 33). Though Miller expended great energy in the effort to compare these theories as a worthwhile historical enterprise, the Irvings reduced the endeavor to absurdity, through both the context of the mock chronicle and its tone.

All of the speculations on the origin of the earth mentioned in the *History,* with one exception, are also found in the *Retrospect.*[15] Note the likeness of the treatments of Buffon's ideas: "A comet falling into the body of the sun with great force, struck from its surface a large mass of liquid fire . . . This fragment forms the globe we inhabit" (*Retrospect,* I, 165). "This globe was originally a globe of liquid fire scintillated from the body of the sun by the percussion of a comet" (*History,* p. 29). Difference in tone may be noted in discussions of Whiston's theory: According to Miller, Whiston supposed "the earth in the beginning to be an uninhabitable comet, . . . in the form of chaos." The flood came about on account of another comet, which "involved our globe in its atmosphere and tail for a considerable time, and deposited its vapours on its surface, which produced violent and continuous rains" (*Retrospect,* I, 160). The *History* states, the earth "was originally a chaotic comet . . . The philosopher adds, that the deluge was produced by an uncourteous salute from the watery tail of another comet; doubtless through sheer envy of its improved condition" (*History,* p. 29).

Miller concluded that eighteenth century science provided orthodox religion with tools to defend the Bible as an historical document: "Every sober and well-directed inquiry into the natural history of man, and of the globe we inhabit," he writes, "has been found to corroborate the Mosaic account of the Creation, the Fall, the Deluge, the Dispersion, and the important events recorded in the sacred volume" (*Retrospect,* I, 434). While the *History* also supports the Mosaic account (pp. 24, 37), its tone in discussing exploration's contribution to revelation is markedly different from Miller's. The *Retrospect* concluded that

> "the geographical discoveries of the last age have contributed to illustrate and confirm Revelation. Behring and Cook were before-mentioned as throwing light on the population of the New World, and thus tending to support sacred history. But besides these, the knowledge gained by modern voyagers and travellers, of the manners, customs, and traditions of different nations, especially those on the Eastern Contient, has served to illustrate the meaning and unfold the beauty of many passages of scripture, before obscure, if not unintelligible" (*Retrospect,* I, 357).

The Irvings

> "should not be surprised if some future writers should gravely give us a picture of men and manners as they existed before the flood, far more copious and accurate than the Bible; and that, in the course of another century, the log-book of the good Noah should be as current among historians as the voyages of Captain Cook, or the renowned history of Robinson Crusoe" (*History,* p. 39).

Circumstantial and textual evidence, then, point to *A Brief Retrospect of the Eighteenth Century* as a likely target for the Irvings: In subject matter and method it closely parallels sections of Book One and is authored by a local historian of importance. But what was their point? Perhaps, following Professor Black's lead, it was that were Miller ever to finish his history of New York, his pedantry would drive him to preface it with the history of the world. In fact, this is what he had done, since for six years prior to the *Retrospect* he had been working on a history, but produced instead a compendium of virtually every area of human acivity except what went on in New York.

The satire may also strike yet closer to home. Miller was the pastor of Irving's father's church. Young Washington—and presumably his brother Peter—disliked the gloom of the frequent prayer sessions to which his father subjected the family. Though Washington never mentioned Miller, it may also be likely that he rebelled against some of the minister's attitudes toward the vocation which drew him: writing. For example, at the same time that Miller accurately analyzed the failure of America to excel in the arts owing to its commercial spirit, he contended that only one novel out of a thousand might be worthwhile, and the others constituted a criminal waste of time (*Retrospect,* II, 173-74).

If, as Charles Dudley Warner wrote, "The bent of Irving's spirit was fixed in his youth, and he escaped the desperate realism of his generation," it was in reaction to a society which would value him more as a lawyer or businessman than as a writer of fiction.[16] Though he would escape family pressures to go into law or business and turn writing itself into a business during his seventeen year sojourn in Europe, in 1809 Washington Irving was a young man for whom Samuel Miller probably represented established, practical values. In the seemingly irrelevant passages on the creation of the world the two brothers may have been quietly rebelling against an intellectual, religious, and social order which excluded so much of the fun which the *History* provided, mocking a figure of authority for the New York Historical Society, the church, and perhaps the Irving household.

Notes

[1] "'The Sketch Book of Geoffrey Crayon, Gent.,'" *The North American Review*, 9 (September, 1819), p. 345.

[2] "Washington Irving's Place in American Literature," *The Sewanee Review*, 14 (1906), p. 174.

[3] "Washington Irving" in *Classic Americans* (New York, 1931), p. 86.

[4] Washington Irving, *Deidrich Knickerbocker's 'A History of New York,'* ed. Stanley T. Williams and Tremaine McDowell (New York, 1927), p. 15. References within this paper are to this edition.

[5] *Knickerbocker's History of New York* (New York, 1848), p. 1.

[6] Williams and McDowell, p. xxi.

[7] Mary Witherspoon Bowden, "Knickerbocker's *History* and the "Enlightened" Men of New York City," *American Literature*, 47 (May, 1975), p. 159.

[8] *Washington Irving: An American Study, 1802-1832* (Baltimore, 1965), pp. 72, 108.

[9] "Knickerbocker's *History*," p. 163.

[10] Samuel Miller, Jr., *The Life of Samuel Miller* (Philadelphia, 1869), I, 110.

[11] *Life*, I, 276.

[12] Michael L. Black, "Political Satire in Knickerbocker's *History*" in *The Knickerbocker Tradition: Washington Irving's New York*, ed. Andrew B. Meyers (Tarrytown, 1974), p. 80.

[13] *Life*, I, 131.

[14] The best study of the *Retrospect* is Gilbert Chinard's "Progress and Perfectibility in Samuel Miller's Intellectual History" in *Studies in Intellectual History*, ed. George Boas (Baltimore, 1953).

[15] The Irvings recount the theories of Buffon, Hutton, Whiston and Erasmus Darwin with some detail. Burnet, Woodward and Whitehurst are mentioned. Only Darwin is not found in Miller.

[16] "Washington Irving," *The Atlantic Monthly*, 45 (March, 1880), p. 408.

INTEGRATING FINITUDE: THE EXPERIENCE OF TIME IN PROUST AND EINSTEIN

SAAD N. AHMED
Department of English
Augustana College, Rock Island, Illinois

Time for you and time for me,
And time yet for a hundred indecisions,
And for a hundred visions and revisions,
Before the taking of a toast and tea.

T. S. Eliot, "The Song of J. Alfred Prufrock," 1915

Everywhere, this second has already been replaced by another second, in a sequence frozen forever. Such a view appeared all the more convincing with the establishment of Standard Time at the turn of the century—all around the globe time was coordinated.[1] From an unused future, existence moves universally towards a shadowy past and ultimately dissolves in the darkness of the forgotten.

In the era that established Standard Time, the work of a novelist, Marcel Proust, and a physicist, Albert Einstein, liberated time from its foreordained tracks. After an active social life in the Parisian salons, Proust, in 1909, began his novel, *À la recherche du temps perdu,* and devoted the rest of his life to its writing. In 1905, the unknown Einstein, working in the Swiss Patent Office, published a short paper, "On the Electrodynamics of Moving Bodies," which initiated the special theory of relativity. Although Proust was aware of Einstein's theories, which gained popularity in France after the First World War, they did not exercise a direct influence on him for the following reasons: 1. he conceived his work before they were popularized; 2. in spite of his admiration for Einstein, he found the language of his theories too unfamiliar.[2] Affinity, rather than influence, defines the relation between these two thinkers.

For both Proust and Einstein, time does not flow in a neutral course but depends on the experiencer. Here, experience means more than just what is empirically present to the perception; it refers to the way man situates himself in the world. Keeping this distinction in mind, the present study pursues the question: how, in the work of Proust and Einstein, does one experience time? While Proust's novel describes qualities of time—the past, present, and future, as related in memory, Einstein's theory delimits quantities of time as measured by a clock. Nevertheless, both present time as an experience of finitude, a finitude which integrates the experiencer in his history and world.

In the long tradition of the quest theme in Western literature, Proust entitles his work, *À la recherche du temps perdu,* which one critic translates, freely but significantly, as *Quest of Time Lost.*[3] Proust once told an interviewer that, "we have both plane and solid geometry—geometry in two-dimensional and three-dimensional space. Well, for me the novel means not just plane (or plain) psychology but psychology in time. It is this invisible substance of time that I have tried to isolate."[4] Proust's quest unfolds within three perspectives: those of the protagonist, narrator, and author. Suffering, changing, and growing, the protagonist, called Marcel, has an immediate interaction with the present. The narrator recounts the growth of Marcel. Throughout the narrative, he observes him moving in the past like a man watching at night the light which left a star years ago. In the last volume, the narrator and his former self, Marcel, merge. The author, Proust, describes Marcel's movement towards the narrator, and then, their merging at the moment when he can pronounce the quest successful.

All three, Marcel, the narrator, and Proust, encounter time through memory. The importance of memory becomes evident in the English title of the novel, *Rememberance of Things Past*. Neglect of memory and the different kinds of memory affect the experience of time. Thus, unaware of its power, Marcel feels imprisoned in time: he lives the hours, days, and years, as they come and pass by, leaving him with a sense of emptiness and waste. But in certain unexpected moments, through the grace of involuntary memory, he relives past events as if they were taking place in the present. When he realizes the significance of these moments, he reaches the insight which the narrator has: now, both have the same experience of time. Although Proust depreciates voluntary memory in favor of involuntary memory, to create a novel of such structural magnitude requires both kinds.[5] The quest which starts with remembering ends with creation.

Time is regained in the creative act. Marcel relives the past as an actuality within the context of the present—this relation between the past and present endows both with a new meaning, for, to use the words of T. S. Eliot, "the past should be altered by the present as much as the present is directed by the past."[6] This active experience of the past in the present influences Marcel's future. Discovering his vocation, to be the artist who writes down his quest, he takes hold of the future. Created by his past, the artist recreates this past. His work of art grounds the shifting perspectives of the past, present, and future.

Unlike Proust, Einstein, the physicist, defines time with a measuring instrument. For this purpose, an object with a rhythmic motion may serve as a kind of clock. From this viewpoint, the human body contains many clocks such as the one established by the heart beat. In the famous example of the time traveller who journeys in space at high speed, he returns to find his world has grown much older than he did. One may speak, in this context, of the human body or a clock interchangeably: the relativity of time affects both in a similar way. However, the present study, because it deals with experience, will refer to a human observer and not a clock.

Time, argues Einstein, depends on the observer measuring it. For an illustration, he stages a scene with three observers: the first one stands on a railway embankment; the second is inside a very long moving train; the third, whom Einstein does not mention, is the physicist himself who observes the other two.[7] The observer on the embankment, with whom the reader identifies, sees a flash of lightning at each end of the train *at the same time*. He supposes that if the observer in the train faced him at exactly the same point when he saw the lightning, then, the observer in the train too should be able to see both flashes *at the same time*. The observer-physicist finds fault with this supposition: for him, the two observers measure time differently because they have different frames of reference.

What the observer on the embankment overlooks is motion: "we cannot attach any *absolute* significance to the concept of simultaneity, but that two events which, viewed from a system of co-ordinates, are simultaneous, can no longer be looked upon as simultaneous events when envisaged from a system which is in motion relatively to that system."[8] Since the universe has no absolute fixed point, one always needs a frame of reference: "Every reference-body (co-ordinate system) has its own particular time; unless we are told the reference-body to which the statement of time refers, there is no meaning in a statement of time of an event."[9] Thus, the physicist has to define the frame of reference of every observer.

Within each frame of reference, time flows uniformly because all that exists within that frame undergoes the same degree of change in time. In the case of the time traveller, he and those he left on earth do not perceive the difference in their aging rate until they meet. Within the frame of reference of the ordinary observer on earth, a frame defined for practical reasons as the same for the whole planet, he can be deceived into believing that his experience of time refers to the ticking of his watch which must be uniform for everyone and everything. He values this measurement as reality and dismisses as subjective lived time (temps vécu), that primordial experience which precedes measurement.[10]

Einstein does not deal with lived time either; he too wants to measure, so to speak, an objective time, albeit a time that depends on a frame of reference. Nevertheless, for him, experience can play a role. At the age of sixteen, he wondered about the paradoxical experience of how light would look to him if he travelled with it at the same speed. The older Einstein concludes that "in this paradox the germ of the special relativity theory is already contained."[11] That a scientist formulates his conception in an abstract theory does not mean that it did not find its source in a representational, even if imaginary, construction.

Experience conceals as well as reveals time. Einstein usually illustrates his theories with representational constructions to show how experience may be deceptive; but then, in explaining the reason behind the illusion, the experience becomes illuminating. In the example under discussion, the observer, from his limited perspective on the embankment, supposes that his counterpart in the train sees the two flashes of lightning at the same time. Actually, the latter, because he is moving towards one flash and away from the other, sees the first flash and then the second. For the observer on the embankment to realize his mistake, he has to adopt the perspective of different frames of reference: his own and that of the train. This, of course, is what the observer-physicist does except that he seems to be nowhere and everywhere. How does he experience time? He can situate himself within the frame of reference of any observer, measuring time as his own but also relative to another frame of reference. If the universe were empty except for one observer, clearly, he could not notice any change in the flow of time. Measuring time in Einstein's theory is a participatory activity which joins interdependent perspectives.

For Proust and Einstein, man experiences time as the horizon of his finitude. In order to be aware of this finitude, he must have opened to him the possibility of seeing through it. The perspectives of Marcel and the narrator parallel that of the observer in the train and the one on the embankment: Proust structures his novel through the viewpoints of Marcel and the narrator; Einstein accounts in his theory for both observers. For the novelist and the physicist the experience of time does not annihilate the finitude of perspectives in one absolute flux but integrates them. Proust becomes the subject and author of his own life. He traces in thousands of pages the labor under finitude. Indeed, finitude dominates his work and life: he died before finishing the last volume, *Time Regained*. But he regains time, not just because, in the usual way, an artist seals his life in a work that may immortalize him, but more suggestively, because the life which the novel depicts discloses a vocation that changes that very life and makes the novel itself possible. The novel points to the integration of a fragmented self in a self-determined history.

Einstein's physicist dwells in an ordered finitude. Time does not stand over against him as an object but pertains to the process of observation itself. Nevertheless, he can measure the time of another observer, systematically. From within his perspective, he realizes that the other observer must see one, then, another flash of lightning. Einstein's theory insists on the observer's perspective, not as a contingent limit, but as a limit binding him to the world.

Both the writer and the scientist encounter in time their integrated finitude. Man belongs to a frame of reference from which he can never escape. Yet, from within this frame, he integrates himself in his history and world. He recognizes that his mode of existing is temporalized.

Notes

[1] On the establishment of Standard Time, see Stephen Kern, *The Culture of Time and Space: 1880-1918* (Cambridge, Massachusetts: Harvard Univ. Press, 1983), pp. 11-15.

[2]. For a detailed discussion of the question of influence, see John D. Erickson, "The Proust-Einstein Relation: A Study in Relative Point of View" in *Marcel Proust: A Critical Panorama,* ed. Larkin B. Price (Urbana: Univ. of Illinois Press, 1973), pp. 247-76.

[3] Robert Champigny, "Proust, Bergson and Other Philosophers," in *Proust: A Collection of Critical Essays,* ed. René Girard (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962), p. 123.

[4] Roger Shattuck provides the complete text of the interview, in English, in the appendix to his *Marcel Proust* (New York: The Viking Press, 1974), p. 169.

[5] See Shattuck, pp. 119-24.

[6] T. S. Eliot, "Tradition and the Individual Talent" in *The Great Critics: An Anthology of Literary Criticism,* 3rd ed., eds. James H. Smith and Edd W. Parks (New York: W. W. Norton and Company, Inc., 1967), p. 715.

[7] *Relativity: The Special and the General Theory, A Popular Exposition*, trans. Robert W. Lawson (New York: Crown Publishers, Inc., 1961), pp. 25-7.

[8] Albert Einstein, "On the Electrodynamics of Moving Bodies" in *The Principle of Relativity: A Collection of Original Memoirs on the Special and General theory of Relativity* by H. A. Lorentz, A. Einstein, H. Minkowski and H. Weyl, trans. W. Perrett and G. B. Jeffery (New York: Dover Publications, Inc., 1923), pp. 42-3.

[9] *Relativity,* p. 26.

[10] On how one learns to live time as defined by a clock, see Leroy Troutner, "Time and Education" in *Existentialism and Phenomenology in Education: Collected Essays*, ed. David E. Denton (New York: Teachers College, Columbia University, 1974), pp. 159-81.

[11] "Autobiographical Notes" in *Albert Einstein: Philosopher-Scientist,* ed. Paul A. Schilpp (Evanston, Illinois: The Library of Living Philosophers, Inc., 1949), p. 53.

MARK TWAIN IN PERSON, 1885: READING IN WISCONSIN

THOMAS PRIBEK
English Department
University of Wisconsin-La Crosse

Mark Twain and his performing partner George Washington Cable devoted a week of their four-month tour during the 1884-85 lecture season to cities in Wisconsin: Janesville, Madison, LaCrosse, and Milwaukee. They appeared in Wisconsin only three weeks before the publication of *The Adventures of Huckleberry Finn.* Interest in Twain's new book was growing as a result of the long and highly successful lecture campaign, and Cable too was quite a sensation with his popular novels of Creole life and his vigorous public campaign for Black equality. Consequently, the two spoke to packed houses across the state and consistently received enthusiastic reviews from their audiences and from the newspaper writers who described the literary event in superlative phrases. The *Janesville Daily Gazette* called their performance "one of the best appreciated given in this city for a long time"; the *Wisconsin State Journal* in Madison said "the entertainment pleased all"; the La-Crosse *Morning Chronicle* pronounced the reading "decidedly the leading success of the winter." One critic has called the tour "the most celebrated reading tour of the decade"; this is the same as calling it *the* entertainment event of the 1880s.[1]

It is no coincidence that we are observing the centennial of *Huck Finn's* publication and a major lecture tour of Twain's career. This tour, his first lengthy stage schedule in fifteen years, was intended to generate sales for *Huck Finn* and raise money for his new publishing house. American publication came on February 18, 1885; *Huck Finn* had been published in England and Canada two months earlier in order to secure the foreign copyrights. Several chapters were serialized by *Century* in December and January to whet the appetites of readers. The lecture tour extended from the middle of November 1884 to the end of February 1885. After a weekend performance in Chicago, Twain and Cable then read in Janesville on January 20th, Madison the 21st, LaCrosse the 22nd, St. Paul, Minnesota the 23rd, Minneapolis the 24th (Sunday the 25th was an off-day), Winona, Minnesota the 26th, Madison again on the 27th, and Milwaukee the 28th and 29th; they then returned to Illinois for readings in Rockford and Chicago. In larger cities like Milwaukee and Chicago, the two would speak on consecutive nights; otherwise, they performed an exhausting schedule of one-nighters. Even Sundays, when Cable refused to work or travel, were hardly restful for Twain. He complained bitterly that Cable's piety actually aggravated the tiresome routine, because Twain could never rest on a day when he performed. During the week the authors usually were traveling and working every day. Twain did make money on the tour and, more importantly, helped stimulate a large first-sale for *Huck Finn,* but he worked considerably harder on the tour than he had planned and, understandably, refused his business manager's proposal to extend it another month. There was never any problem in finding bookings.

Twain's stage performances, part of the marketing for *Huck Finn,* suggest how he wanted the book received. His selections from it are exclusively humorous: Huck and Jim discussing the wisdom of Solomon or the logic of having a separate language for Frenchmen; Huck and Tom planning their ridiculous "evasions" for freeing Jim; and the episode of the river tough fighting, already printed in *Life on the Mississippi.* Twain had considered a program from *Huck*

Finn alone but decided for more variety.[2] Still, he emphasized local color and humor, but not exactly satire. Notice that Jim is likely to be simply a clown in these stage readings. Twain on stage seemed rather like the man who wrote the headnote to *Huck Finn* demanding no serious moral interpretations.

The emphasis on humor from Twain was wise publicity, of course. But in larger context, the tour itself was still part of the long creative process that produced *Huck Finn,* a book which transcends mere entertainment, and marks a change in the direction of Twain's career. He was revisiting his youth in towns where he once lived—Hannibal, Missouri and Keokuk, Iowa, for example—as he had done in 1882 to finish *Life on the Mississippi.* Furthermore, Cable, a friend for two years now, was certainly an influence on Twain's thought. He was best-known, in fact, as a Southerner speaking out against the South for its racism. His latest book had suggested that the South's losing the Civil War was a fortunate outcome. Moreover, Cable actually had helped set the groundwork for *Huck Finn's* reception by breaking from the unofficial literary tradition of Southern apology for slavery and the war. Two years earlier Twain's most biting comments on Southern culture written for *Life on the Mississippi* had been suppressed. (Cable also encouraged Twain to read Malory's *Morte D'Arthur,* and some of his first notebook entries on *A Connecticut Yankee in King Arthur's Court* appear during the tour.) Cable's part in sharpening Twain's social criticism has never been fully explored. Shortly after the tour was finished, Twain wrote a letter, recently discovered, in which he promises to pay tuition and board for one of Yale University's first Black law students.[3]

This lecture tour of the two reconstructed Southerners is also interesting as a portrait of Twain, not just as a footnote to the publication history of *Huck Finn.* It was one of the few (and maybe last) times in Twain's life when everything seemed to be going well for him. His marriage was happy, his reputation as a writer was established, and he was socially and financially secure. At age fifty, Samuel Clemens was a success, before family tragedies and financial difficulties impelled his creative talents toward social invective. A middle-aged man now, everything he wrote sold. He was comfortable with his work and his audience, and they were comfortable with him. He was "Mark Twain" to them, the humorous writer from the American frontier, recognized as such and generally pleased by his reputation. He did once, at least, complain to Cable that he was cheapening himself as the humorist only, but any dissatisfaction with his public role never came through his stage performances.[4] At the height of his career as Mark Twain the funnyman, the author had no trouble staying with that public persona. His creative talents, too, were at a high point all through this four-month tour.

Twain varied his readings somewhat so that his performance was always fresh and so that he would not repeat himself too much for return audiences. He was especially unhappy and bored when Cable did not change his readings. In his Wisconsin appearances, Twain's selections from *Huck Finn* were read with "The Awful German Language," "The Jumping Frog," "A Desperate Encounter with an Interviewer," and the ghost story of "The Golden Arm." Advertisements and programs usually left his concluding piece open, and Twain often tried to choose something appropriate to his audience's particular responsiveness. After a few unsuccessful attempts at simply reading early in the tour, Twain spoke from memory, a delivery which reviewers usually noted with compliments. On stage, before this tour, Twain had presented original lectures and read sparingly.[5] Now, he intended mainly to read material published or already set in print, but he was always careful to adapt his material for a vocal stage delivery.

This off-hand manner of delivery increased his casualness and spontaneity and also helped audiences perceive him—as he wished—as a natural story teller, a born wit. His humor was "dry, unconscious, apparently spontaneous," said the Janesville *Daily Recorder.* "He never smiles when telling a story that causes his audience to laugh until tears trickle down their cheeks, but on the contrary, pulls his iron gray moustache and scowls," but, "He put his audience in good humor with the first sentence and it continued until the last." The *Janesville Daily Gazette* published a preview which described Twain's delivery as "a dry, earnest manner, as though he really believed . . . the ludicrous situations . . . and expected his listeners to." The *Wisconsin State Journal* said Twain was "active in his movements . . . [but] carelessly," like "some awkward overgrown boy. The expression of his face scarcely changes during an entertainment, though when the audience laughs intrude there is the greatest air of injury about it."

His delivery was always studied, however, just as he describes his formula in "How to Tell a Story." Twain was a careful performer, and he received enthusiastic responses which justified the rather steep admission prices of fifty cents, seventy-five cents, and a dollar. Incidentally, the prices never varied, except that sometimes a good auditorium had no fifty-cent seats. Twain was going out to make money. Now, a river city like LaCrosse was probably economically more prosperous in 1885 than in 1985, compared to other cities in the state; but, even so, packing the local opera house with a thousand people strained more people's incomes there than in Chicago or Milwaukee. Still, not one newspaper writer anywhere in the state complained about the admission cost; in fact, writers usually complained about the audiences or auditoriums, if they were not suitable for such an important literary event. The LaCrosse *Chronicle* and Milwaukee *Evening Wisconsin* particularly noted that people arriving fashionably late were disturbing the performers and disrupting the show. The *Wisconsin State Journal* and Janesville *Daily Recorder* said the theater was too hot or too cold. But no one ever said that the spectators did not get their money's worth, even though Twain himself privately expressed doubts on occasion.

Cable usually spoke first (Twain particularly hated to work to an unsettled house). The two then took turns on stage and varied the tempo and tone of the program. Twain was the humorist and Cable the serious social commentator. The Janesville *Daily Recorder* said Cable's appearance and delivery denoted "intelligence . . . and the gestures and movements of a polished gentleman," while "Twain's every moment [on stage] was indicative of the droll humor that was fairly bubbling out of him." The paper concluded, "They are both stars of no little magnitude in their specialties."

These roles were deliberately complementary. By design, Cable was to portray moral sentiment and edifying thought, Twain to evoke uncontrolled laughter. Twain was the better-known personality, but he was known principally as a comedian and performer, and Cable actually enjoyed the reputation of being the more literary man.[6] Reviews often sounded as though they were paraphrasing the advertisements, which promised "superb fun" and "wit" from Twain and "exquisite humor and pathos" from Cable. The LaCrosse *Chronicle* dutifully reported on Twain's "grotesque humor" and Cable's "delicate pathos." the *Janesville Daily Gazette* promised viewers "sentiment, pathos, and delicate touches of humor" from Cable and "the wildest flights of hyperbole" from Twain, "superbly droll and outrageously extravagant."

Twain always received top billing in the advertisements; it was his tour, of course, and Cable worked on salary from him. In addition, Twain always received more praise as an entertainer when the two were reviewed together, but Cable was not slighted or criticized. It was not uncommon for a reporter to give more space in a review to Mark Twain's doing and sayings but to reserve his chief accolade for the art of Cable's writing and reading—appropriate for their intended roles, Cable the thoughtful literary artist and Twain the natural "character."[7] For instance, the Janesville *Daily Recorder* called Cable "a good elocutionist and a man of literary ability," but Twain was simply unique "in his inimitable style." Occasionally, there was feature material in papers on Cable's social thought. Both the *Wisconsin State Journal* and the *Milwaukee Sentinel* printed some correspondence between a Black resident of Wisconsin and Cable in which he (by implication, the papers too) stressed the necessity for cultural assimilation. In addition, the *Madison Daily Democrat* reviewed only Cable to emphasize his social beliefs.

This lecture tour was a literary event, but one finds that local papers showed their biases in characterizing and complimenting the performers. The tour was front-page news both in Madison and LaCrosse, for example, but in the state capital it was Cable the reformer featured on page one, and in the river town it was the unruly former steamboat pilot. The LaCrosse *Republican and Leader,* for instance, wrote about Twain's restlessness, his constant smoking, talking, and moving among train cars as though he was particularly uncomfortable about traveling in civilized society. However, in Milwaukee, the *Evening Wisconsin* and *Sentinel* featured stories on Cable because he had based characters in his Civil War novel on people then living in that city. The largest press coverage, about two columns each, was in papers for LaCrosse and Milwaukee. Twain had been in LaCrosse as a traveler and described it favorably in *Life on the Mississippi,* although this is not mentioned by the *Chronicle* reporter. Three years earlier the paper had written about Twain's brief stop. It is easier to explain the interest of the *Milwaukee Sentinel* and *Evening Wisconsin.* In addition to whatever civic pride they may have had, the two dailies competed for news and feature material about the season's biggest literary event, one interviewing Cable and the other Twain.

The critical reviews were always uniformly favorable although some of the uniformity borders on plagiarism. One of the stories in the *Wisconsin State Journal* contains a paragraph that is copied almost word-for-word from the *Janesville Daily Gazette* of the day before. Of course, this was within the limits of usual journalistic practice a hundred years ago and constitutes only an endorsement of the first review. Twain's selections usually were reviewed at greater length than Cable's. Usually, however, papers refrained from detailed description of the entertainment. One particularly effective piece which was summarized a few times was "The Awful German Language," in which Twain said that he would rather decline two drinks than one adjective, a fairly literary joke to cite. "The Golden Arm" was described in several papers, showing how Twain could methodically lead his listeners to the sensational conclusion of the story when everyone jumped at the ghostly accusation, "You've got it!" On the whole, papers quote sparingly; in fact, the LaCrosse *Chronicle* reporter observes that the local audience was familiar with these two popular writers. Reviews usually describe manner of delivery and appearance more than content. The emphasis, especially for Twain, is more on the literary "character" of the author rather than any particular work.

The Janesville *Daily Recorder* pronounced the entertainment the "literary event of the season"; Twain in particular was "enthusiastically received." According to the *Janesville Daily Gazette,* "Mark Twain, from his first bow to the close of the entertainment, kept the audience in continued laughter, while Mr. Cable was listened to with deep interest." The *Madison Daily Democrat* quoted a press review from St. Paul: "The audience laughed only once during the evening, but that was from 8 o'clock till 10." The dry understatement of this observation was typical in a way; general pronouncements on the readings often came in cliche-like superlative praise, but for description reporters sometimes tried to imitate Twain's comic style.[8] So it was that the reporter for the LaCrosse *Chronicle* noted the disparate appearances of the two authors and said, "Such a pair—such a team, let us say—in animal life, would make a horse laugh. But they pull well together."

Twain's appearance and stage delivery were suited for the image he wanted to project of a completely artless, unselfconscious wit. The Milwaukee *Evening Wisconsin* said he "carelessly and indifferently sauntered upon the stage" and read "[w]ithout ceremony." The *Wisconsin State Journal* called his stage style a dry recital" which nonetheless "kept the audience in a constant roar of laughter." The LaCrosse *Chronicle* said, "He comes upon the stage as though looking for a pin on a floor covered with eggs." Then, "Speech falls from his lips as though against his will." Finally, "He disappears with a canter and if he had not said a word, there would still be something to laugh at."

In physical appearance, the LaCrosse paper said, he was "tall, stooping, shambling of gait with tumbled hair and uncertain moustache, the counterpart of nothing except his odd self." Other papers reported the same. The Janesville *Daily Recorder* noted that he was "tall, awkward, with heavy bushy hair . . . heavy moustache . . . and he drawled his words out." Reporters and audiences came to these readings with an image of Twain derived from his books, and Twain was always in character for them. The *Winona Daily Republican* even headlined its story "Innocents Abroad" and noted Twain's movements as "side-long, awkward stride, amusing in itself . . . [with] a natural and easy force to his gestures."

Everywhere Twain spoke in Wisconsin he had a full house; often he sold out before the night of the performance. The *Wisconsin State Journal,* on his second stop in Madison, thus promised an entertaining night for "people [who] were not able to secure seats" at the first. "These two gentlemen are drawing marvellously wherever they appear," it said. And every audience called for encores; Twain offered two encores in LaCrosse. Cable too was usually recalled to the stage, but he always allowed Twain to finish the program if any encores were called for. Twain never explicitly insisted upon this, but he clearly wanted to remain the star attraction of the tour.

The apparent success of the tour at all stops in Wisconsin and Minnesota gave no hint of troubles in the background. In fact, Twain was not entirely pleased with receipts and blamed his business agent, nor was he pleased with Cable over the course of time. Cable's unwavering Sabbath piety irked Twain. Cable had started out encouraging Twain to accompany him to church services and reading his Bible to him on the train, both of which he diplomatically discontinued when Twain ignored him. Cable never swore or smoked, although there is no record that he ever upbraided Twain for these favorite hobbies of his. Worse, perhaps, Cable would not play billiards with Twain. Cable's expense account was a bit rich for Twain, and, worst of all, his time on stage seemed too great. These are all complaints which Twain often wrote to his wife, particularly often after the new year began and the tour went into the mid-west. He seems to have kept his complaints to himself on the tour, however; at least Cable did not record any awareness that Twain was growing irritated with him. In fact, Twain did not continue any criticism of his partner after the trip ended—actually he called him a perfect traveling companion—and it is reasonable to say he simply lost patience at times for all the traveling and work, and for the January weather in Wisconsin. From Madison, Twain wrote that he was cold in his hotel. In LaCrosse, his business manager noted that he was "a little sharp" with people at the train depot. In Milwaukee, Twain tried a hot bath before going on stage in order to refresh himself, but this apparently only tired him more. Twain actually confided to Cable that he felt the second night in Milwaukee was a disaster.[9] Twain and Cable generally suffered from nothing worse than weariness, cold, and occasional impatience with each other, but their manager suffered a mild heart attack in Madison and had to be left behind in Milwaukee to recuperate. The *Evening Wisconsin* noted the agent's illness but not how heavily it actually weighed down the spirits of the two performers.

From what one can know of the background to this lecture tour, already almost three months long, it is remarkable that Twain always managed to stay "on stage," so to speak, for local audiences and reporters. For instance, a *Milwaukee Sentinel* reporter sent to interview Cable went mistakenly into Twain's room and found him "decidedly en dishabille." His "afternoon attire" was "a long white nightshirt . . . and a cigar." In effect, Twain was discovered with his pants down, but he corrected the reporter's directions and played up to his amazement with obvious pleasure. In Madison, "about twenty" people followed Twain and Cable to their hotel. Cable came down from his room and greeted each one individually and politely, even though "he expected to meet but two or three," according to the *Wisconsin State Journal.* Twain only sent his regrets by Cable, and the paper granted him "a little needed slumber." Apparently, no one felt slighted.

Twain did grant an interview to a reporter from the *Evening Wisconsin* in Milwaukee, who found him quite agreeable despite showing obvious signs of the cold weather. Twain had read his imaginary "Desperate Encounter with an Interviewer" in Milwaukee, and the *Evening Wisconsin* reporter was perhaps a bit unprepared for the urbane person he actually met. He described Twain as "brusque but genial . . . the result of the varied life he has led." Twain told him that he enjoyed the lecturing, was pleased by the size and responsiveness of the crowds, and was living a hermit-like existence in Hartford, Connecticut. The reporter described Twain's former wild occupations of steamboat pilot, miner, and traveler. He had had "a rough experience generally," the writer noted, but was only the more admirably masculine for it—an "almost perfect specimen of physical manhood," American frontier character. Twain politely discussed the need for international copyright, his sales of books to date and hopes for *Huck Finn,* and a rather embarrassing bit of publicity for the new book which had leaked out. An engraver had created an obscene illustration out of one woodcut for the salesmen's advance copies of *Huck Finn,* which Twain casually dismissed as "a slight gouge of a graver . . . an indelicate addition to . . . one of my characters." (It was an erect phallus added to a sketch of Reverend Silas Phelps, with Aunt Sally apparently staring at it amusedly and asking, "Who do you reckon it is ?")[10] Twain said that all adulterated copies of the book had been suppressed, and no one need fear finding any obscene illustrations.

In general, no news during Twain's week in Wisconsin showed any hint of the weariness and irritation Twain expressed privately about the long tour and his traveling companions, nor any of his anxiety about preserving his reputation for humor and decency while *Huck Finn* was going to press. The lecture tour was a success in the most important way for Twain; Samuel Clemens was able to remain Mark Twain without fail for over four months. The newspapers usually call him Twain, a tribute to the currency of the literary character he made of himself. The LaCrosse *Chronicle* writer could not even spell Clemens correctly, and the *Milwaukee Sentinel* reporter who was introduced to Mr. Clemens immediately called him Twain. Without exception, newspapers emphasized the colorful, vivid, and entertaining man—just the image Twain cultivated.

Notes

[1] Fred W. Lorch, *The Trouble Begins at Eight: Mark Twain's Lecture Tours* (Ames: Iowa State University, 1968) 164. Since constant footnoting or even parenthetical references to dates of all newspapers quoted here would simply be intrusive, I have foregone this documentation. With the itinerary in the following paragraph, anyone who wishes to find specific stories can do so easily. All Wisconsin papers are available on microfilm in the State Historical Society, Madison.

[2] Lorch 165.

[3] See Guy A. Cardwell, *Twins of Genius* (East Lansing: Michigan State University, 1953) 68-77. In addition, see the brief summary of Twain's letter to a dean of the Yale law school in *Time* 25 March 1985: 69.

[4] Cardwell 25.

[5] Lorch 162; Paul Fatout, *Mark Twain on the Lecture Circuit* (Carbondale: Southern Illinois University, 1960) 216; and Arlin Turner, *George W. Cable: A Biography* (Baton Rouge: Louisiana State University, 1966) 177.

[6] Cardwell 17; and Fatout 205-06, 216-17.

[7] Fatout 222; and Turner 188.

[8] Cardwell 29.

[9] See Cardwell 49; Fatout 211-12; Lorch 174; and Turner 180.

[10] See Walter Blair, *Mark Twain and Huck Finn* (Berkeley: University of California, 1960) 364-67.

SOME EFFECTS OF CLEARCUTTING ON SONGBIRD POPULATIONS IN THE NORTHERN HARDWOOD FOREST

JAMES F. STEFFEN
Manitowoc

Abstract

A study was conducted in Marinette Co., Wisconsin on the breeding bird diversity occuring in six northern hardwood forest stands; 3, 5, 11, 17, 35 and 45 years of age. Breeding bird censuses were conducted along one to several transects in each of the stands in 1976 and 1977. A trend was observed in which diversity was low in the 3 year old stand and increased to a high in the 11 year old stand followed by a decline toward the 45 year old stand. The trend in bird species diversity was not correlated with vegetation density, plant species composition, or plant species diversity in any of the stands.

INTRODUCTION

Today, the term forest resource has taken on a much broader meaning than just timber. The current concept also includes, water, wildlife, range, and recreational resources of the forest. Forest managers as well as the public are seeking more precise information about the effects following different uses in specific forest situations.

In terms of species composition and structure of vegetation, windfalls and fires have altered much of our forest habitat many times in the past. However, the effects on fauna of such management practices as clearcutting may differ greatly from those occurring after storm fellings and burns (Ahle'n, 1975).

Clearcutting (removal of all standing timber) has been carried out in one form or another since settlement of this country. Ward (1974) believes that virtually all hardwood forests in the northeastern United States have sustained two or more clearcuts.

Aspen regeneration requires some type of disturbance so that clearcutting is the silvicultural practice most often utilized for the propagation of this forest type. Because the aspen-birch forest type is the most important source of pulpwood in Wisconsin (and other Lake States) and represents nearly 4 million acres (Spencer and Thorne, 1972, Giese, et al., 1976) there is no doubt that clearcutting represents an important perturbation in Wisconsin forests.

Some of the public resentment toward clearcutting relates to physical impact such as poor road placement and severe erosion. However, it is evident that much of the recent public concern about timber cutting practices can be traced to its visual impact (Lang, 1975, Giese, et al., 1976). It is because of this public reaction that more emphasis is being placed on quantifying the effects of clearcutting on flora, fauna, soils and other environmental parameters. Forest managers, whether public or private, also need to know precisely what effects the size of the area being clearcut has on various wildlife species and their densities (Severinghaus and Tombaugh, 1975).

A few studies concerning animal populations, aesthetic impacts and other non-silvicultural parameters, with respect to clearcutting, were begun in the early 1960's. Federal hearings in 1972 on forest management practices resulted in increased research efforts. The effects of clearcutting on wildlife are largely unmeasured and not easy to quantify. As a result wildlife has not been adequately included in multiple-use management plans for forestry practices (Webb, 1973).

Because of their conspicuousness, territorial behavior, and well known systematics, birds have been commonly utilized in measuring the effects of the alterations in habitat resulting from logging operations (Odum, 1950, Jarvinen and Sammalisto, 1973). Several recent reports studied changes in bird species diversity following various amounts of logging on differing forest types: eg. Hagar, 1960; Conner and Adkisson, 1975; Adams and Barret, 1976; Webb, et al., 1977; and Ahle'n, 1975 and Asbirk, 1975.

Bond (1957) investigated breeding bird distribution in the upland forests of southern Wisconsin. Some recent studies on bird species diversity in Wisconsin have concerned campground bird communities (Guth, 1978) and avian utilization of small woodlots (Howe and Jones, 1977) but the effect of clearcutting on bird diversity has been little studied.

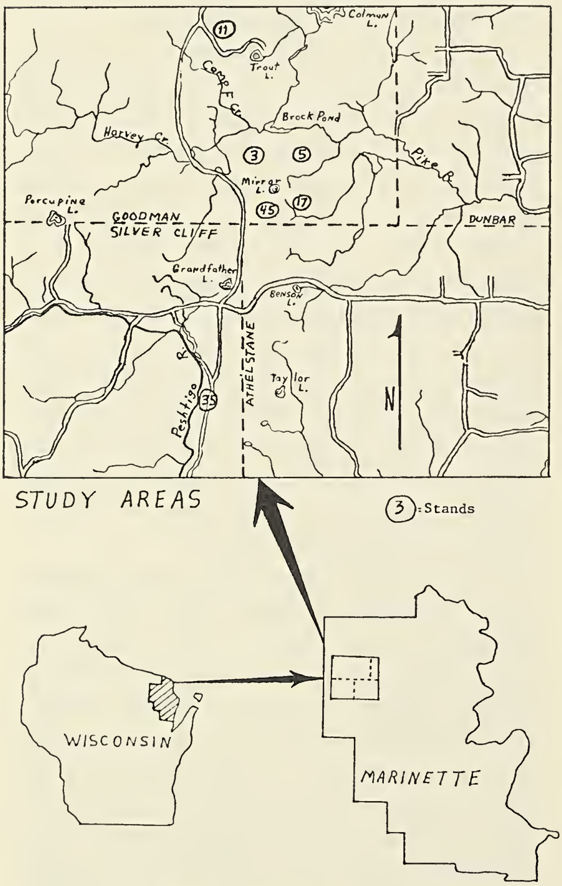

Fig. 1. Study area

This investigation was initiated to examine the changes which occurred in breeding bird populations as a result of clearcutting in the northern hardwood forest of Wisconsin. Goals of this study were to (1) document the change in breeding bird species composition as a result of clearcutting, and (2) to describe the relationship between bird species diversity and age of stand since cutting. The data presented here were gathered between April, 1976 and October, 1978.

Study Area

The study was conducted in the townships of Goodman and Silver Cliff in northern Marinette County, Wisconsin (Fig. 1). The vegetation of this region is composed of Hill's oak (*Quercus ellipsoidalis*), quaking aspen (*Populus tremuloides*), large-toothed aspen (*P. grandidentata*) with some white oak (*Quercus alba*). The importance of the aspen in this area is demonstrated by the fact that the aspen-paper birch (*Betula papyrifera*) type of commercial forest comprises 243.3 thousand acres (98,380 hectares) or 27.4% of Marinette County (Spencer and Thorne, 1972). The prevalent ground cover is *Aster macrophyllus, Carex pennsylvanica, Maianthemum canadense, Oryzopsis asperifolia, Pteridium aquilinium, Vaccinium angustifolium and Waldsteinia fragarioides.* Six aspen stands were selected for study; they were 3, 5, 11, 17, 35 and 45 years old. All six sites were within 6.5 kilometers of Mirror Lake. The 3, 5, 17 and 45 year old stands were in sections 30, 29, 31 and 31 respectively of R18E, T36N. The 11 year old stand was located in section 13 of R17E, T36N. The 35 year old stand was located in section 24 of R17E, T35N.

The 3, 5, 11 and 45 year old stands were the largest being approximately 90, 65, 50 and 140+ hectares respectively. The 17 and 35 year old stands were smaller in area being approximately 15 and 30 hectares respectively.

The topography is one of gently rolling hills with a total relief of 10 meters, as determined from USGS quadrangle maps.

The soils under the stands are mapped as sandy loams, originating from glacial drift and wind blown loess, with leached A horizons and tend to be acidic (Beatty, et al., 1964).

All of the areas studied showed indications of having been burned in the past, i.e., occasional charred stumps and burn meadows were observed on the sites. The method of cutting appeared to have been similar on all the stands. All standing timber, except for scattered live trees and dead snags, was cut down and usable logs removed. No scarification (scraping the soil clean) of the substrate was apparent, nor had logging residue been removed or burned. Logging residues were less evident in the older stands.

Methods

Vegetation Sampling

Density was sampled using 100 randomly located quadrats each $1m^2$ for herbaceous species and 40 randomly located $16m^2$ quadrats for shrub and sapling species. The point quarter method (Cottam and Curtis, 1959) was utilized for sampling trees greater than 4 inches DBH at 40 points in each stand.

Vegetation Analysis

Total basal area, relative frequency, relative density, relative dominance and importance value were calculated for all tree species on the 11, 17, 35 and 45 year old stands. A diversity index was computed for trees and shrubs as in Shannon-Weaver (1964). The formula is $-\Sigma_i P_i \log_e P_i$ where P_i equals the proportion of all plants which belong to the i^{th} species.

A shrub density index was computed for each stand by summing the individual densities for all the species in a given stand.

Avian Sampling

The strip census or transect method similar to Conner and Adkisson (1975), Gavereski (1976) and Milewski and Campbell (1976) was used to sample the bird species present. Randomly located transects 200 meters long were established in each of the 6 stands: 4 transects were established in the 3 year old stand, 3 in in the 5 and 45 year old stands and 1 each in the 11, 17 and 35 year old stands. Only one transect was established in 3 of the stands because of size limitations. Each transect was run 3 times, suggested by Emlen (1971) to be the minimum number necessary to derive valid population estimates on a transect.

Those birds heard singing or observed within 50 meters on either side of the transect were recorded. Censusing was conducted only on calm mornings to avoid bias due to wind interference in detecting singing birds. Several flags were tied at a distance of 50 meters from each transect to aid in identifying the boundaries of the sampling area. All transects were placed at least 50 meters from the edge of any given habitat type. All birds, breeders and nonbreeders, observed on the study areas were recorded. A factor of (2.0) was applied to the number of singing males in each census to estimate the total population including females. Counts were begun at 0600 and were concluded by 0900. Counts were not conducted on mornings that were heavily overcast or during periods of precipitation.

Avian Analysis

In the formula for species diversity (Shannon and Weaver, 1964), H is the bird species diversity index, P_i is the proportion of all individuals which belong to the ith species. This statistic includes both richness (number of species) and evenness (number of individuals of each species) factors and better expresses diversity than would a simple count of species number.

Richness values were also computed for each stand, utilizing $D = \frac{S-1}{\log_e N}$ (Margalef, 1958), where D is the richness value, S is the total number of species and N is the total number of individuals.

In addition, evenness values were computed, utilizing $e = \frac{H'}{\log_e S}$ (Pielou, 1966), where e is the evenness value, S is the total number of species and H′ is the bird species diversity index.

Results

Vegetation Analysis

Species Composition—Observations indicated that the herbaceous vegetation was relatively uniform in all the stands, and thus herbaceous vegetation was sampled only on the 3 and 45 year old stands. Sorenson's similarity index (1948) of 82 for the 3 and 45 year old stands supports the observed uniformity of the herbaceous growth in the stands. These data, along with observations made on the remaining 4 stands, suggest that wood aster (*Aster sp.*) and bracken fern (*Pteridium aquilinium*) had higher cover and frequency than any of the other constituents in the herbaceous layer. The species contributing most to the shrub layer in terms of density was hazel *(Corylus americana*) (Fig. 3). Tree importance values (Curtis, 1959) are presented for the 11, 17, 35 and 45 year old stands (Table 1).

Quaking and large-toothed aspen were found to have the highest importance values (Table 1) of all the species present on any of

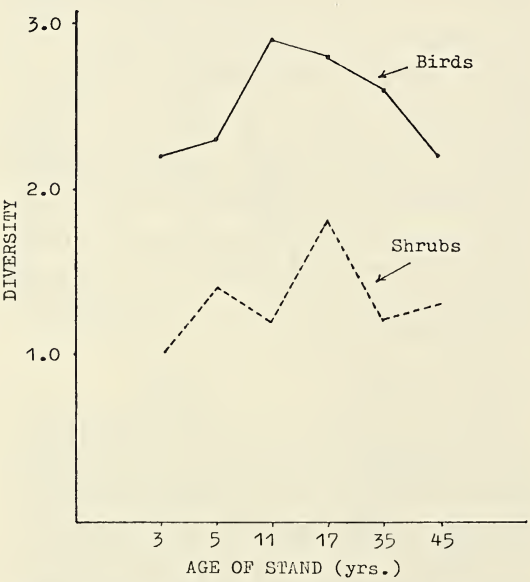

Fig. 2. Shrub diversity and bird species diversity plotted against age of stand.

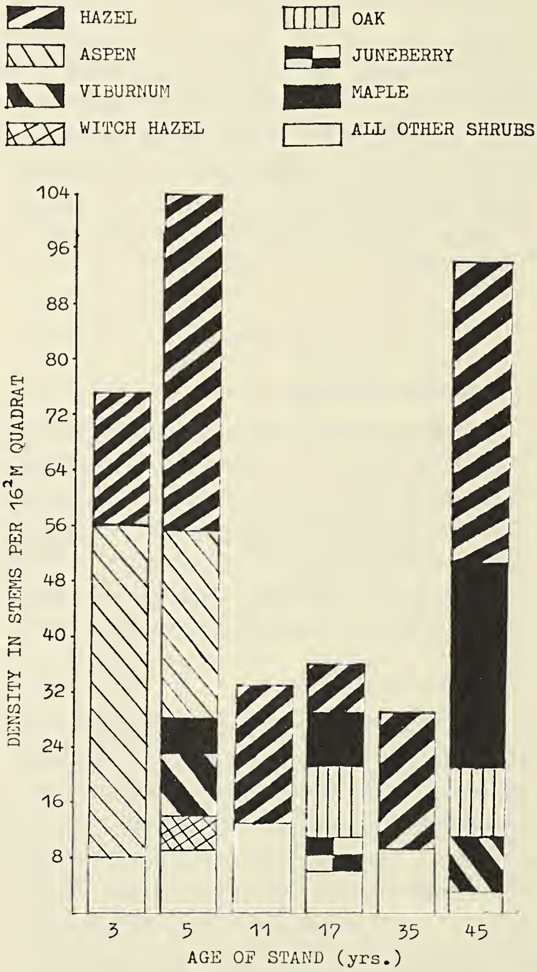

Fig. 3. Shrub layer species with densities greater than 5 stems per 16 sq. meter quadrat for the six study areas.

TABLE 1. Importance values for trees on the four older stands.

Species	*11 yr.*	*17 yr.*	*35 yr.*	*45 yr.*
Aspen	290.0	208.8	267.4	187.2
Hill's oak	—	49.9	8.4	42.9
Red maple	—	2.8	9.9	33.1
Paper birch	—	20.2	—	37.0
White pine	—	9.8	—	—
Jack pine	—	7.6	—	—
Red pine	—	—	14.9	—
Black cherry	7.4	—	—	—
Total	297.4	299.1	300.6	300.0

the stands. In the 3 and 5 year old stands these species were represented by saplings. Hill's oak and paper birch also had relatively high importance values for the 45 and 17 year old stands. The 11 year old stand had fewer tree species than any of the other three stands.

Foliage Structure—Although species composition differences were noted, the principle vegetational difference between stands was a structural one. While no foliage height diversity measurements were made on any of the stands, it became apparent from observations that foliage structure was different in each of the stands. These structural differences were in terms of fairly well defined layers of foliage as to height in the forest (Fig. 4).

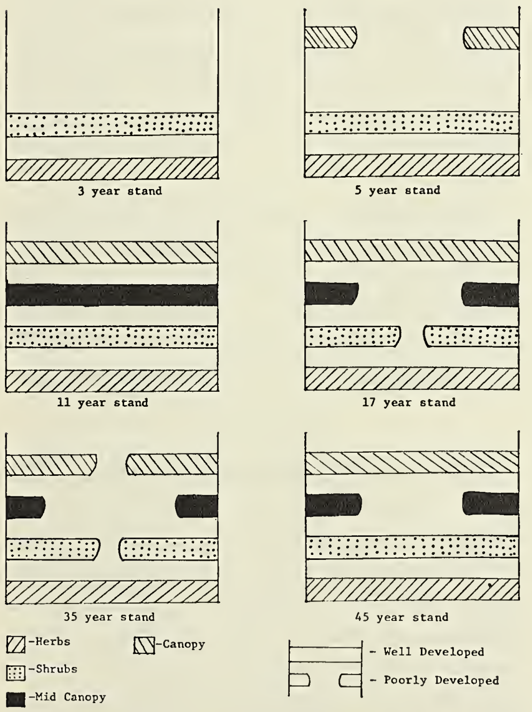

Fig. 4. Observed vegetational layering in the six study areas.

The 3 year old stand had only herbaceous and shrub layers. The shrub layer in this case was composed mostly of aspen saplings. The height of the canopy in this stand was measured at 2.0-2.5 meters.

In the 5 year old stand the sapling canopy was attaining sufficient height to begin establishing a third vegetational layer, a tree layer. The height of the canopy in this stand was measured at between 4.0-5.0 meters.

The 11 year old stand had the most complete layers of all 6 stands, as determined by visual observation, including herbaceous, shrub, mid-canopy and canopy layers. The mid-canopy layer was formed from pole-sized trees of aspen and black cherry (*Prunus serotina*) and tall shrubs such as Juneberry. This mid-canopy layer was located above the shrub layer and below the forest canopy. The height of the canopy in this stand was estimated to be 9.0-10.0 meters.

The 17 year old stand appeared less layered than the 11 year old stand in that the mid-canopy layer was less evident. The shrub layer in this stand was found to be relatively sparse. Because of this reduced shrub density the stand presented a much more open understory than the 11 year old stand. The height of the canopy in this stand was estimated at 10.0-15.0 meters.

Layering in the 35 year old stand was similar to the 17 year old stand with a more open understory. The canopy of the 35 year old stand was approximately 15.0 meters.

The 45 year old stand differed from the 35 year old stand in having a more developed shrub layer and a more closed canopy. The height of the canopy was approximately 15.0 meters.

Avian Analysis

Bird Species Diversity and Abundance—Bird species diversity (BSD) indices were computed. Figure 5 is a plot of the regression equation for these indices against age of stand. A highly significant fit of the data to this curve was obtained (P <.01). The regression analysis and plot of the regression equation clearly show a projected rise in BSD in the early stages after cutting from an estimated value of 2.02 at year 0 to a peak of 2.90 at about year 23 after which it declines.

The 11 year old stand was found to have the highest BSD, 2.87 with 20 species. A relative abundance statistic (Conner and Adkisson, 1975) computed for each stand (Table 2) shows the most abundant species in the stand to be the chestnut-sided warbler (*Dendroica pennsylvanica*), rose-breasted grosbeak (*Pheucticus ludovicianus*) and veery (*Catharus fuscescens*).

The 17 year old stand had the second highest BSD, 2.76 with 16 species. The most abundant species in this stand were the ovenbird (*Seiurus aurocapillus*), veery and least flycatcher (*Empidonax minimus*).

The 35 year old stand had the third highest BSD, 2.59 with 16 species. The most abundant species in this stand were the least flycatcher, red-eyed vireo (*Vireo olivaceus*), ovenbird and veery. The least flycatcher had the highest abundance in this stand.

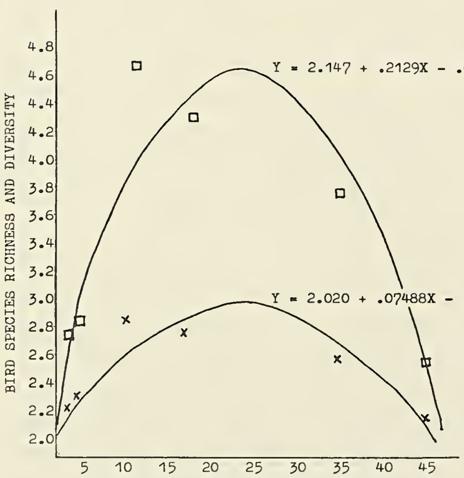

Fig. 5. Plot of regression equations and data for bird species diversity (X) and richness (□).

The 5 year old stand had the fourth highest BSD, 2.32 with 17 species. The most abundant species in this stand were the chestnut-sided warbler, ovenbird, Nashville warbler (*Vermivora ruficapilla*) and rufous-sided towhee (*Pipilo erythrophthalmus*).

The 3 year old stand had the fifth highest BSD 2.20 with 16 species. The most abundant species in the stand were the chestnut-sided warbler, mourning warbler (*Oporornis philadelphia*) and rufous-sided towhee.

The 45 year old stand had the lowest BSD, 2.16 with 13 species. The red-eyed vireo had the highest abundance in this stand.

Bird Species Richness—The richness component (number of species) of bird species diversity was computed for each of the stands. Figure 5 is a plot of the regression equation of species richness against age of stand. A significant fit of the data to this curve was obtained (P<.02). The regression analysis and the plot of the regression curve clearly show a projected increase in species richness in the early stages after cutting from a value estimated at 2.15 at year 0 to a peak value of 4.61 at year 24 after which it declines.

Bird Species Evenness—The evenness component (number of individuals of each species) of bird species diversity was computed for each stand. A regression analysis of species evenness values showed no significant difference with age of stand (P<0.3).

Discussion

Trends in BSD With Age of Stand—This study demonstrates an almost complete change in the avian fauna over a 45 year period following clearcutting. These results agree with the findings of Conner and Adkisson (1975). A trend in BSD was observed in which diversity was low in the 3 year old stand, high in the 11 year old stand and low in the 45 year old stand. Data collected in 1976 suggests that the BSD in the 3 year old stand was initially lower and BSD in the 45 year old stand was nearly the same as in 1977. There was no difference in the evenness component of BSD with respect to age of stand. Tramer's (1969) work on the components of Shannon's Formula of diversity lends support to this observation in that he found breeding bird communities to be relatively constant with respect to the evenness component of species diversity. Alternatively, Adams, et al., (1976) and Webb, et al., (1977) found evenness to be greatest in the early stages after clearcutting.

The richness component of the BSD index

TABLE 2. Relative abundance of bird species in the six study areas.

Species	*3 yr.*	*5 yr.*	*11 yr.*	*17 yr.*	*35 yr.*	*45 yr.*
Tree swallow	.033					
House wren	.067					
Gray catbird	.067					
Brown thrasher	.033	.088				
Mourning warbler	.100		.064			
Indigo bunting	.067	.029	.032			
American goldfinch	.033					
Rufous-sided towhee	.100	.088	.064	.073		
Field sparrow	.033					
Chestnut-sided warbler	.200	.147	.096	.037	.035	
Golden-winged warbler	.100	.058	.032			
Northern flicker	.033					
Eastern kingbird	.033					
Eastern phoebe	.033					
Brown-headed cowbird	.033	.029	.032	.037	.035	.038
Song sparrow	.033					
R.-t. hummingbird		.029				
Blue jay		.058	.032	.037	.035	.038
Veery		.058	.096	.111	.107	.153
Red-eyed vireo		.058	.032	.111	.107	.192
Ovenbird		.088	.064	.074	.107	.115
Rose-breasted grosbeak		.029	.096	.074	.071	.076
Nashville warbler		.088	.032			
Black and white warbler		.029	.032			
Canada warbler		.029				
American woodcock		.058				
Yellow-bellied sapsucker		.029			.035	
Downy woodpecker			.064			.038
Great crested flycatcher			.032	.037		.038
Least flycatcher			.064	.111	.178	.115
Eastern wood pewee			.032	.074	.071	.076
Black-capped chickadee			.032	.037		
American redstart			.032			
Scarlet tanager			.032	.037	.035	.038
American robin				.037	.035	
Wood thrush				.037		.038
Cedar waxwing				.074	.035	
Hairy woodpecker					.035	
Ruffed grouse					.035	
Black-throated green warbler						.038
TOTAL individuals	60	68	62	54	56	52
TOTAL species	16	17	20	17	16	13

in the present study increased to a maximum in the 11 year old stand and then decreased with continued age of stand. This trend is similar to that found for oak-hickory clearcuts by Ambrose (1975) and Conner and Adkisson (1975), although this trend was not observed by Conner, et al. (1979) for pine-oak clearcuts. This evidence suggests that the kind of trend which might be expected for the various components of the breeding bird species diversity index for any given region might be dependent on stand type.

BSD In Relation To Vegetation Structure—The trend in BSD starting at a low diversity, increasing in the early stages after cutting and then decreasing again is not supported by a corresponding trend, either positive or negative, in tree or shrub species diversity (Fig. 2). Several researchers have suggested a close correlation between breeding bird diversity and foliage structural diversity. Although no measurement of foliage height diversity was made in this study, it was observed during vegetation sampling that the 11 year old stand appeared to be more complex, in the development of vegetation layers, than any of the other stands (Fig. 4). Tramer (1969) suggested that it is possible that the foliage height diversity determines the number of niches (at least in the physical sense) and thus the number of species which can coexist within a given community. BSD appeared to be associated with vegetation structural diversity in the present study.

Milewski and Campbell (1976) suggest a correlation between floristic diversity and bird species diversity. However, Bond (1957) and MacArthur, et al., (1962) suggest that there is little or no dependence of bird species diversity on floristic diversity. The results of the present study tend to support the latter idea.

Clumping of vegetation or patchiness has been found to relate to faunal diversity (Wiens, 1974, Hooper, et al., 1975) and in some cases has been shown to be more important than foliage height diversity (MacArthur, et al., 1962). Horizontal heterogeneity (patchiness) of vegetation was not measured in the present study. However, patchiness was observed in the 3 year old stand. This patchiness was in the form of clumps of stems occurring at the site of old stumps of maple and oak where sprouting took place. In some cases these clumps consisted of around 25 to 75 stems. Patchiness of slash caused breaks in the vegetation, but did not seem to greatly affect the BSD of the 3 year old stand as indicated by its relatively low BSD index. It is possible that some of the other stands may have had greater, but less visible, patchiness in their vegetation which may have affected the BSD found on those stands.

In the 5 year old stand the aspen saplings began to separate from the shrub layer to form the beginnings of a distinct tree canopy (Fig. 4). Wilson (1974) suggests that in a series of increasing complexity of vegetational structure, the addition of trees in the series has a major impact on the addition of avian species. Karr and Roth (1971) express a similar concept when they state that the maximum rate of increase in avifauna diversity occurs between 100 and 150% cover when both shrub and tree layers are being added. It can be seen in Table 3 that the number of species (across the cline in age since clearcutting) begins to increase in the 5 year old stand. It should also be noted that in the 5 year old stand and moving towards the older stands the number of forest bird species increases rapidly, replacing species of open field and shrub habitats.

Conclusions and Summary

The data presented here clearly demonstrate a nearly complete change in the

Table 3. Bird species number in relation to stand size.

Age of Stand (years)	*Size of Stand (ha.)*	*Number of Species*
17	15	17
35	30	16
11	50	20
5	65	17
3	90	16
45	140	13

species composition of the breeding bird population in a northern hardwood forest following clearcutting. Predicted bird species diversity is initially reduced by clear-cutting and then begins to increase until the stand reaches 22 years of age after which it declines. While the plot of the data suggests that the numbers of species decreases rapidly after the high value is passed at the stand age of 22 years, the actual situation would probably be close to that shown by Conner and Adkisson (1975) where the number of species levels off or increases as a climax condition is approached. Structural changes in the vegetation brought about by clearcutting and the subsequent successional stages are most important. The data also indicate that the shift back toward the original species composition occurs rather rapidly in the first 10-11 years following cutting after which the change is much slower.

It is clear from the present study that clearcutting increases bird species diversity and increases density of individuals. An important loss due to clearcutting is the almost complete displacement of the original species population; however, this displacement is not a long time effect, since 85% of the species found in the control stand were re-established in the 11 year old stand.

It appears that clearcutting in relatively young aspen-birch stands is not deleterious to avian diversity over the long term. In terms of management, cutting should be done to preserve sections of the original habitat in order to assure the maximum diversity of bird life in the area. Although forest fragmentation may not be a serious problem in northern Wisconsin because of the extensive forest canopy present, it may be a consideration in individual cases of clearcutting.

The size of the area being clearcut is a factor which must be a part of a management plan. The stands examined in the present study ranged in size from 15 to 140+ hectares. Conner, et al. (1979) has suggested a size limit of approximately 12-16 hectares which should be large enough to include most species of birds with the exception of those having large home range requirements. Data from the present study do not support a correlation between number of bird species and size of clearcut (Table 3). However, it should be remembered that these stands are not of equal age. Although these data do not suggest a size limit for clearcuts, it would seem apparent that a limit could be at some size equal to or less than the smallest stand in this study (15 ha.).

Acknowledgements

This study was supported in part by the Steenbock Fund of the Wisconsin Society for Ornithology and the University of Wisconsin-Green Bay Graduate School. I would like to thank Robert S. Cook, Keith L. White and D. M. Girard for reviewing earlier drafts of the manuscript. Also I would like to acknowledge D. Jowett and Christa Schwintzer for advice and technical assistance. The staff of the Wausaukee ranger station provided weather information and helped in locating clearcut stands. Amy Steffen and John Baum assisted with field work and manuscript formulation.

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RELATIVE NESTING SUCCESS OF YELLOW-HEADED AND RED-WINGED BLACKBIRDS

Michael E. Minock
U.W. Center-Fox Valley, Menasha

Abstract

At Collins Marsh, Manitowoc Co., WI, Red-winged Blackbirds fledge significantly fewer young per nest and have a significantly higher rate of nest failure than Yellow-headed Blackbirds. As a result of interspecific territoriality Red-wings are prevented from breeding in areas they would otherwise use. Thus, competition for nesting habitat results in lowered reproductive rates among Red-wings. A major factor causing the lower reproductive rates is increased egg predation.

Previously Minock and Watson (1983) reported that Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*) and Red-winged Blackbirds (*Agelauis phoeniceus*) are interspecifically territorial at Collins Marsh, Manitowoc County, Wisconsin. This has also been found in western parts of North America (e.g., Orians and Willson 1964, Miller 1968), and in both regions it results in Yellow-heads using emergent vegetation over deeper, more open, water for nesting and Red-wings being forced to the periphery of the marsh. We found mean water depth of 37 cm beneath 25 Yellow-head nests and all nests were in cattails (*Typha* sp.), while 18 Redwing nests were over water of mean depth of 21cm and 12 were on land. Red-wing nests were placed in vegetation of at least 7 different species.

As pointed out by others, this means that Yellow-heads exclude Red-wings from their "optimal niche space" (Robertson, 1972). I was interested in whether specific detrimental effects of this displacement of Red-wings at Collins Marsh could be quantified in terms of influence of the Yellow-head presence on Red-wing nesting success. One way to do this would be to remove Yellow-heads from the marsh and then compare nesting success between Red-wings on the periphery and those in what was Yellow-head habitat. This was not feasible. A second approach would be to compare nesting success between Red-wings at Collins with those at another similar nearby marsh without Yellow-heads. I did not attempt this and do not know if an appropriate situation exists. A third approach is to compare nesting success between Yellow-heads and Red-wings at Collins. I did this in 1980. A problem with this procedure is that there is no guarantee Red-wings would fare the same as Yellow-heads if the former had access to the area used by the latter. Such results, however, may be suggestive.

Nest searches were conducted in the southwest corner of the marsh. The nesting data reported here were gathered on 12 visits to the marsh from 16 May to 25 June and 1 visit on 3 July. Return visits to nests reported on in this paper, with one exception as follows, were made until young fledged or failure occurred. One way to estimate nesting success is to determine the number of young fledged per active nest (at least one egg laid). Nestlings were considered to have fledged if they were alive the next to last time I checked the nest and were gone and would have been old enough to fledge by my last visit. In addition, three 8 day old nestlings in a Red-wing nest on my last visit to the marsh were considered to have fledged, but three later active Red-wing nests were not included in the data. The results (Table 1) show a fledging

Table 1. Fledging success per active nest of Red-Winged and Yellow-headed Blackbirds at Collins Marsh.

	No. of nests	Young fledged	Young fledged per nest
Yellow-heads	19	36	1.9
Red-wings	23	24	1.04
*p			<.032

*Mann-Whitney U Test, one-tailed.

rate in Yellow-heads nearly twice that found among Red-wings. In addition to the difference in number of young fledged per nest, 14 of 23 Red-wing nests fledged no young whereas only 5 of 19 Yellow-head nests were total failures. This difference is significant ($P < .05$, Chi-square).

The two species are capable of producing similar numbers of eggs per clutch (e.g., Orians 1980). Red-wings are generally thought to have greater nesting success within marshes than in upland situations (e.g., Case and Hewitt 1963, Robertson 1972) (However, see Dolbeer, 1976). Young (1963), in a study mainly concerned with age-specific egg and nestling mortality, also found lower nesting success among Red-wings than Yellow-heads at a marsh near Stoddard, WI. These facts, together with my data, strongly suggest that competition with Yellow-heads for breeding territories is reducing reproductive success of Red-wings at Collins Marsh.

Of the 14 failed Red-wing nests, 12 were cases where eggs disappeared. This occurred in 3 of the 5 failed Yellow-head nests. It is likely that parts of the marsh preferred by both species but obtained only by Yellow-heads are less susceptible to predation than areas used by Red-wings. In his study Young (1963) suggested one reason for lower egg and nestling mortality among Yellow-heads might be reduced predation because of "the generally deeper water at the nest site." Robertson (1972) found that predation was the most common cause of mortality to Red-wing eggs (and nestlings) in both marsh and upland habitat but that it was greater in uplands. The other 2 cases of nest failure among Red-wings at Collins were from drowning due to nest submersion from rising water on a flood plain, and failure of eggs to hatch in a deserted wind-tilted nest. The remaining two nest failures among Yellow-heads were due to desertion and/or starvation since dead young were found in the nests. I have not attempted to analyze causes of egg or nestling mortality in nests that were partially successful. The role of differences in food availability to each species was not studied.

Acknowledgements

Thanks to Ronald Barrett for reviewing the manuscript, to Daniel Olson of the Wisconsin Dept. of Natural Resources for approval of use of the marsh and to John R. Watson for telling me about Collins Marsh in the first place.

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BIRD BEHAVIOR IN RESPONSE TO THE WARMTH OF BLACKTOP ROADS

PHILIP CLASON WHITFORD
Biological Sciences
University of Wisconsin-Milwaukee

Abstract

In summer small birds are commonly seen on the surface of blacktop roads, particularly when the air is cool (< about 25° C, 77° F). In this study I recorded the species and numbers of birds on the road as observed from a car on a specific 20.6 km route daily and at different times of day; I related these observations to concurrent temperatures of air, road surface, and surface temperatures of adjacent open and shaded habitats.

The mean road temperature in full sunlight was 6.7° C higher than air temperature in shade. The highest numbers of birds (75.6% of total) on the road occurred when road temperatures were 7-10° C above air temperature (road 26-34° and air 19-26° C). Since the lower critical temperatures (LCT) of thermoneutrality for many passerine birds is 22-23° C, the birds can conserve metabolic energy by utilizing the solar heat stored in the road surface during the several hours each day when the road is at or above LCT and the air is colder. Additional stationary observations of birds and the length of time each stayed on the road at different road temperatures showed a similar pattern. Responses to other factors including wetness (after rain), clouds and wind were also considered.

The wide availability of the warmer microenvironment of blacktop roads, and the behavioral adaptation of the birds using it, may conserve enough energy in the critical breeding season for species at the northern margin of their range to reproduce more successfully or even to extend their breeding range.

Roads represent one of man's commonest and most extensive intrusions into natural areas. Road beds surfaced with asphalt have the capacity to absorb and retain large quantities of solar heat. The stored heat is released during the late afternoon and evening hours. As sunset approaches, the angle of incidence of sunlight decreases; therefore the sun's effectiveness as a radiant energy source for avian behavioral thermoregulation also decreases. Due to its heat storage and release characteristics, the road surface continues to offer a thermal environment often well above known lower critical temperatures (LCT) of thermoneutrality for many passerine species until well past sunset. Thus, when air temperature is cool and direct solar energy is least available, birds may still conserve metabolic energy by using the thermally favorable environment provided by lightly-traveled asphalt-surfaced roads. To do so the birds must modify daily behavior patterns so that they are present on the road during periods when the road surface is above, and ambient temperatures below, the species' LCT.

The purpose of this study was two-fold: first, to determine the magnitude and extent of difference in temperature regimes of the blacktop road and that of several adjacent natural micro-environments, and secondly, to determine whether daily road-visiting patterns of a wild passerine population indicated a relationship to road surface temperatures which could be construed as a form of behavioral thermoregulation. In addition data were collected to determine the extent of influence of rain, wind, and other weather phenomena on road-visiting behavior of birds.

Methods

Description of Study Area

Marquette County, in central Wisconsin, is an area of sandy moraine, outwash and wetlands. Agricultural land use has declined, many of the original farms reverting to natural vegetation, thus creating successional stages which offer ideal habitat for many bird species. The study area included parts of Shields, Crystal Lake, Newton and Harris townships. Aerial photographs indicate the area is approximately ¼ cropland and abandoned fields, ¼ remnants of oak savanna (chiefly *Quercus ellipsoidalis* and *Q. alba,* Whitford and Whitford, 1971) or plantations of red and white pine *(Pinus resinosa* and *P. strobus)* and ½ open marshes and swamps of tamarack *(Larix larcina).*

Data Collection

Observations of birds on the road surface were recorded at least once daily from 30 May through 30 August, 1974 and 1975, from an auto traveling a standard 20.6 km route over local roads of typical asphalt-gravel composition at a steady speed of 56 km/hr (35 mph). Traffic on these roads ranged from 0 to 10 vehicles per hour, averaging approximately 5 per hour. Data records included the times of meeting oncoming vehicles and the times during which I knew vehicles ahead had disturbed the birds. Analysis was based only on those samples without known disturbance. In addition, seven hours of stationary observations recorded the lengths of time birds remained on the road at various road and air temperatures.

Bird observations were recorded as the number of birds, by species and in total, which were seen upon the road surface during each 10 minute sample period. Birds observed on the road were grouped into three classes: those with ruffled feathers, demonstrating Class I sunbathing (radiant energy absorbing) posture (Hauser 1957); those with feathers smoothed, erect posture and no visible activity; and those involved in visible searching activity which would indicate anting or feeding behavior. The latter group was omitted from data analysis to eliminate potential confusion between feeding behavior patterns and thermoregulatory behavior patterns. The first two groups were analyzed independently to separate birds actively absorbing radiant energy from those which appeared to be in a thermoneutral state where they had no need to actively absorb energy to augment metabolic heat production.

Temperatures were measured with laboratory-quality mercury bulb thermometers and a three-probe remote-sensing thermistor recording unit. Probe placement was as follows: a) on the ground in a medium-dense stand of herbaceous plants dominated by grasses; b) on the litter surface under 20 year old pines; and c) at a height of 1.2m in shade to measure ambient air temperature. Two thermometers, bulbs shaded, were placed on the road surface until the readings stabilized to measure surface temperature in shade and in sun. Temperatures of all sites were recorded immediately before and after each bird counting period. The wide temperature range which was sampled allowed the road to serve as its own control for the study by comparing bird observations during both optimal, i.e. above LCT, and sub-optimal road temperatures.

The road surface was classified as wet, dry or damp (having puddles of standing water on an otherwise dry surface). Weather conditions such as rain, percent cloud cover and wind speed were recorded to determine their possible influence on bird presence on the road.

Data Analysis

Significant differences in microenvironment temperatures were determined using a calculator programmed for the mean and standard deviation of hourly groups. 09:00-21:00, on a monthly basis for June, July and August, 1974 and 1975. Analysis of variance was calculated for all hourly groups.

Influence of various weather factors and temperatures on bird use of the road was determined by comparing the mean number of individuals observed during all 10-minute periods for each weather condition or temperature range. The average number of minutes birds remained on the road at various road surface temperatures was analyzed in a similar manner for stationary observations.

An *a priori* Chi-square test, using temperatures arbitrarily grouped by 5° C units, was used to establish whether distribution of individuals was influenced by road surface temperature.

Finally, it was necessary to separate the effects of time and temperature, two strongly interrelated factors, to determine which had the greater influence on bird presence on the road. This was done by deriving coefficients of determination for each factor.

The specific formula used to separate the influence of time and temperature was designed by Dr. Eugene Lange, then a biostatistician with the University of Wisconsin-Milwaukee, and is as follows (Lange, 1978, pers. communication):

$$Y_{ij}k = \underbrace{\beta_o + \beta_1 H_i + \beta_2 H_i 2 + \beta_3 H_i 3}_{①}$$

$$+ \underbrace{\beta_4 T_j + \beta_5 T_j 2 + \beta_6 T_j 3}_{②}$$

$$+ \underbrace{\beta_{1,4} H_i T_j + \beta_{1,5} H_i T_j 2 + \beta_{2,4} H_i 2 T_j}_{③} + J_{k(ij)}$$

where $Y_{ij}k$ = k^{th} observation of j^{th} temperature and i^{th} time period

H_i = i^{th} time period of the day

T_j = j^{th} temperature

β_o = constant

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, (\beta_{1,4}), (\beta_{1,5}), (\beta_{2,4})$ = partial correlation coefficients

and where

1 produces the effect of time independent of temperature

2 produces the effect of temperature independent of time

3 produces the combined effect of time interacting with temperature.

The equation made it possible to use a regression analysis where hitherto this had not been possible due to the curvilinear relationships of temperature and activity. Regression analysis followed the form:

I Y = β_o = ①

II Y = β_o = ②

III Y = β_o = ③

IV Y = β_o = ① + ②

V Y = β_o = ① + ③

VI Y = β_o = ② + ③

VII Y = β_o = ① + ② + ③

Results and Discussion

The most commonly observed species were the Vesper Sparrow *(Pooecetes gramineus)*, American Robin *(Turdus migratorius)*, House Sparrow *(Passer domesticus)*, and the Mourning Dove *(Zenaidura macroura)*. In all, 2102 birds of 36 species were observed on the road surface.

Laboratory studies indicate that House Sparrow daily activity is energetically most efficient at an ambient temperature of 22° C (Kontogiannis 1968, Kendeigh 1969). Vesper Sparrows were found to have a LCT of 22.5° C, White-crowned Sparrows *(Zonotrichia leucophrays)* 23° C (Yarbrough 1971, King 1964). The metabolic rate of Red-winged Blackbirds *(Agelaius phoeniceus)* increases significantly at ambient temperatures below 25.6° C (Lewis and Dyer 1969); they concluded that this increased energy output was necessary to maintain proper body temperature, indicating that this is their LCT of thermoneutrality.

The road in full sunlight had a mean temperature for all observation periods 6.7° C higher than ambient air, 6.3° C higher than the ground layer in grassy cover, and 7.4° C higher than the litter surface under the pines. Analysis of variance for the various micro-

TABLE. 1. Temperature relationships of sites, 0900-2100 hours (CDT), May-August. Degrees of freedom and f-ratio are included for all samples seven or greater. Data from 1974 and 1975 records.

Month	Site	0900 N	0900 X °C	0900 SD °C	1100 N	1100 X °C	1100 SD °C	1400 N	1400 X °C	1400 SD °C	1500 N	1500 X °C	1500 SD °C	1600 N	1600 X °C	1600 SD °C	1800 N	1800 X °C	1800 SD °C	1900 N	1900 X °C	1900 SD °C	2000 N	2000 X °C	2000 SD °C
June	Air*				15	21.84	4.65				14	26.48	3.26				5	18.11	4.62	19	20.73	4.43	62	17.57	4.10
	Hbg				2	22.22					1	27.20					5	20.66	4.28	19	20.82	4.01	49	16.92	3.42
	Llp				15	22.12	4.34				14	26.23	3.41				5	17.56	4.03	19	19.41	4.93	62	16.51	4.12
	Rds				15	30.03	4.04				14	38.43	5.10				5	24.67	4.62	19,	27.34	5.01	62	22.82	4.73
d.f., f-value					3,	54,	12.17				3,	51,	26.23							3	72,	9.12	3,	231	30.22
July	Air	3	18.14	0.85	26	26.00	3.63	4	25.00	3.21	27	28.66	3.05	8	25.69	4.22	12	27.82	3.13	35	24.33	3.20	72	22.98	2.94
	Hbg	3	17.59	0.85	2	32.80		4	33.92	6.10	4	30.28	0.96	8	27.08	3.42	12	27.92	1.47	35	23.97	2.94	72	22.43	2.94
	Llp	3	18.14	0.32	26	26.49	3.67	4	25.00	2.57	27	29.19	3.32	8	27.01	4.63	12	27.27	3.36	35	23.93	3.54	48	22.36	3.07
	Rds	3	27.78	1.47	26	34.67	5.16	4	36.39	4.17	27	34.21	5.62	8	36.46	5.03	12	37.36	3.89	35	31.38	4.31	72	28.31	3.09
d.f., f-value					2,	75,	34.18				2,	78,	14.86	3,	28,	10.41	3,	44,	28.30	3,	136,	37.17	2,	213,	84.46
Aug	Air	7	18.49	1.51	17`	25.16	2.96				13	28.59	3.76	9	24.40	3.83	20	21.22	3.08	22	20.76	2.31	24	19.93	2.86
	Hbg	7	18.73	1.05	1	31.11								9	23.64	2.94	20	21.47	3.96	22	20.22	2.34	14	18.13	1.93
	Llp	7	18.89	1.61	17	25.58	2.76				13	28.50	3.16	9	24.81	4.22	20	20.50	3.19	22	19.89	2.48	24	19.51	3.07
	Rds	7	25.47	1.99	17	34.34	3.36				13	39.60	5.05	9	34.69	4.40	20	28.92	3.48	22	26.86	2.39	24	25.58	3.12
d.f., f-value		3,	34,	34.07	2,	48,	33.52				2,	36,	21.56	3,	32,	12.25	3,	76,	19.42	3,	84,	32.53	2,	69,	20.30

*Column 1 indicates the sites, or microenvironments, of the compared temperatures: Air is ambient air temperature at 1.5 m height in shade; Hbg is the herb layer in open grassy cover; Llp is the litter surface in shade under pines; Rds is the road surface in the sun; Rsh is the road surface in the shade. The road surface readings were taken in places which had been in sun and shade respectively for at least one hour before the readings. All sites lay within a 20 yard radius and readings at each time were taken in rapid sequence. (See Methods).

environments sampled indicated that a significant difference of temperature existed between the road surface and all other areas sampled for all hourly sample sizes larger than seven ($p < 0.01$, Table 1). Temperature differences between the naturally occurring areas studied were not found to be significant; however a larger data base would permit statistical differentiation of these areas (Johnson and Davies 1927).

Temperature records, grouped into hourly averages for each month, June-August, indicate that the road surface offered favorable temperatures for several hours after air and other microenvironmental temperatures had fallen below 22° C, the LCT of most of the species observed (King and Farner 1961). June records indicate that environs other than the road had mean temperatures above 22° C from 11:00-16:00 hours, while the road surface was 22° C or above from 07:00-20:00 hours daily (see Fig. 1). Road surface temperatures above 22° C were typical from 06:00-23:00 in July and from 08:00-21:00 in August, while temperatures of other environs sampled exceeded this level only from 11:00-20:00 and 10:00-17:00 respectively. Therefore, during these months, the road surface temperature was within or above the birds' thermoneutral range an average of seven hours more per day than were temperatures of ambient air or of other local habitats.

Of all non-sunbathing birds observed on the road, 75.5 percent were seen when the road temperatures were between 22 and 33° C; 12 percent were at temperatures above 33° and 12.5 percent at temperatures below 22° C. These temperature ranges represent 46, 30 and 24 percent of data collection periods respectively. Birds were observed in sun-bathing posture only occasionally at road surface temperatures of 20-26° C, but rapidly increased in number when road surface temperatures dropped below 20° C. Indeed, all non-feeding birds observed in the range of 10-16° C road temperature were exhibiting sunbathing behavior.

Stationary observations (Table 2) indicated that the greatest numbers of birds per hour (18) were observed at road surface temperatures of 30° C. This decreased to 1/hr at 19° C and 4/hr at 40° C. The mean length of time birds remained on the road per visit followed the same pattern as number of visits per hour, namely 5.4, 1.0 and 1.7 minutes per visit respectively.

In observations from the moving car,

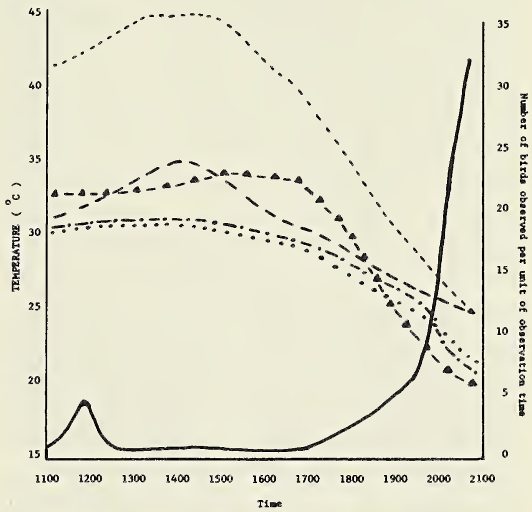

Fig. 1. Temperature curves of the five microenvironments for June 21, 1974, and total number of birds observed relative to time and temperature factors. Air --.-., Road in the sun ------, Road in the shade ——, Tall grass-....., Pine litter layer --▲-▲, Birds observed -- solid line.

Table 2. Time birds were present on road at various road surface temperatures. One hour of observation was conducted at each temperature level.

Temperature °C	*Birds Observed*	*Length of Time (minutes)** *Range*	*Mean*	*Standard Deviation*
40.0	4	1-3	1.75	0.96
35.0	7	1-4	2.14	1.21
32.5	13	2-9	4.69	2.39
30.0	18	1-11	5.39	2.57
26.5	9	1-7	4.44	2.23
23.0	2	1-2	1.50	0.71
19.5	1	NA	1.00	NA

*Times were recorded by 1-minute units with lengths of time over a minute recorded to the nearest minute.

mean numbers of birds per ten-minute period varied from 0.00-7.11 (range 0-26) when compared to specific road surface temperatures. Bird numbers were greatest when air temperature was 7-10° C below road surface temperature. Correspondingly, the mean number of birds observed on the road per ten-minute period was greatest within road surface and air temperature ranges of 26-34° and 19-26° C respectively.

The *a priori* Chi-square test of distribution of birds on the road surface relative to temperature indicated that distribution was not rectangular (99% confidence level, 6 d.f., 85.12). A similar test of bird distribution relative to time failed to show the relationship significantly non-rectangular. Rectangular distribution of an *a priori* Chi-square is a form of null hypothesis which assumes that one factor has no influence on another (Games and Klare 1967). Therefore, rectangular distribution, relative to temperature, would be expected if foraging or other behavior patterns were the primary reasons for birds being present on the road. Non-rectangular distribution relative to temperature indicates that the presence of birds was strongly related to temperature. Coefficients of determination were used to further isolate the effects of time of day from those of temperature via the formula given earlier. These indicated that temperature had nearly four times as great an influence on bird presence as did time of day, once the effects of the interaction of time and temperature were removed. The coefficient of determination derived for temperature was .1014 as opposed to .0270 for time of day. These figures represent only relative influence of the two factors and are not to be interpreted as correlation coefficients. However, they do support the hypothesis that bird presence was related to the temperature of the road-surface and not to temporal behavioral patterns.

General trends of influence for various weather factors and road surface conditions, based on the mean number of birds observed in each category, were as follows: 1) more birds were present when vegetation was damp from dew or rain than during dry conditions (14.7 vs 4.0 birds per 10 minute period, respectively); 2) scattered or broken cloud cover resulted in greater bird numbers observed than in clear or overcast conditions; 3) bird numbers steadily decreased (5.9 vs 2.6 birds per 10 minutes) as wind velocity increased from 0-19 km/hr; 4) bird numbers were greatest (10 per 10 minutes) when the road surface was wet and were lowest (4.4 per 10 minutes) when the road was dry.

As indicated above, damp vegetation resulted in nearly a four-fold increase in bird numbers observed, whereas numbers steadily decreased as wind strength increased. Explanation of these differences is relatively easy, i.e. wet feathers conduct heat more rapidly than dry and thus increase energy loss to the environment while the warmer, drier air at the road surface both reduces this heat loss and increases the rate of drying. Increasing wind speed also increases the rate of conducted heat loss from the birds which may partially or wholly negate the benefit of the warmer microenvironment. Both heat conductance and radiant energy flow are important to animals in terms of behavioral thermoregulatory processes and reduction of metabolic energy demands (Rosenberg 1974, Porter and Gates 1969).

Avian thermoregulatory behavior is highly flexible, e.g. feather ruffling permits change of insulation properties while sun-bathing behavior uses incident light orientation to control the rate of heat absorption (Lustick 1969). Great mobility allows birds to move to sheltered areas to reduce radiant and/or conductant heat loss or to select warm microenvironments which serve the same purpose. While many methods of behavioral thermoregulation exist, the ultimate goal of all the methods is the same, to achieve thermoneutrality with the environment. By definition, thermoneutrality is obtained when the minimum activity period metabolic rate of a resting animal is sufficient to offset heat loss to the environment and maintain proper body temperature. In other words, this is the temperature range in which the animal is energetically most efficient. Once thermoneutrality is obtained, radiant or conductant energy input cannot further reduce the metabolic rate of the organism; such inputs are of energetic importance only when the organism has an elevated metabolic rate in response to temperatures below the LCT of the species (Morton 1967). Thus radiant energy absorbing behavior would have significance primarily when road surface temperatures were below the species' LCT or when other weather factors increased energy loss rates.

Sunbathing birds were observed when road surface temperatures were near, or more commonly, well below the LCT of the species. Under these conditions, birds apparently utilized radiant energy absorption in combination with the favorable thermal environment of the road surface in the effort to attain thermoneutrality with the macroenvironment.

Birds observed at road temperatures above 26° C, and most birds at 20-26° C, were not sunbathing, they were simply resting on the road with no particular orientation to incident light. This would seem to indicate that these birds were in thermoequilibrium with the thermoneutral zone they were in. Bird numbers on the road were greatest when the road surface temperature was within, and air temperature below, the LCT of the species observed (Fig. 2). The presence of the birds on the road seems, therefore, to indicate not an energy-absorbing response but a behavioral pattern of perhaps equal importance, the selective use of thermally favorable microenvironments when ambient temperatures are suboptimal. Such behavior reduces heat loss to the environment and therefore aids the bird in achieving thermoneutrality and thus reducing energy demands. The potential energy saving to the individuals adopting this

Fig. 2. Total number of birds observed on the road surface relative to both road surface and air temperatures. Air --*, Road surface -- + .
(Note that the greatest number of individuals were observed when the road surface temperature was within the birds' optimum temperature range and the air temperature was not.)

behavior pattern is a function of the amount of additional metabolic energy which would be required to maintain themselves at the lower ambient temperature for an equal length of time. Therefore, to determine the bioenergetic importance of this road usage, it would be necessary to know the extent to which individuals utilize this resource on a daily and seasonal basis. No such data exist at the present time.

On a theoretical level, widespread availability of lightly-traveled asphalt roads with their favorable thermal microenvironment offers a very real potential for northward range extension by avian species. The road surface in summer is above LCT of common passerine species an average of seven hours per day longer than ambient temperature. Sunbathing on the road when it is slightly below LCT (and air temperature well below), further extends the potential energy-conserving period. Obviously, feeding and other activities prevent full use of this potential resource. However, it has been shown that in cool climates avian species with altricial young often live near their limits of adult energy reserves during the breeding season (Yarbough 1970, Morton et al. 1973, Holmes 1976). Under these circumstances even moderate use of the roads' warm microclimate might reduce metabolic energy demands enough to improve breeding success and/or permit northward extension of breeding range by species displaying this behavior. The road surface average of 5-8° C above the ambient (climatic) temperatures is roughly equivalent to a 5-7° southward shift in latitude (480-800 km) (Goode 1975). Considering the magnitude of this microclimatic diurnal temperature difference, it would be surprising if bird species failed to respond by extending their ranges northward, especially since availability of suitable microclimates has been shown to be a major determinant of plant and animal distribution at the extremes of species ranges (Grimm 1937, Geiger 1965, Rosenburg 1974).

Summary

This study demonstrated that significant temperature differences existed between the natural habitats studied and the microenvironment of asphalt road surfaces. Road surface temperatures remained above 22° C, the LCT of many bird species, an average of seven hours per day longer than in the other adjacent microclimates.

Observations of 2102 birds of 36 species on the road surface were compared with time, temperature, and weather data to determine whether a pattern of usage existed. Analysis of these relationships indicated that road surface temperature was the major determinant of bird presence on the road.

Bird numbers were greatest when ambient air temperatures were below species' LCT and the road surface was above this temperature. All evidence indicates that these birds have modified normal diurnal behavior patterns to utilize selectively the thermoneutral temperature zone of the road surface. This occurred primarily during periods when birds would have had to elevate their metabolism to compensate for the decreasing environmental temperatures. Therefore, birds evidencing this behavior were able to reduce daily metabolic energy expenditures in proportion to the length of time they spent on the road each day.

Further studies are needed to determine quantative daily and seasonal energy savings derived by individuals using this behavior. Data derived from such studies would make it possible to assess more accurately the extent to which this altered behavior pattern may influence and alter breeding distribution of the species involved.

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THE BIOLOGY OF *CLASTOPTERA ARBORINA* BALL (HOMOPTERA: CERCOPIDAE) IN WISCONSIN

F. M. Kuenzi *and* H. C. Coppel
Department of Entomology
University of Wisconsin-Madison

Abstract

Clastoptera arborina Ball is a spittlebug (Homoptera: Cercopidae) that feeds on *Juniperus* and has been recorded recently in Wisconsin. It is univoltine, with the eggs hatching early in June, and the nymphs developing through five instars until early to mid July. Adults appear in early July and persist through early October. Nymphs spend most of their time feeding, primarily on the sap of the green succulent tissue. The fluid waste is formed into a frothy mass (spittle) in which the nymph lives. They usually stay within a few centimeters of their first feeding site while immature. The imaginal molt occurs outside the spittle. The adults are relatively freely living, capable of jumping and flying several meters or more. Adults also spend much time feeding. Mating is done in an end to end configuration and can last up to five hours. Eggs are deposited singly or in pairs under thin flaps of juniper bark. No parasitoids were collected, but the adults may fall prey to a variety of arthropod and vertebrate predators. No physical damage to the host was observed; however, large numbers of nymphs producing the spittle-like froth may be unsightly on ornamental plantings.

Introduction

Ornamental conifers, including the many varieties of juniper (*Juniperus* spp.) and white cedar (*Thuja*) are widely used in landscape plantings. Their range of color and shape, tolerance of dry conditions, and longevity make them ideal low maintenance plants for beautifying the many harsh environments created by human habitation and business. Insects that damage the aesthetic value of these plants therefore, can become as economically important as those that cause physical and physiological damage. Some species of spittlebugs (Homoptera: Cercopidae) are known to directly damage the host by causing yellowing and browning of the leaf tips, and by vectoring a wide variety of pathogenic organisms (Hamilton, 1983; Wilson and Dorsey, 1957). The spittle bug, *Clastoptera arborina* Ball utilizes *Juniperus* and perhaps *Thuja* as a host. The nymphal excreta of *C. arborina* is a white, frothy fluid deposited around the insect's body in the form of a spittle-like globule, and many such globules can be unattractive when viewed against the dark green foliage of most varieties. It also feeds on native *J. virginiana* L., which is an important part of the dry, rocky bluff and glade habitats common in Wisconsin. Therefore, both because of its possible economic significance, and because little is known about the general biology of the genus *Clastoptera,* we shall present our observations on the development, behavior, and ecology of *C. arborina.*

Systematic Position, Distribution, and Hosts

Clastoptera arborina (Homoptera: Cercopidae) was described by Ball (1927) as *C. obtusa* var. *arborina,* a color variety of what he considered to be a species based on structural information. The following year Doering (1928), realizing that an even more detailed structural examination was necessary to classify within the genus, published a revision in which the *arborina* variety was given species status. This scheme was maintained in her later keys of the Cercopidae (Doering, 1930, 1941). Hamilton (1978) found that she had misidentified her specimens of *C. arborina* in 1928 as *C. newporta* Doering, a new species, and had described a truly new species as "*C. arborina.*" Therefore, he synonymized *C. newporta* with *C. arborina,* and renamed the new species. This revision is maintained in his later key (Hamilton, 1983).

Ball (1927) originally recorded *C. arborina* from Muscatine, Iowa. Doering (1928) recorded collections (as *C. newporta*) from Connecticut, Lakehurst, NJ; Lake George, NY; and Newport, RI. Hamilton (1983) described its distribution from southern Ontario, south to N. Carolina and west to Iowa.

The type specimens were collected from "white cedar," presumably *Thuja occidentalis* L., by Ball (1927). However, Hamilton (1978) was unable to confirm this, but collected many specimens from eastern red cedar, *Juniperus virginiana* L.

Investigational Studies

Ten specimens of the insect collected in 1981 by H.C.C. were identified as *Clastoptera arborina* by J. P. Kramer of the Beltsville Agricultural Research Center, USDA, Beltsville, MD. This series and additional collections from 1983 and 1984 are kept in the research collection of the University of Wisconsin-Madison, Department of Entomology. *C arborina* was first recorded in Wisconsin from a *J. virginiana* planting in the southwest section of Madison, WI, where this study was subsequently undertaken on populations of *C. arborina* in: a residential area, the Odana Hills Golf Course, and two areas in the University of Wisconsin-Madison Arboretum: the Longenecker Horticultural Gardens, and the Juniper Knolls.

Materials and Methods

Number of Instars:

Dyar's law, that a dimension of a sclerotized structure should increase by a constant ratio between instars, was used to determine the number of instars of *C. arborina*. Every two days at least 10 spittle masses were collected from the field and taken to the laboratory. The nymphs were removed from the spittle singly and partially dried on ground glass using cross pins for manipulation. The greatest width of the head was measured under a stereo microscope at approximately 54X with a calibrated ocular micrometer. The daily sample size was not constant because some spittle masses contained more than one nymph, and all available nymphs were measured to ensure an adequate number of each instar for further study.

To determine the size of each instar, the measurements were grouped according to instar and numbered consecutively within the group. A random sample of 30 was obtained by using the total data, or a random sample chosen with the aid of a random number table (Snedecor and Cochran, 1980). The data are primarily from 1983, except for the measurements of the first instar, and additions to the second and third instars to complete the sample.

Seasonal History:

Random samples of 20 spittle masses were obtained approximately every other day, beginning with the first sighting of spittle on May 6, 1984. Randomization was done by constructing a grid over the surface of a juniper bush. At every sampling, 20 coordinates were drawn from a random number table (Snedecor and Cochran, 1980), and the spittle mass nearest each coordinate was removed from the bush. From head capsule size or general morphology, all nymphs were classified according to instar, and the frequency distribution (% of each instar) was recorded for each sampling day. When adults were found, the procedure was modified by counting either the fifth instar exuvia, patches of meconia, or both, if present, as an adult. Actual adult insects were not counted. This interpretation proved unambiguous, as the exuvia and meconia persisted in place for several days.

Hosts:

The plantings of *Juniperus* spp. and *Thuja occidentalis* in the University of Wisconsin-Madison Arboretum provided a unique opportunity for the investigation of hosts of *C. arborina*. Within the Longenecker Horticultural Garden, the "Pinetum" collection contained 32 cultivars of *J. chinensis,* 9 cultivars and varieties of *J. communis,* 1 *J. rigida,* 3 cultivars of *J. sabina,* 1 cultivar of *J. scopulorum,* 1 cultivar of *J. squamata,* and 18 cultivars and varieties of *J. virginiana.* All of these were in a 5600 m^2 area on a south facing hillside. A neighboring area contained more cultivars of *Juniperus* spp. and a hedge of *T. occidentalis* in juxtaposition. The other area of importance was the Juniper Knolls, which included a large area of juniper canopy and its fringe of isolated and semi-isolated *Juniperus virginiana* trees. A stand of *T. occidentalis* was located 50 m to the east, and the two areas were separated by an extension of the prairie habitat.

When the *C. arborina* nymphs were beginning the fifth instar, all plantings in the above areas were searched extensively for spittle masses. Approximately one month after the appearance of adults, a second survey was conducted including these same areas and the plantings around the administration building. In this study, adults were collected by sweeping the foliage with an insect net.

To determine the part of the plant utilized, the spittle masses observed in the seasonal history survey were scored according to the part of the branch they occupied. The categories were: a) "Core," including the trunk, major branches, and minor branches covered with true, cambium-derived bark; b) "Dry Twig," or the smaller branches covered with dried scales; c) "Green Twig," or the photosynthetic twig composed of long scales, concressent proximally with only the tip free; and d) "Foliage," which in most varieties takes the form of branchlets bearing small, closely appressed scales.

TABLE 1. Head capsule measurements for nymphal and adult stages. n, sample size; $\bar{x} \pm$ SD, mean $\pm$ standard deviation; Ratio, nymphal instar/previous instar.

Instar	*n*	$\bar{x} \pm SD$	*Range*	*Ratio*
I	30	0.333 ± 0.011	0.32 - 0.36	
II	28	0.485 ± 0.021	0.45 - 0.52	1.45
III	30	0.695 ± 0.037	0.60 - 0.76	1.43
IV	30	1.038 ± 0.047	0.90 - 1.13	1.49
V	30	1.552 ± 0.080	1.35 - 1.70	1.50
Adult	30	1.841 ± 0.080	1.66 - 1.96	
male	15	1.809 ± 0.080	1.66 - 1.94	
female	15	1.872 ± 0.068	1.72 - 1.96	

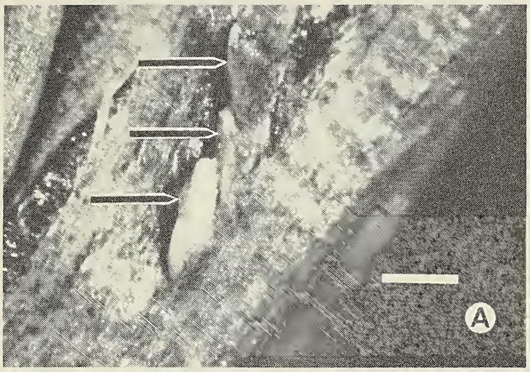
RESULTS AND DISCUSSION

Number of Instars:

Head capsule measurements clearly differentiate five nymphal instars (Table 1). The growth ratios are reasonably constant, and generally agree with the 1.4 expected from Dyar's law. The ranges of the 5th instar and the adult measurements overlap, but the head capsule width is otherwise diagnostic for each instar. The adult and nymph are easily distinguished morphologically. There is a significant difference ($P < 0.05$) between the adult male and female measurements, and the increasing standard deviation with each instar (Table I), particularly in the case of the 5th instar, may be partially due to this sexual dimorphism. Unfortunately, a lack of preserved specimens prevented statistical testing of the immatures.

Descriptions of Stages and Instars:

Egg (fig. 1): The egg is elongate, oval, and 0.835 ± 0.057 mm (n = 16) long. In the fall it



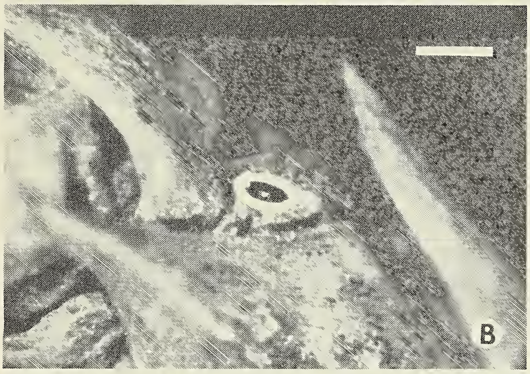


Fig. 1. *Clastoptera arborina* eggs *in situ:* A) during the fall (3 eggs, side view), and B) in the spring before hatching (1 egg, face view). Note the shiny black "egg burster" in B. Bar equals 0.5 mm.

is laterally flattened, with the broad side 0.362 ± 0.061 mm (n = 15) wide, and the narrow side 0.197 ± 0.037 mm (n = 12). It is deposited under a flap of the plant tissue with one end and most of a side (¼ to ½ of the circumference) remaining exposed. The exposed end is more pointed and narrower than the blunt inner end. A white patch of thickened chorion covers the central portion of the exposed area, but the peripheral chorion, like that covered by the bark or epidermis, is membranous and translucent to the yellow yolk. The white patch has a dark sagittal streak under the chorion. In the spring the egg swells, becoming round and splitting the chorion over the streak to expose a shiny black, oval "egg burster" (fig. 1B).

First Instar (fig. 2A,B): The head is yellow, round, and the width at the eyes is little more than the clypeus. The labium is surprisingly long compared to the total body length, and in dorsal view protrudes beyond the tip of the abdomen. Each eye consists of ten pigmented ommatidia. The antennae are short and two-segmented.

The thorax is yellow, cylindrical, narrower than the head, and dominated by the pronotum. The mesonotum has lateral triangular sclerotizations, and the metanotum is entirely membranous. The legs are translucent, long, and spider-like. The tarsi are two segmented.

The abdomen is initially yellow, contracted, only slightly wider than the thorax, and carried with the tip directed dorsally. After feeding it becomes distended (fig. 2B). There is a shallow groove parasagittally which marks the attachment of the dorsoventral muscles, and there are irregular transparencies in the integument permitting partial observation of the digestive and circulatory organs. Paired, brush-like structures of transparent filaments occur ventrally on segments 5 and 6 (fig. 3). These are shed with the exoskeleton at each molt. Similar structures are on segments 7 and 8 of *L. quadrangularis* and *Aphorophora parallela* Say (Guilbeau, 1914). Unlike the condition in *Tomaspis saccharina* Dist. (Kershaw, 1914), *Lepyronia quadrangularis* (Say) (Doering, 1922), and *Philaenus lineatus* (Sulc, 1910), the terga actually fuse in the ventral midline rather than merely touch or overlap (fig. 2G). The last tergum (9) is sclerotized, and its lateral edges curve ventrally and touch without fusing. Thus, the air canal enclosed by the sterna is a complete tube, closed anteriorly by a posteriorly directed triangular ridge of sternum 3, and open posteriorly at the margins of tergum 9. The remainder of the abdominal cuticle is unsclerotized.

Second Instar (fig. 2C): The second instar resembles the first, although it is larger. The eyes consist of 12-15 ommatidia on a widening of the head, and the antennae are short

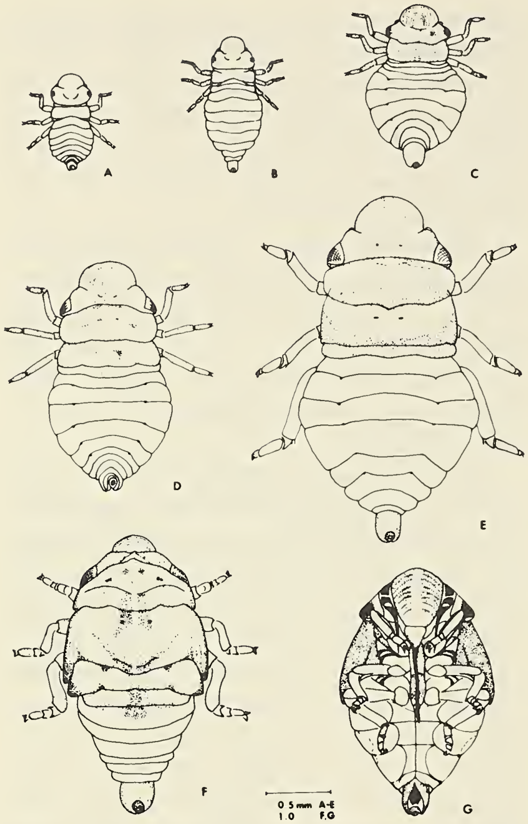


Fig. 2. Nymphal instars of *C. arborina*. A) newly emerged nymph; B) late first instar; C) second instar; D) third instar; E) fourth instar; F) fifth instar, dorsal view; G) fifth instar ventral view. Note the different scale for F and G.

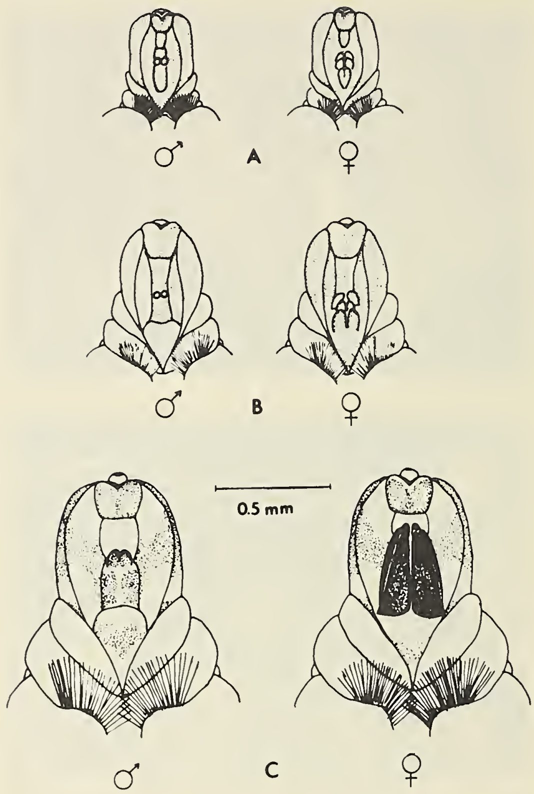


Fig. 3. Development of the genitalia. Ventral views of abdominal segments 5-9. Segment 6 is concealed by the enlarged fifth tergum and the curvature of the abdomen. The filaments mentioned in the text are shown as one clump. A) third instar; B) fourth instar; C) fifth instar.

and two-segmented. The thorax is more dorsoventrally flattened, and dominated by the prothorax. There is some sclerotization of the lateral meso- and metanota. The head, thorax and last abdominal tergum are usually olive green, and the remainder of the abdomen is yellow.

Third Instar (fig. 2D; 3A): The head is olive green and broad. The eyes are hemiconical and multifaceted, with the distal ommatidia darkly pigmented. Each antenna has two basal and one flagellar segment, and the ocelli first appear.

The thorax is dorsoventrally flattened, with the pro- and mesonota prominent. The legs and dorsal thorax are olive green. Wing pads become evident in this instar.

The abdomen is light yellow, although some internal organs may impart a greenish tinge. The ventrolateral areas of segments 4 and 5 may appear bright orange, due to a number of large pigmented cells in the body cavity of this region. Similar tissue was reported by Garman (1923) as the "spittle gland" of *C. obtusa* Say, and is also found in *L. quadrangularis* (Doering, 1922). The developing male and female genitalia become evident in the ninth sternal region (fig. 3A).

Fourth Instar (fig. 2E;3B): The fourth instar is generally similar in form and color to the third instar. The antennae have two basal segments, but flagella have a number of irregular, colored bands suggestive of segments. The sclerotized structures are olive green, although the shade is highly variable, and the head and thorax have dark patches. Anterior wing pads are prominent, and trachea can be seen entering them. Posterior wing pads are slightly developed. Each leg bears a fringe of apical tibial spurs.

Fifth Instar (fig. 2F,G;3C): Dorsally the head is crescent-shaped due to further broadening and shielding posteriorly by the pronotum. The color is olive green. Antennae are long and filamentous.

The thorax varies from dark green to grey or brown, and the darkening of the midline and wing areas makes it appear three-striped. The anterior wing pads are well developed, and exhibit some of the features of the adult tegmina. The posterior wing pads are less well developed and appear as lateral triangular thickenings. The meso- and metathoracic legs each bear a comb of apical spines, and all tarsi are three-segmented. Late in the stadium, black-tipped adult tibial spurs are visible under the nymphal cuticle.

The first abdominal segment is sclerotized and colored like the thorax. The second segment has a triangular, darkly pigmented patch, anteriorly as wide as the margin in dorsal view and narrowing to a point halfway along the midline. The remainder of the abdomen, except for the last tergum can be yellow or white depending on the individual. The genitalia are plainly visible on the last sternum; the valves of the ovipositor are jet black, and the claspers of the male are dark and sclerotized (fig. 3C).

Adult: Doering (1928) illustrated and described the adult in detail as *C. newporta.* We have found that the ovipositor's third valvulae are fused dorsally for one third their length and bear 68 ± 5.57 ($n = 25$) teeth along the dorsal margin between the fusion and the apex. Doering (1928) reported "about 82 teeth" for *C. arborina* while *C. doeringae* Hamilton has "81 to 90" and *C. media* Doering has "about 78." The structure of these valvulae is supposed to be of great comparative value for these closely related species. The red abdominal tissue is well developed, but not visible due to the pigmentation of the integument.

Seasonal History:

Clastoptera arborina is univoltine in Wisconsin, and overwinters in the egg stage. This is consistent with most other *Clastoptera* at this latitude on the continent, e.g. *C. hyperici* Gib. in Michigan (Hanna, 1969), but differs from the bivoltine *C. obtusa* of Connecticut (Garman, 1923).

The seasonal distribution of the different instars from the 1984 data (fig. 4) generally corresponds to the 1983 observations. Eggs with the "egg burster" were found in the third week of April, 1984. First instar nymphs were found on June 6, 1984, and an egg was observed hatching June 7, 1984. In both 1983 and 1984, adults began to appear in early July. Mating was first observed in mid July, and observations of mating continued into early October, when the last adults were collected (both years). Eggs were found in twigs caged with adults from July 27 to September 26, 1984. The seasonality of *C. hyperici* is similar to this, although Hanna (1969) does not give specific dates, and Garman's (1923) records for the species

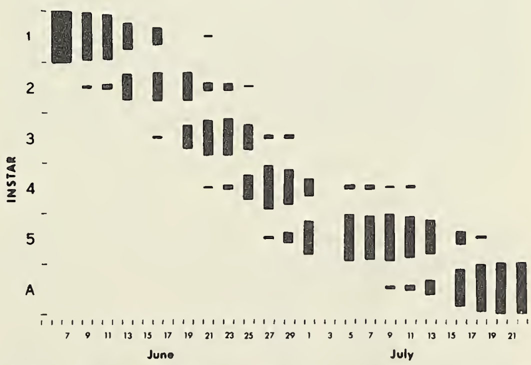


Fig. 4. Seasonal history of *C. arborina.* Vertical length of bars indicates percentage of day's sample represented by each instar. Eggs were not sampled.

mentioned above show a slightly contracted seasonality, with the first generation being advanced about 3 weeks.

Hosts:

Nymphs and/or adults of *C. arborina* were found on the following cultivars or varieties of *Juniperus* spp: *Juniperus chinensis* cultivars Ames, Blaauw, Columnaris Glauca, Fairview, Iowa, Keteleeri, Mission Spire, Mountbatten, Obelisk, Pfitzerana Aurea, Pfitzerana Glauca, Robusta Green, and Story; *Juniperus communis* cultivar Laxa; *Juniperus sabina* cultivars Fastigata and Von Ehren; and *Juniperus virginiana* from Juniper Knolls and cultivars Burkii, Canaertii, Globosa, Hillii, Hillspire, Pyramidalis, Skyrocket and variety *glauca.* A large collection of *J. horizontalis* was not examined for spittle masses, and no adults were collected; however, the low creeping growth of this species made the sweeping technique ineffective. *J. rigida, J. squamata,* and *J. scopulorum* supported neither nymphs nor adults, but together they made a small contribution to the total planted collection. Otherwise *C. arborina* is able to complete development on several species and varieties of *Juniperus.* Doering (1942) listed three other *Clastoptera* spp. collected from *Juniperus,* including *C. elongata* Doer., *C. juniperina* Ball, and *C. doeringae.*

Both the nymphs and adults of *C. arborina* prefer to feed on the green twigs of *Juniperus.* A Chi square (χ^2) test against the null hypothesis of equal utilization of the four areas was highly significant (Table II, $P < 0.05$). The green twig was the preferred feeding site, as this category made the greatest contribution to χ^2. Also only 5th instar nymphs and adults were found in the dry twig area, which can be attributed to the relocation of spittle masses toward the trunk as described below, and the free movement of the adults respectively.

TABLE 2: Parts of the juniper plant utilized for feeding by *Clastoptera arborina.*

Stage	*Core*	*Dry twig*	*Green twig*	*Foliage*	*Total*	χ^{2*}
Nymph	0	7	124	40	171	227.24
Adult	0	19	44	16	79	50.27

* 3 degrees of freedom.

Habits of the Nymphs:

Eclosion: The "egg burster" acts as a trap door at hatching, as its seam breaks cleanly through most of its circumference. The nymph is positioned in the egg with its head in the outer tip and its venter against the "egg burster." As it wriggles out of the chorion, its legs are worked free, and extended and flexed repeatedly until one catches an object such as a scale or twig. This action enables the nymph to pull itself into a standing position. The time from chorion rupture to complete eclosion is approximately 5-10 min. The nymph remains nearly motionless for about 20 min, after which it begins crawling about the foliage and twigs until it establishes the first feeding site.

Spittle Production: Doering (1922) briefly reviewed earlier accounts of bubble forming movements and related morphology in cercopid nymphs. In general, her description and conclusions accurately apply to the observations of *C. arborina* nymphs. As noted previously, four clusters of filaments are present near the opening of the air canal. Guilbeau (1914) reported that they are a secretion of the dermal glands of Batelli. His experimental and histological studies indicated that the secretion is necessary for the retention of bubbles in the excrement. We observed that the filaments usually come in contact with the newly formed bubbles as they are expressed from the air canal, so they may indeed contribute to this phenomenon.

Spittle production and maintenance was virtually continuous; however, the rhythmic movements of bubble making were frequently interrupted by short, ca 30 sec periods of breathing, where only a small "Y"-shaped vent (the space on either side of the anus and the adjoining median cleft between the tergal plates) was open for the passage of air into the air canal.

Activity: Nymphs are generally sedentary, although they are capable of rapid movement while immersed in the spittle. The principal activity is feeding, with the stylets inserted in the plant tissue. This necessarily renders the insect immobile, except for the abdomen, which is almost continually pumping back and forth. When the spittle is disturbed however, the nymph will withdraw its abdomen from the surface and its mouthparts from the plant, move to the opposite side of the twig, and take shelter in the axil of a scale if available. Usually the mass of froth is sufficient to obscure the presence and movements of a completely submerged nymph. The insect may remain submerged for at least a minute, although, unless disturbed again, it will protrude its abdomen and begin bubble making within a few seconds. Molting from one nymphal instar to another takes place inside the spittle mass, and one to several exuvia can be found floating in the fluid after the first instar.

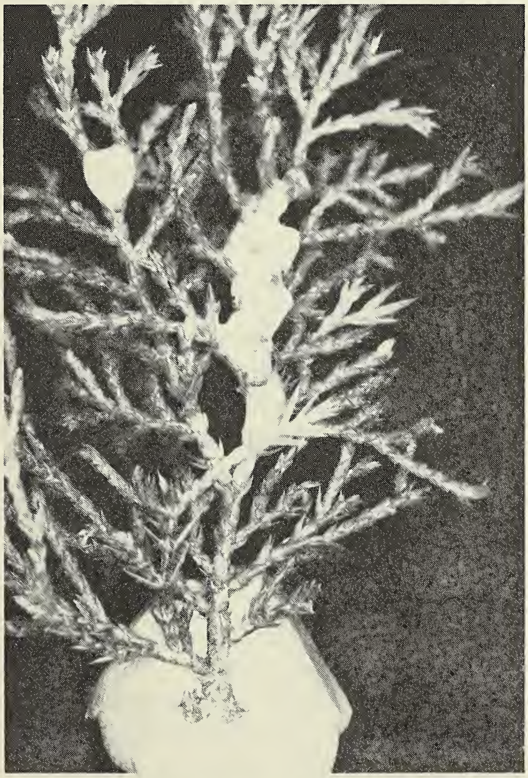


Fig. 5. Aggregation of eight fifth instar nymphs.

A nymph may abandon its original spittle mass and move to a new feeding site, usually on the same branch. Most abandoned spittle masses are a result of this relocation rather than nymphal death. This is based on observations of the number and location of spittle masses on marked twigs. The new masses were usually closer to the center of the plant. The number of exuvia in fifth instar spittle also suggests that this movement occurs during the third or fourth stadium. Wandering nymphs carry a film of spittle over their backs, and a cache of bubbles and fluid around their coxae. They crawl randomly, and intermittently probe the twig surface with their labellum until a new feeding site is found. If they contact another spittle mass however, they stop and enter it. This sometimes leads to aggregations of up to 8 nymphs in one continuous spittle mass (fig. 5). This is no doubt a common feature of the immature Cercopidae (Hamilton, 1983).

Natural Enemies: Nymphs may fall prey to a variety of arthropod predators, primarily of the order Hemiptera (Insecta) (Hamilton, 1983). Although we found no direct evidence of this, members of the family Reduviidae, Nabidae, Pentatomidae, and Miridae were found on juniper in association with *C. arborina.* One case of an ectoparasitic larva was observed, but it died soon after discovery, and no identification was made. It did bear resemblance to the illustrations of the drosophilid found on temperate *C. obtusa* (Baerg, 1920; Garman, 1923).

Impact: In spite of sometimes heavy feeding, we observed neither yellowing nor browning of the branchlet tips nor significant necrosis of the tissue around feeding sites. Thus, the physical or physiological damage caused by *C. arborina* is likely to be minimal for plants in unstressed environments.

Habits of Adults:

Imaginal Molt: The final molt occurs outside and usually towards the tip of the branch from the last spittle mass. Newly emerged adults are pale yellow without definite markings. As the thorax is freed from the nymphal skin, the wings are expanded, while being held in a vertical position. The legs and abdomen are then pulled free, and the genitalia are expanded to full size, and spread. After complete expansion, the wings are first lowered till horizontal and longitudinal to the body axis, and then slowly, ca 2 min, laid flat on the back. Emergence takes approximately 20 min. Failure to molt properly is a frequently observed mortality factor.

After molting, the adult may crawl a short distance before pausing for cuticular tanning. Development of the mottled white, tan, and black markings usually requries two or more hours, during which time the meconium is cast. The meconium is splattered on the foliage, and dries as a white plaster-like substance, resistant to rain, and persisting through the fall. After feeding, adult excreta is also splattered on the foliage as droplets of transparent fluid.

Locomotion: The adult *C. arborina* is essentially sedentary, spending much time feeding and mating, and it will usually tolerate the manipulation of foliage necessary for close observation. Short distance movement is by crawling, with the anterior four legs used in the typical insect gait, and the metathoracic (jumping) legs either held next to the abdomen in a "cocked" position, or used in an anterior-posterior pushing motion. Jumping is accomplished by an explosive extension of the hind legs, accompanied by a slightly audible popping noise. About 15 sec is required for cocking the legs after landing. Jumping is a frequent means of escape, but has also been observed in the froghopper's unmolested activity. In addition, after jumping, *C. arborina* may use its wings to alter its course, or extend its range several meters. Specimens of *Clastoptera* spp. were captured in the 20 m tower at Belle Plain, NJ (New Jersey Dept. Agr., 1927), which indicates a potential for long range dispersal of these insects, probably mediated by active flying.

Mating: During courtship the male rides on the back of the female, with the couple facing forward. The male and female genitalia are then coupled and mating begins. The pair may continue in this configuration, but usually the male lets loose and turns to face in the opposite direction. While joined, they do not feed, but can crawl in a push-pull fashion, and jump approximately 30 cm vertically. Copulation lasts from two to five hours.

Oviposition: Eggs are laid singly or in rows of 2 or 3 under a flap of either bark (most common, fig. 1), or the green twig or foliage epidermis. When in the latter succulent tissue, a brown necrotic area forms around the egg. The long axis is usually at a 20° to 50° angle with the long axis of the twig, or when laid in the axis of a branch and twig, its direction is nearly perpendicular to the plane of the branch and twig. The egg penetrates the bark and parenchyma, and often the phloem and outer xylem as well. In nature a twig rarely contains more than two oviposition sites.

Fecundity: Ten females dissected between July 25 and August 20, 1984 contained from 6 to 11 ovarioles in each ovary (median = 8). Mature oocytes (length = 0.773 ± 0.053 mm, n = 28 from 4 females) were present in the ovarioles and lateral oviducts beginning July 25, but some specimens contained only developing oocytes. From late July to early October all specimens contained one or more mature oocytes, and mating was observed throughout the interval. Unfortunately, adults did not survive more than a week when caged on juniper, so no estimate of total fecundity was possible.

Predation: Adults are probably more susceptible to predation than nymphs, although the small size and cryptic coloration of the former when viewed against the dry twig may provide some protection. In the laboratory they have been preyed upon by a toad, and a variety of arthropod predators including *Zelus socius* Uhler (Hemiptera: Reduviidae), *Phymata pennsylvanica* Handlirsch (Hemiptera: Phymatidae) and *Misumenops asperatus* (Hentz) (Arachnida: Araneae: Thomisidae), all collected from juniper. The froghoppers were captured by the predators only while moving about between feeding periods, presumably because their motion increased their visibility. Also they could frequently escape even after capture by using their explosive jump.

Acknowledgements

This research was supported by the College of Agricultural and Life Sciences, University of Wisconsin-Madison, and by research funds from The Wisconsin Department of Natural Resources through the School of Natural Resources, University of Wisconsin-Madison. We wish to express our sincere gratitude to John Haanstad for the photographic assistance, to Steven Krauth for the taxonomic assistance, to Dr. E. Hasselkus for maps and planting records of the Arboretum collection, and to the staff at the Arboretum for their cooperation.

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FEEDING SITE AND SPITTLE OF *CLASTOPTERA ARBORINA* BALL (HOMOPTERA: CERCOPIDAE)

F. M. Kuenzi *and* H. C. Coppel
Department of Entomology
University of Wisconsin-Madison

Abstract

Feeding punctures of *Clastoptera arborina* Ball stained bright red with safranin 0 dye in cross sections of juniper twigs. The punctures were primarily intracellular, passed through all tissue layers, and ended in the outer layers of xylem tracheids. Xylem feeding is consistent with this and other aspects of *C. arborina*'s biology, and with the habits of other cercopids. Most feeding sites were established midway between the resin canal and the scale edge, and a disproportionate number entered through the stomata. The stylet sheath bore diameter increased with age, and matched the maxillary stylet diameter. The mandibular stylets do not penetrate beyond the outer mesenchyme and/or epidermis.

In the field, spittle is a white frothy mass, but this becomes more fluid in later instars. Many kinds of insects are found in spittle masses, but these are probably accidental entrapments, and not indicative of natural enemies. Under 100% humidity, the spittle production rate of a fifth instar nymph is 109.6 mg/day.

Introduction

Juniperus virginiana L., the host plant of *Clastoptera arborina* Ball, usually grows in the well drained soil of limestone outcroppings, bluffs, and glades. These more arid environments present special problems of water retention for developing insects, especially during the cuticle tanning period immediately following ecdysis. Spittle insects are well adapted for coping with these problems, as they are able to utilize the plant's own sap to create a virtually aquatic microhabitat in a semiarid environment. The following study establishes the source and acquisition of nutrients and water for *C. arborina,* and describes the spittle and its rate of production.

Materials and Methods

1. Feeding Site Description

Twigs with spittle masses were removed from the plant and trimmed as close as possible to the feeding nymph. The nymph was usually removed from the twig before the twig sample was fixed in formalin, acetic acid, and 50% ethanol (18:1:1) for one or more days. The specimens were dehydrated in an ethanol series with 2 changes of 100% ethanol, cleared in xylene, and infiltrated and embedded in Paraplast.

Young juniper twigs consist of a fibrous xylem core surrounded by phloem and mesenchyme. The difference in hardness between the former and the latter two often resulted in the fracture of the vascular cambium during sectioning. This artifact was eliminated in later work by trimming one end of the Paraplast block down to the specimen and soaking the block in water for one or more weeks. The embedded specimens were then mounted on wood blocks and sectioned at 10μm. The resulting ribbon of serial sections was mounted on glass slides, stained with safranin 0 and fast green according to Johansan (1940), and covered with a cover slip. Measurements were made with a calibrated ocular micrometer.

2. Rate of Spittle Production

A humidity chamber was constructed of a 25 x 25 cm square polyethylene sheet. A hole approximating the mouth aperture of a polyethylene funnel (about 5.5 cm in diameter) was cut in the center, and the funnel taped in place, being fastened around its entire circumference. Two opposing edges were taped together to form a cylinder, with the funnel nozzle directed outward.

The host plant was a small, potted *J. virginiana* kept in an incubator under a photoperiod of 18 hours light and 6 hours dark. A trial began by placing a fifth instar nymph on an appropriate section of twig in the humidity chamber with the funnel directly below the nymph. The chamber was closed tightly around the twig proximal to the trunk with a twist tie, and similarly with the distal end, except that a moistened dental wick was included in the closure so that one end projected to the outside. The wick was kept moist throughout the trial. A preweighed vial was then fastened with tape or clay to the funnel nozzle. Similar units not containing nymphs served as zero controls. After three days the twig and apparatus were removed from the plant and examined. Only those setups with healthy nymphs remaining at the end were used for spittle production data. The vials and collected spittle were weighed on an analytical balance, and the volume estimated by drawing the contents into a 1 ml pipet graduated in 0.01 ml divisions.

Results and Discussion

1. Feeding Site Description

The histological study showed the feeding punctures of *C. arborina* in the tissues of its host, *Juniperus* spp., as indicated by the following evidence. Generally one feeding puncture was located in each twig specimen. Because *C. arborina* remains in the same spittle mass through several stadia however, two feeding punctures were occasionally found in the same specimen. Also, as nymphs sometimes withdraw their mouthparts and move when disturbed, they may move far enough away from the feeding site such that the sheath is excised during trimming. Thus, some samples inevitably contained no feeding sheaths, but in general the number found was as expected. When two nymphs were fixed with the twig specimens, their mouthparts were observed inserted in the feeding punctures after sectioning. Finally, no other type of damage was found consistently that would befit the mouthpart morphology and feeding behavior of *C. arborina*. The feeding punctures are very distinctive (Fig. 1).

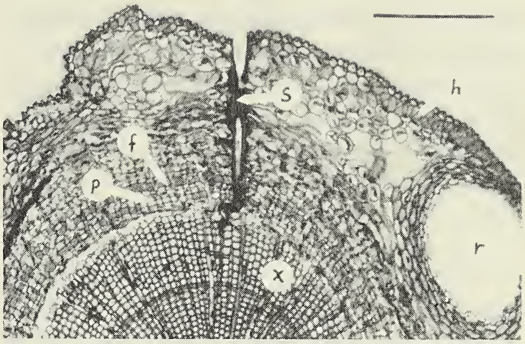

Fig. 1. Cross section of Juniper stem showing feeding sheath of fifth instar *Clastoptera arborina* Ball. *Abbr.* f - fiber cell band, h - hypodermis, p - phloem, r - resin canal, s - feeding sheath, x - xylem. *Bar* equals 0.25 mm.

As is the case with most Cicadoidea, the feeding puncture is primarily intracellular, and is lined with a sheath staining bright red with safranin 0 dye (Wiegert, 1964; Pollard, 1967; Cheung and Marshall, 1973). This is thought to be a salivary secretion, although some basophilic staining may be due to autolysis of the ruptured cells (Pollard, 1967). From observations on a cicadellid feeding through an artificial membrane, Bennett (1934) reported the secretion of a colorless fluid from the mouthparts that quicky coagulated to form a hyaline sheath around the stylets. This corresponds with the nature of the sheath reported here. Aphids produce a similar structure, but the feeding track is primarily intercellular (Balch, 1952).

The bore of the sheath is smooth, with the diameter increasing with the insect's age (see below), and the outer surface is irregular, being constricted by the plant cell walls, and expanding slightly into the cytoplasm, although not replacing it. The sheath continues through the air spaces between mesophyll cells, where its surface exhibits helical ridges, like twisted wrought iron.

The feeding tracks passed through many tissue types before ending in the xylem. A fibrous hypodermis was present near most feeding sites (Fig. 1), although it was absent directly below the stomata and other areas where punctures were predominantly located. Other tissues always encountered were the mesophyll, phloem sieve cells, ray parenchyma, and concentric bands of thick walled fiber cells. The stylets were usually worked *between* the latter. Except for the cells broken by the stylets, there was no other sign of damage to the tissues. Seventy-seven percent of all sheaths terminated in the xylem tracheids. These were generally in the outer layer of vessels, and usually only one cell showed signs of damage. The deepest tracks ended in the seventh layer of xylem from the outside. Sixteen percent ended in the xylem ray parenchyma, and here there was no evidence of xylem feeding. Pollard (1967) noted however, that in the mesophyll feeding cicadellid, *Eupteryx melissae* Curtis, maxillary extrusion was commonly far beyond the end of the sheath, in which instance, xylem actually may have been contacted. The thickness of our sections however, made this difficult to establish. In contrast to that of the phloem, xylem sap is a very dilute solution of inorganic ions, amino acids, and sugars. Thus xylem feeding is in keepng with the large amounts of fluid excreta produced by *C. arborina* nymphs and other spittlebugs, as large volumes of sap must be processed to extract the necessary nutrients.

The angle of stylet penetration was usually radial, although in 37% of the cases it was skewed from 20° to 45° from the radial. Also, the course of the stylets was generally straight, but in some specimens it curved slightly in either the transverse or longitudinal plane (29% of the cases), showed a slight elbow (14%), or curved in an "S" shape (2%). Branching was very infrequent, and often occurred at the level of the fiber cell bands. Usually only one branch was patent.

Clastoptera arborina nymphs and adults prefer the outer twigs and foliage branchlets of *Juniperus,* with the younger individuals predominantly on the more succulent tissue (Kuenzi and Coppel, 1985). Histological location of the actual punctures provides more specific circumstantial evidence characterizing feeding site choice and establishment. Examination of 42 sites revealed penetrations at virtually any point around the twig's circumference, including: between the resin canal and the scale edge (fig. 1) (88.0%), between scales (2.4%), at the edge of a scale (4.8%), into the resin canal (2.4%), and through the periderm (2.4%). Usually the point midway between the resin canal and the edge of the scale coincided with the lateral edge of an overlying scale (47.6% of the total), which is in keeping with the nymph's preference for sheltered locations. Where a first instar attempted penetration directly into a resin canal, sheath material was deposited a few microns inside the canal lumen, but there was no sign of continuation through to the other side. Interestingly, 54% of all penetrations were directly between guard cells of the stomata, and in two additional cases they were within one cell of a stoma. Brandes (1923) also noted that the stylets of *Aphis maidis* Fitch frequently entered the thin cuticle of the guard cells in corn, and Putman (1941) found over 10% of the stylets either entering the stomata, or passing between a guard cell and an adjacent epidermal cell in the mesophyll feeding cicadellid, *Typhlocyba pomaria* McAtee. As the stomata rarely occupy a large fraction of epidermal surface (7.8% of 218 mm^2 in

Juniperus), these observations may reflect a tendency of the spittlebugs either to use the vapor leaking through open stomata as a cue to initiate a feeding puncture, or simply to use the stoma as a path of low mechanical resistance.

The bore diameter, measured midway between the epidermis and xylem ranged from 4.2 to 25.2 μm (Table 1). A one way analysis of variance showed a highly significant instar effect ($P < 0.005$), but a least significant difference test failed to detect differences between successive instars at the 90% confidence level. A regression of the bore diameter against instar (the adult considered as the sixth instar) gave a linear trend with a slope of 2.7 μm ($P < 0.001$) and R^2 of 69.8%. It should be noted however, that the ranges and 95% confidence intervals of the first and second instar measurements overlapped completely (Table I). Excluding size, the stylet sheaths of the nymphs were all similar in morphology. The thickness of the sheath was from 2.9 to 11.6 μm in the second instar, and those of the other immature instars fell within this range. The sheaths of the adults and some fifth instar nymphs however, were very thin or not visible, and did not appear to traverse the air spaces as did those of the younger nymphs. The older individuals also damaged the xylem tracheids more, with several vessels being ruptured.

Pollard (1967) suggested that the mandibular stylets penetrated very shallowly, with the maxillae being extruded much farther. Thus the presence of such long sheaths in *C. arborina* feeding punctures may indicate extensive mandibular penetration into the plant tissue. As *C. arborina* feeds with its body aligned with the long axis of the stem, and the mandibular stylets are positioned lateral to the maxillae, the sheath bore diameter should correspond to either the maxillary or the combined stylet width. Transverse sections of second and fifth instar nymphs allowed direct measurement of the stylets. Allowing for some shrinkage of the plant tissue, the combined mouthparts were clearly too large to account for the bore diameter, but the maxillae were only slightly larger than the bore (Table I). Thus the mandibles of *C. arborina* are apparently inserted only a short distance, and in contrast to the mesophyll feeding *E. melissae,* sheath material is deposited along the entire length of the maxillary track.

Pollard (1967) also found that the depth of penetration increased with each instar in *E. melissae,* but this would not be expected in *C. arborina* due to the uniform thickness of mesophyll in the photosynthetic twigs. Indeed, a one way analysis of variance showed no difference in average penetration (all measurements were trigonometrically corrected for nonparallel sectioning) with an

Table 1. Measurements in micrometers of the sheath and mouthparts of *Clastoptera arborina* Ball. Numbers in parenthesis indicate sample size; $\bar{x} \pm SD$, mean ± standard deviation; Rep., representative value.

Instar	Sheath *Bore Diameter* *($\bar{x} \pm SD$)*	*Thickness* *(range)*	*Length* *($\bar{x} \pm SD$)*	Mouthparts *Maxillae* *(Rep.)*	*Max. and Mand.* *(Rep.)*
I	6.13 ± 1.69 (6)		519 ± 64 (5)		
II	6.18 ± 1.18 (8)	2.9 – 11.6	489 ± 118 (8)	8.7	17.4
III	10.09 ± 3.65 (8)		482 ± 90 (8)		
IV	12.78 ± 5.16 (6)		533 ± 97 (6)		
V	15.75 ± 3.48 (5)	4.4 – 8.7	507 ± 99 (5)	29.5	49.2
Adult	19.43 ± 4.66 (4)		551 ± 61 (4)	29.5	49.2

overall mean of 513 μm and pooled standard deviation of 94.7 (30 degrees of freedom; $P > 0.25$). This is demonstrated by the values in Table I.

2. Description of Native Spittle

Early in the season the spittle produced by a first instar nymph is a small, white mass of tiny bubbles deposited in the fork of foliage branchlets or outer twigs. The size of this mass and of the bubbles increases with the growth of the insect, and the whitish appearance persists. Even in the first instar, the spittle often includes silken strands of unknown origin, plant hairs and other detritus, and the bodies of dead insects. All these components, with the addition of crystalline material, are found on the twig surface in abandoned spittle masses. In later instars, especially the fifth, the spittle becomes less frothy, and large globules of clear to yellowish, gelatinous spittle are found, sometimes with correspondingly colored patches of crust on the surface. Other than this, there is no change in the spittle of the pharate adult, as opposed to the condition of *Philaenus spumarius* (L.) and *Lepyronia quadrangularis* (Say), where, at this stage, the spittle is allowed to dry, and a cavity formed inside to accommodate the ecdysing insect (Doering, 1922; Weaver and King, 1954).

The following insects were found in various spittle masses in the summer of 1983: in the order Hemiptera: *Plagiognathus ilicis* Knight, *P. annulatus* v. *cuneatus* Knight (Miridae); in the Hymenoptera: *Euderomphale,* and *Omphale* (Eulophidae), *Aphanogmus* (Ceraphoronidae), *Copidosoma* (Encyrtidae), *Laelius pedatus* (Say) (Bethylidae), *Chelonus* (Braconidae), *Polynema* (Mymaridae), *Metaclisis, Platygaster* (Platygasteridae); in the Psocoptera: *Psocus* (Psocidae), and *Lachesilla pedicularis* (L.) (Pseudocaeciliidae); and a moribund unidentified dipterous larva. None of these have been reported as predators or parasitoids of cercopids, and we believe that their occurrence is either entirely accidental, or that they became trapped while utilizing the spittle as a water source.

3. Rate of Spittle Production

The spittle collected under near 100% humid conditions in the laboratory was slightly different from the spittle in the field. There were almost no bubbles in the mass around the insect, and usually none in the spittle collected in the vial. The spittle was very fluid and colorless, and never mucoid or of yellow tint. Most of it flowed from the insect into the vial, leaving only a film and a few bubbles covering the nymph and surrounding twig.

The liquid volume of spittle collected in the field was impossible to determine due to the difficulty in disassociating the entrapped bubbles (these bubbles were very persistent, even in alcohol-preserved spittle masses). Thus, without invoking more elaborate instrumentation, the density of native spittle could not be determined.

The density of spittle collected in the humidity chamber was 1.04 ± 0.02. The daily spittle production was 194.6 ± 73.7 mg ($n = 9$, range 101.6 − 291.3) for the three days. For comparison, Horsfield (1978) found that the fifth instar of *P. spumarius* produced 1310 ± 80 mg/day under similar conditions, or 6.7 times that of *C. arborina. P. spumarius* is a larger animal feeding on herbaceous plants, and this may account for some of the discrepancy. Upon desiccation, a thin residue consisting of a mat of very fine interconnected fibers and small white crystals was deposited on the vial walls. None of the silken strands or detritus associated with the field spittle was observed. The residue thus probably corresponds to the filmy varnish seen coating the crystals and foreign inclusions in abandoned spittle masses in the field, and this soluble component, being concentrated by evaporation from the surface, could act as a thickening agent to increase the viscosity and structural integrity of the spittle mass. No further tests were performed, but studies have demonstrated the presence of amino acids (Wiegert, 1964; Hagley, 1969), sugars, and microorganisms (Wilson and Dorsey, 1957) in spittle of other cercopids.

Acknowledgements

This research was supported by the College of Agricultural and Life Sciences, University of Wisconsin-Madison, and by research funds from the Wisconsin Department of Natural Resources through the School of Natural Resources, University of Wisconsin-Madison. We express our sincere gratitude to John Haanstad for providing Figure 1, and to Steven Krauth for his taxonomic assistance.

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EFFECTS OF RECENT ECOSYSTEM CHANGES ON LAKE WINGRA BLUEGILLS

JAMES JAEGER
Department of Zoology
University of Wisconsin-Madison

Abstract

Since the International Biological Program funded studies in the late 1960's and early 1970's, Lake Wingra has undergone major floral and faunal changes. Among the most dramatic alterations are the disappearance of once-abundant yellow bass, the decline of European water milfoil beds, and the stocking of muskellunge on an almost yearly basis. This paper documents the timing of these changes and their impact on Lake Wingra bluegills. A winter 1984 sample shows a bluegill population with more rapid growth than at the last recorded sampling. The mean lengths for one, two, three, four, and five year old bluegills were 70, 102, 134, 154 and 165 mm respectively.

INTRODUCTION

The term "invisible present" was coined by Magnuson, et al., (1983) to describe the sum of ". . . . the events, processes, and changes occurring over decades . . . in the scientific study of lake ecology." Unfortunately, status quo surveys recording a lake's current conditions have traditionally been viewed as less exciting or intellectually challenging than other types of ecological research, and thus vital historical documentation remains sadly incomplete. Thus the recent concern over acid rain produced renewed interest in past environmental conditions, but records of lake chemistry, flora and faunal populations ranged from poor or spotty to nonexistent.

Ecological studies usually last one or two years and are generally not repeated, making long term changes difficult to assess. One exception is Lake Wingra's fish population, for it has been the subject of several studies during the past forty years. Serving as another link in the documentation of Lake Wingra's "invisible present," this paper describes recent changes in the lake's aquatic environment and especially its bluegill population.

Lake Wingra, a 140 hectare lake with a mean depth of three meters, is bordered on one side by the City of Madison and on the other by the University of Wisconsin Arboretum. Due to its proximity to the university, Lake Wingra has been regularly studied, and fifteen years ago its ecology and fish poplations were intensely researched in International Biological Program studies (Adams et al., 1972). Major work on Lake Wingra's fishes includes that by Pearse and Achtenberg (1918), Helm (1958), Baumann (1972), El Shamy (1976), and Churchill (1976). All these workers concentrated their studies on the abundant panfish: bluegills, yellow bass, perch, black crappies and white crappies. Baumann, et al., (1974) described the history of Lake Wingra's fish community up to 1973.

Bluegills, *Lepomis macrochirus,* numerically dominate the Lake Wingra fish community and they are also the most common fish in the angling catch. The average size is small (140-160 mm), and many fishermen consider them too small to bother catching or cleaning. However, a substantial size increase in bluegills taken through the ice has occurred in recent years. This increase occurred shortly after several dramatic changes in the Lake Wingra ecosystem, most notably the disappearance of the yellow bass, *Morone mississippiensis,* from the fish community, the decline of the aquatic macrophyte beds which formerly ringed the shoreline, and the stocking of muskellunge by the Wisconsin Department of Natural Resources.

Materials and Methods

In February and March of 1984 forty-eight bluegills were collected from the south end of Lake Wingra near the Aboretum's big spring. The fish were taken by angling from water less than one meter deep, using mousies (syrphid fly larvae), a small ice fishing jig, and two pound test line.

The bluegills were measured in total length to the nearest mm, and they were weighed to the nearest 0.01 gram. Scales were taken from below the lateral line in the area beneath the end of the pectoral fin.

Three scales from each fish were mounted between two glass slides, and the anterior scale radius and annular distances were measured to the nearest mm with a KEN-A-VISON model TECH-A scale projector which projected an image of the scales enlarged by 47 times. Average values from the three scales were used to back calculate lengths at each annulus. The best fit equation was $L = 51.53 + 0.78\ S$ ($r = 0.957$) where L = total body length (mm) and S = anterior scale radius ($\times 47$). Calculations used the Lee method as described by Carlander (1981).

Information on yellow bass disappearance came from my fishing records of Lake Wingra catches for the past fifteen years. This diary also provided information on the relative abundance of fish species in the winter catch from Lake Wingra.

Results

The high catches of yellow bass in 1969-72 (Figure 1) are misleading because I later learned to partially avoid them by fishing closer to shore. In spite of this, I believe that

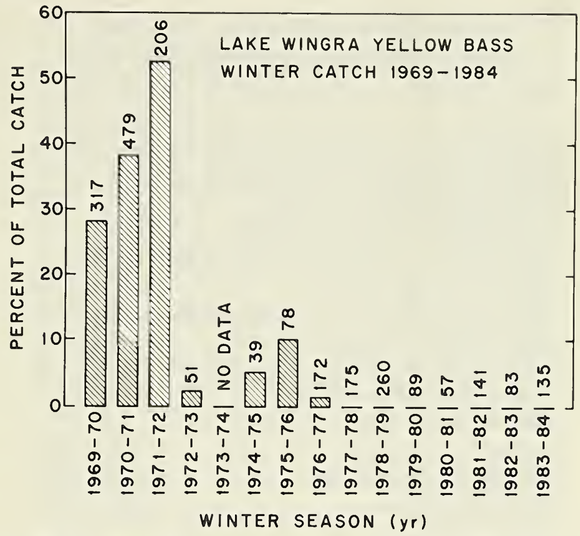

Fig. 1. The author's winter angling catch of yellow bass from Lake Wingra, 1969-1984, shown as a percentage of the total catch. The total number of fish caught is given above each column.

the trend shown in Figure 1 is real and that the yellow bass population had declined greatly before their ultimate disappearance. Yellow bass averaged 6.7% in Churchill's extensive sampling from 1972-74 (Churchill, 1976), and I caught a very similar percentage of yellow bass from 1972-75 (Figure 1). I caught my last yellow bass from Lake Wingra on January 10, 1977. I caught only two yellow bass that entire winter, indicating an extremely low population. I have not caught a yellow bass since then nor have I seen anyone catch a yellow bass; I therefore believe they are completely extirpated from Lake Wingra.

Prior to 1977, yellow bass made up 30% of my catch, bluegills 60%, perch 7%, and crappies (black and white combined) 2%. After 1977, no yellow bass were caught, bluegills made up 66% of the catch, perch 17%, and crappies 15%. Table 1 lists the actual catch data and taxonomic names for the various species.

The length-weight relationship for Lake Wingra bluegills in my 1984 sample was $\log W = -5.23 + 3.24 \log L$ ($r = 0.994$) where

TABLE 1. The number of fish of different species caught from Lake Wingra 1969-1984.

	Pre 1977	*Post 1977*
Yellow bass *(Morone mississippiensis)*	397	0
Bluegill *(Lepomis macrochirus)*	801	618
Pumpkinseed *(Lepomis gibbosus)*	10	7
Golden shiner *(Notemigonus crysoleucas)*	2	7
Perch *(Perca flavescens)*	98	162
Black crappie *(Pomoxis nigromaculatus)*	30	80
White crappie *(Pomoxis annularis)*	2	64
Largemouth bass *(Micropterus salmoides)*	2	0
Northern pike *(Esox lucius)*	0	1
Green sunfish *(Lepomis cyanellus)*	0	1
Total	1342	940
Number of fisherman hours	126.75	112.25
Fish/fisherman hour	10.59	8.37

W = weight in grams, L = total length in mm, and log = log to base 10.

Table 2 gives the back-calculated lengths for bluegills of each age class as well as a weighted average for the population. This 1984 sample shows that I, II, III, IV, and V annulus fish average 70, 102, 134, 154, and 165 mm total length respectively.

DISCUSSION

A major problem inherent in ecological field research is that variables cannot be carefully controlled nor accurately assessed. At least three major changes have occurred in Lake Wingra since the last published work on the bluegill population. These changes are a) the disappearance of yellow bass, b) the decline of the European water milfoil beds, and c) the stocking of muskellunge. The following discussion summarizes the history and possible causes of these changes, and attempts to assess their importance in sculpting the "invisible present" of Lake Wingra today.

A. What Happened To The Yellow Bass?

Ironically, yellow bass are now absent from both Lake Wingra, the site of the best Wisconsin study on yellow bass (Helm, 1964), and Lake Monona, the capture site of the world's angling record yellow bass—2 pounds, 2 ounces (Anonymous, 1976).

Figure 1 documents clearly the disappearance of yellow bass from Lake Wingra in 1977. At this same time yellow bass disappeared from nearby lakes Mendota and Monona, and populations of the closely related white bass dropped to very low levels. White bass did not occur in Lake Wingra in the 1970s; they had dropped to very low levels in Lake Monona in 1966 (Wright, 1968); and were declining in Lake Mendota in the early 1970s. Conjecture held that the yellow bass were eliminating the white bass by interbreeding with them. Supporting this idea, some Lake Mendota catches circa 1970 contained a few white bass, many yellow bass, and many fish which appeared to be hybrids between white bass and yellow bass. Therefore, the species disappearance in the winter of 1976-77 was primarily of yellow bass, since the white bass had declined earlier.

TABLE 2. Calculated lengths at each annulus and lengths at capture of bluegills from Lake Wingra, 1984.

Age	*Mean total length at capture (mm)*	*Number of fish*	*Estimated total length (mm) at time of annulus formation*				
			I	*II*	*III*	*IV*	*V*
I	117	14	70				
II	140	11	70	103			
III	160	17	69	103	134		
IV	168	3	70	93	129	153	
V	180	3	72	107	136	154	165
		Weighted Average =	70	102	134	154	165

Yellow bass, white bass, and crappies are all known to exhibit extensive population fluctuations, the causes of which are unclear. While white bass have begun to reappear in Lakes Monona and Mendota as of 1984, yellow bass have not yet returned. The total extinction of yellow bass from lake Wingra was not sprayed. The simultaneous population fluctuation. Natural population control factors such as diseases and parasites seldom exterminate their hosts.

Local fishermen blamed the final yellow bass disappearance on spraying done to control aquatic macrophytes; however, Lake Lingra was not sprayed. The simultaneous disappearance of yellow bass in all three lakes implies a more widespread cause.

Baumann et al. (1983, p. 98) suggested that a more likely cause was the severe winter of 1976-77 when ice on area lakes froze to an extraordinary three foot thickness. Madison, Wisconsin, was at the northern edge of the yellow bass range, and moreover the yellow bass was likely a non-native species, introduced during the fish rescue operations in the 1930s and early 1940s (Noland, 1951). Baumann, et al., reasoned that this severe winter may simply have been too extreme for these more southern fish. Several facts argue against this idea. First, yellow bass inhabited Lake Wingra successfuly for approximately forty years in spite of some very cold winters. Second, Figure 1 shows a drop in the yellow bass populations beginning circa 1972, almost five years before their ultimate disapparance. This second fact especially argues for a long term cause, not the single event of one very cold winter.

Another more probable cause is the low background levels of agricultural chemicals which all our waters are currently receiving in rainfall and runoff. Even within the city of Madison one can go outside in the spring and smell the volatile chemicals being currently sprayed on the surrounding croplands. An atmosphere thick with herbicide droplets will dump its toxic load in every rainfall. The possible additive and synergistic effects of agricultural chemicals at low levels is unknown and unstudied.

The catch data in Table 1 indicate that yellow bass have been replaced in the fisherman's bag by perch and crappies. Catch per unit effort data support my observation that the perch and crappies do not currently approach the abundance shown by yellow bass in the early 1970s, and that bluegills are also less abundant now than in the early 1970s. Before 1977, my winter catch rate was 10.6 fish/fisherman-hour. After 1977, the catch fell to 8.4 fish/fisherman-hour, and the last three winters only 5.4 fish/fisherman-hour were caught. Comparison of crappie catches in the pre-1977 and post-1977 years is done with reservations. Use of more efficient equipment after 1977 resulted in a reduced crappie escape rate. Assuming this change in technique effects black and white crappies equally, the white crappie population appears to have increased since 1977.

B. The Decline of Water Milfoil

The second major change in Lake Wingra since the early 1970s is the dramatic decline in European water milfoil, *Myriophyllum spicatum*. After its introduction into the eastern United States from Europe, milfoil spread across the country, eventually dominating the aquatic macrophyte community in many lakes, including Lake Wingra and the other Madison lakes. According to Carpenter (1980), the decline of European water milfoil in Lake Wingra occurred during the summer of 1977. Many milfoil beds disappeared entirely, and the milfoil biomass in the remaining beds dropped to less than half its previous levels. Such patterns of changing abundance are typical for introduced species and are usually attributed to diseases and parasites catching up with the host plant. Carpenter was not able to attribute the decline of milfoil in Lake Wingra to any single observed factor. In 1984 Lake Wingra supported a more diverse aquatic macrophyte community, containing *Potamogeton, Ceratophyllum,* and *Vallisneria* in

Table 3. Muskie stocked in Lake Wingra 1972-84.

1984	700 Hybrid*
1983	No Stocking
1982	690 Hybrid 144 Muskellunge
1981	1000 Hybrid 15 Muskellunge
1980	1000 Hybrid 32 Muskellunge
1979	24 Muskellunge
1972-78	No Stocking

Hybrid = Northern Pike × Muskellunge.

*Anticipated stocking for 1984.

addition to *Myriophyllum.* Current macrophyte beds, however, are much less extensive than the water milfoil beds of the early 1970s which ringed Lake Wingra in a solid unbroken mass extending approximately 100 feet from shore.

C. Here Come The Muskies

The third major change in the Lake Wingra ecosystem is the stocking of predator species in the years following 1979. The rates of stocking are given in Table 3 (Klingbiel and Brynildson, 1984). A few pure muskellunge (*Esox masquinongy*) were stocked, but most fish were "tiger muskies," northern pike (*E. lucius*) X muskellunge hybrids. The great majority of stocked fish were fingerlings, juvenile fish about five inches long. Besides being highly prized sport fish, muskies are major predators on small panfish. However, muskies are stocked primarily to promote sport fishing and only secondarily to control panfish populations. Fishery biologists currently feel that stocking predatory fish at any reasonable level has a negligible effect on panfish numbers (Klingbiel and Snow, 1962).

Have Lake Wingra's panfish populations been measurably affected by the above ecosystem changes? Figure 2 compares the growth in length of Lake Wingra bluegills found in three separate studies. Adult bluegills in my 1984 sample grew at the same rate as adults in El Shamy's 1969-70 sample, but the fish are now 10 to 20 mm longer at each annulus. Churchill's 1972-73 sample calculated average lengths for bluegills which were almost identical to El Shamy's. Notice that Helm in 1955-57 found the same growth in the first year as El Shamy, but afterwards Helm's bluegills grew faster, and his curve gradually separated from El Shamy's. My more recent data show a major increase in the growth of young bluegills during the first year of life. This first-year increase in growth requires a cause which effects young of the year bluegills more strongly than adults.

My length-weight relationship ($\log W = -5.23 + 3.24 \log L$) supports the contention that bluegills are growing better now. El Shamy (1976) reported a length-weight relationship of $\log W = -3.788 + 2.57 \log L$ for Lake Wingra bluegills. Churchill (1976) reports a length-weight relationship of $\log W = -4.8904 + 3.062 \log L$ for bluegills caught in 1972-73. Churchill's results indicate that only three years after El Shamy's

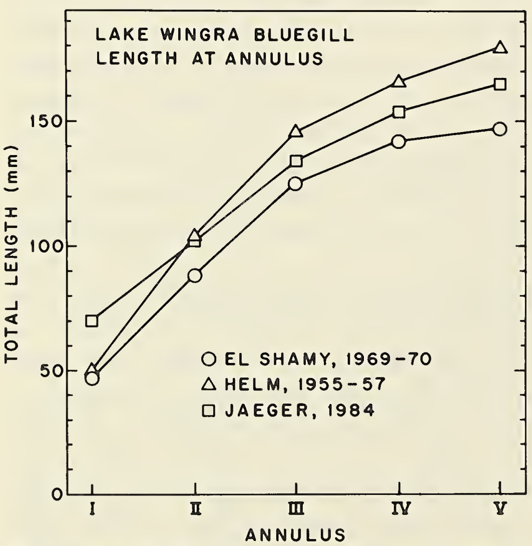

Fig. 2. The average calculated length at each annulus as determined by three recent studies of Lake Wingra bluegills.

1969-70 sampling, the bluegill length-weight relationship was already changing toward that which we see now. In fact, my length-weight relationship for Lake Wingra bluegills today is much closer to that of El Shamy's for Lake Mendota ($\log W = -4.99 + 3.21 \log L$), where bluegills consistently have grown much larger than in Lake Wingra. Simply stated, Lake Wingra bluegills of a given length are now considerably heavier than they were in 1969-70. This increase, effecting fish in all age classes, is the expected result in a population released from a major food competitor.

Thus we may now speculate with some confidence on how the three ecosystem changes discussed, acting alone or in combination, could produce the observed increases in bluegill growth. The disappearance of yellow bass, eliminating a potential food competitor, probably had the greatest impact on bluegill growth. The decline of the macrophyte beds may have allowed greater predation through a decrease in protective cover, again leaving the survivors with more food per fish. Or, the more open weed beds may simply make feeding easier for bluegills. Artificially elevating the predator population through muskie stocking would lower bluegill populations slightly, perhaps easing intraspecific competition. However, since relatively few muskies were introduced, predator stocking probably had the smallest effect on panfish populations.

It appears that competition between the remaining panfish species may be reduced by habitat selection and food preferences. While examination of stomach contents of perch and bluegills taken through the ice shows that both feed primarily on chironomids (lake fly larvae), interspecific competition is limited because perch are more pelagic and bluegills more littoral. Winter crappies eat small copepods not taken by bluegills or perch, and therefore appear not to compete with perch or bluegills for winter food. At the height of their abundance, yellow bass overlapped the habitats of all these species, especially the open water perch and crappies.

Summary

This study documented recent major species changes in the Lake Wingra ecosystem. Yellow bass, previously codominant with bluegills, vanished in 1977. The European water milfoil that once dominated the littoral zone has greatly declined. Muskellunge and northern pike-muskie hybrids were introduced. In response, the Lake Wingra bluegill population currently shows a greatly increased growth in the first year, and adult bluegills are longer at a given age and heavier at a given length than they were previously. Continuing documentation of the various aspects of Lake Wingra's changing "invisible present" are necessary to accurately assess and predict future ecosystem and fish population changes.

Acknowledgments

I would like to thank the Zoology Department for providing space and the scale projector, C. Hughes for illustrations, and D. Chandler for photography.

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ZOOPLANKTON DYNAMICS IN LAKE MENDOTA: ABUNDANCE AND BIOMASS OF THE METAZOOPLANKTON FROM 1976 TO 1980

Carlos Pedrós-Alió*
Department of Bacteriology

E. Woolsey
Department of Zoology

T. D. Brock
Department of Bacteriology
University of Wisconsin-Madison

Abstract

Metazooplankton species composition, abundance, and biomass were followed from 1976 to 1980. Fairly similar annual cycles were found for the years studied. However, three types of differences were found: substitution of one species for another of the same genus, differences in the number of peaks and their time of appearance for certain species, and the maximum population abundances of most organisms. Results give insight into year-to-year variations and provide a data base to be compared with a similar study done almost one hundred years ago by E. A. Birge.

Introduction

The success of some long-term ecological studies (Bormann and Likens, 1979; Erlich, 1979) has recently focused attention on the need to have continuous records of data spanning as many years as possible. Studies of this sort address questions on a broader time scale than is possible with sporadic or seasonal studies. Thus, they allow distinctions to be made between seasonal changes and long-term trends, as well as to ascertain long term effects of human action or slowly changing environmental parameters upon ecosystems. Recognizing the importance of such studies, the National Science Foundation has established a new funding program termed Long Term Ecological Research (Callahan, 1984). The northern lakes of Wisconsin have been included as one of the eleven study sites funded by this program.

Lake Mendota, having been studied for almost a hundred years, offered a unique system for comparison of long and short term changes in its characteristics. By comparing data from modern studies with those from the existing literature, conclusions might be drawn about long-term changes in the lake. Stewart (1976) has made similar comparisons of data for oxygen concentrations and Secchi disk readings. The extensive studies carried out on the zooplankton of Lake Mendota by Birge (1897) offered a unique opportunity to contrast results gathered eighty years apart. Other studies on the zooplankton of the lake (see Frey, 1963, for a review) concentrated on particular aspects, such as vertical migration (Juday 1904), total biomass (Birge, 1923), sampling problems (Neess, 1949), patchiness and its causes (Ragotzkie and Bryson, 1953), feeding by fish (McNaught and Hasler (1961), or

* Present address: Department of Microbiology, Facultad de Ciencias, Universidad Autónoma de Barcelona, Bellaterra, Barcelona, Spain.

were concerned with taxonomy of different groups such as rotifers (Harring and Myers, 1921), cladocera and copepoda (Birge, 1918; Birge and Juday, 1908). However, no extensive study of zooplankton species density had been done since Birge's landmark paper (1897), and no quantitative studies on rotifers had been ever done.

Therefore, we carried out a study of Lake Mendota zooplankton, including species composition, abundance and biomass, from 1976 to 1980. The impact of feeding by zooplankton on the bacteria of the lake (Pedrós-Alió and Brock, 1983) and quantitative comparisons with Birge's data (Pedrós-Alió and Brock, 1985) have been published already. Detailed data for every species, sampling date, and depth can be found in Pedrós-Alió (1981). Here we describe the annual cycle of the zooplankton and discuss differences among the five years of the present study, as well as relations with their food sources, phytoplankton and bacteria. It is hoped that the results will become a useful data base from which to draw conclusions about long-term changes in a lake ecosystem.

Materials and Methods

Zooplankton sampling. Samples were taken at the deepest part of the lake (24.2 m) located towards the center of Lake Mendota. Three different techniques were used to collect zooplankton. The first one, vertical tows taken with a 20 cm diameter plankton net (mesh size 156 μm), was used during all years of the present study for two reasons: first, to provide an integrated picture of the zooplankton throughout the lake, and second, because this method is practically identical to that used by Birge (1897), which consisted of vertical tows taken with a 166 μm mesh size zooplankton net. In our study, the net was towed slowly from 23 m depth to the surface, thus sampling a water column of 723 1. Since not all the water in the column could pass through the net, the volume actually sampled would be somewhat smaller. Replicate subsamples, of 1 or 2 ml depending on the abundance of zooplankton in the sample, were removed with a Hansen-Stempel pipette and all the animals counted. The whole zooplankton sample was also examined to count all the individuals of *Leptodora kindtii,* since its relative scarcity and large size made counting of small volumes unreliable.

In addition to the vertical tows, two different techniques were used in 1979 and 1980, respectively, to provide information on vertical distribution of the zooplankton. During 1979, a fairly detailed discrete sampling technique was used. Samples were taken at a number of depths with a 5 1 Van Dorn bottle, and at least one liter from each depth was filtered on a Whatman GF/C glass fiber filter. The volume was reduced to a few milliliters and the vacuum disconnected. The filters were rinsed at least twice with filtered lake water and the wash water added to the concentrated sample. Examination of the rinsed filters showed a substantial amount of algae remaining on them, but no animals were ever found. This concentrate was then transferred into a gridded Petri dish and counted, using a dissecting microscope. Samples were also preserved in 4% formalin for later study. A simplified method, based on that of Likens and Gilbert (1970), was used during 1980. Discrete duplicate samples were again taken with Van Dorn bottles from several depths. Circular pieces of Nitex 64 net (64 μm mesh size) were fitted to a Sartorius filtering apparatus and volumes of water proportional to the lake volume at each depth interval were filtered through the Nitex net. During the period when the lake was totally mixed, two filtrations, representing a volume proportional to the whole lake were filtered. During the stratified period, two filtrations from the epilimnion and two from the hypolimnion were carried out separately (the thermocline was usually found between 10 and 12 m).

Thus, we had total population data from the vertical tows from 1976 to 1980, and ver-

TABLE 1. Lengths of the main zooplankton species in Lake Mendota for each sampling date during 1980. Average length in mm and, between parenthesis, ±95% confidence limits.

Date	Daphnia galeata	Diaphanosoma leuchtenbergianum	Chydorus sphaericus	*Calanoids*	*Cyclopoids*
Jan. 15	1.19 (.24)	—[a]	—	—	0.92 (.04)
Feb. 7	1.23[b]	—	—	—	—
Mar. 17	1.31 (.08)	—	—	1.25[b]	0.97 (.04)
Apr. 1	1.29[b]	—	—	—	—
Apr. 22	—	—	—	—	1.10 (.12)
May 12	—	—	0.34[b]	—	0.79 (.09)
June 2	1.20 (.18)	—	—	—	0.61 (.07)
June 11	1.22 (.13)	—	—	1.12 (.07)	0.66 (.04)
June 24	0.97 (.10)	—	—	0.70 (.09)	0.59 (.04)
July 1	1.41 (.16)	1.02 (2.9)	—	0.86 (.09)	0.86 (.07)
July 8	1.35[b]	0.74 (.37)	—	0.89 (.07)	0.88 (.07)
July 23	—	0.51 (.07)	0.18 (.01)	0.71 (.09)	0.54 (.08)
Aug. 12	—	0.73 (.13)	0.24 (.01)	0.96 (.06)	0.99 (.14)
Aug. 27	—	0.68 (.14)	0.24 (.01)	0.92 (.08)	0.73 (.09)
Sept. 8	0.91 (.36)	0.82 (.11)	0.24 (.02)	0.93 (.05)	0.67 (.09)
Sept. 22	1.63[b]	0.92 (.19)	0.26 (.01)	0.91 (.07)	0.69 (.08)
Sept. 29	1.56[b]	1.06 (.15)	0.27 (.01)	1.01 (.07)	0.84 (.09)
Oct. 6	1.48 (1.8)	0.97 (.10)	0.27 (.01)	0.93 (.07)	0.76 (.06)
Oct. 20	0.80 (.22)	0.94 (.11)	0.27 (.02)	0.98 (.06)	0.79 (.06)
Nov. 20	0.91 (.16)	1.21 (.09)	0.32 (.01)	1.05 (.02)	0.82 (.01)
Dec. 18	—	—	0.31 (.02)	1.07 (.03)	0.91 (.04)

[a] Not present.
[b] Not enough individuals for reliable statistics.

tical distribution data and rotifer data for 1979 and 1980 from the other techniques. By statistical analysis, we found that total numbers calculated from the techniques using Van Dorn samples were not significantly different from those of the vertical tows.

Zooplankton lengths. Except in 1979, at least 30 individuals of each major species were measured under a dissecting microscope, at each sampling date, to the nearest 30 μm, and the average size for that date calculated. In 1979 between 15 and 20 individuals were measured. The species most abundant and variable in size were divided into size classes and individuals assigned to them. For species that were too rare to permit counting of a significant number of individuals at any given date, all the individuals present were measured and the average length from measurements throughout the year was assigned to them. Average lengths for every sampling date of the last year of the present study (1980) are shown in Table 1.

Zooplankton weights. Except in 1979, average dry weights were calculated with the regression equations of dry weight vs. length given by Dumont, Van de Velde and Dumont (1975), and those for average values are given in Table 2. In 1979, the most abundant species were divided into size classes

TABLE 2. Formulae for calculating zooplankton dry weights from average lengths calculated during the present study.

Organism	*Formula*
Daphnia galeata and *D. retrocurva*	$W = 9.93 \times 10^{-8}\ L^{2.56} + 2.97$
Diaphanosoma	$W = 1.88 \times 10^{-6}\ L^{2.11} - 0.14$
Cyclopoids	$W = 2.00 \times 10^{-8}\ L^{2.75} + 8.41$
Calanoids	$W = 8.40 \times 10^{-7}\ L^{2.33} + 1.06$

W: Average weight in μg.
L: Average weight in μm.

and dry weights calculated for each size class independently, with the same equations of Dumont *et al.* (1975). These regressions were not checked for Lake Mendota zooplankton, but the same relationship was assumed for the same species in both studies. A carbon to dry weight ratio of 0.4 was used to convert to carbon biomass.

Results and Discussion

Validity of the techniques used. According to Ruttner-Kolisko (1977), statistically reliable counts of rotifers can be obtained if more than 100 individuals of each species are counted. She compared three sampling methods for rotifers (vertical tows, Ruttner bottles and pump) and showed that the results were not comparable among the different techniques. Nevertheless, Ruttner-Kolisko concluded that numbers of rotifers could be used even if duplicates and/or sampling methods gave results differing by two fold, because the animals tend to change their numbers by several orders of magnitude throughout the year. In the present study, differences between duplicates and techniques were considerably smaller than those found by Ruttner-Kolisko. Average coefficients of variation (CV) for replicates taken with Van Dorn bottles were 19% for cyclopoids, 15% for calanoids, 31% for *Daphnia* species, 17% for *Daphnia galeata mendotae,* 20% for *Chydorus sphaericus,* 29% for other cladocerans, 26% for rotifers, and 15% for the most abundant rotifer, *Keratella cochlearis.*

When simultaneous samples taken with Van Dorn bottles and vertical tows were compared, average CV's were 22% for cyclopoids, 21% for calanoids, 47% for *Daphnia* species, 26% for *Chydorus,* and 38% for other cladocerans. Rotifers could not be counted in vertical tow samples because they were not retained by the zooplankton net. Coefficients of variation from vertical tow samples were only slightly higher than those for replicates of Van Dorn samples. Two way analyses of variance (ANOVA) without replication (Sokal and Rholf, 1969) were performed on abundances from vertical tows and Van Dorn samples for seven sampling dates to compare variability due to different sampling techniques with variability due to the different zooplankton species. As expected, the latter was always highly significant, due to the different population dynamics of different species. On the other hand, variability due to the different sampling techniques was never significant ($P > 0.05$), making possible comparisons of numbers obtained with all of the various techniques.

To check the variability due to horizontal location in the lake, on July 20, 1979 vertical tows and Van Dorn samples were taken at three stations in the eastern, central, and western parts of the lake. A three way ANOVA without replication (Sokal and Rohlf, 1969) was conducted, checking the variability of counts due to horizontal location, species, and sampling technique. Again, the latter was not significant ($P > 0.05$), while variability due to locations and to different species were both significant ($P < 0.05$ and $P < 0.001$ respectively). All this indicates that counts from any of the sampling methods can be used together in calculating zooplankton abundances, but that results from the central station, the station used for the present study, may not be easily extended to the whole lake, due to patchiness in the distribution of the organisms. Therefore, when values are given on an areal basis they should be understood as representing the central part of the lake.

Species composition. In the present study fourteen main species were found: 3 cyclopoid copepods (*Diacyclops bicuspidatus thomasi* (S. A. Forbes), *Mesocyclops edax* (E. A. Forbes), and *Acanthocyclops vernalis* (Fischer)), 3 calanoid copepods (*Leptodiaptomus sicilis* (S. A. Forbes), *L. siciloides* (Lilljeborg), and *Aglaodiaptomus clavipes* Schacht), 4 species of the genus *Daphnia* (*D. galeata mendotae* Birge, *D. pulex* Leydig, *D. parvula* Fordyce, and *D. retrocurva* Forbes), and 4 other cladocerans (*Chydorus sphaericus* (O. F. Müller), *Bosmina longirostris* (O. F. Müller), *Diaphanosoma leuchtenbergianum* Fischer, and *Leptodora kindtii* (Focke)). In addition, one cyclopoid copepod (*Tropocyclops prasinus* (Fischer)), one calanoid copepod (*Skistodiaptomus oregonensis* (Lilljeborg)), *Ceriodaphnia quadrangula* G. O. Sars, and *Ergasilus* sp. were observed occasionally in very small amounts.

Rotifers were identified to genus, except in the easily distinguished *Keratella cochlearis* (Gosse) and *K. quadrata* (Müller). The other genera present were *Polyarthra* Ehrenberg, *Brachionus* Pallas, *Asplanchna* Gosse, *Trichocerca* Lamarck, *Filinia* Bory de St. Vicent, *Conochilus* Hlara, and *Conochiloides* Hlara.

Annual cycle. The general pattern of zooplankton abundance and species composition was similar from year to year and to that found by Birge (1897) eighty years ago. We illustrate this general pattern with the data from 1979. During this year, we sampled 28 times with both vertical tows and Van Dorn bottles, and therefore, information was obtained on vertical distributions and total abundances and species composition of the zooplankton. Vertical distribution and total abundance for each organism or group of organisms are shown in Figures 1 to 13 for this year. However, since significant differences could be found from year to year, we will present data from other years when necessary. Each main group of organisms will be analyzed separately. Year-to-year variations are specifically treated in a later section.

1. *Cyclopoid copepods.* Birge (1897) mentioned only three species of cyclopoid copepods in Lake Mendota. *Cyclops Leuckartii,* corresponding to the currently recognized *Mesocyclops edax,* is the North American counterpart of the European *Mesocyclops leuckartii* (Cocker, 1943). The North American species followed the same type of annual cycle as the European species, being

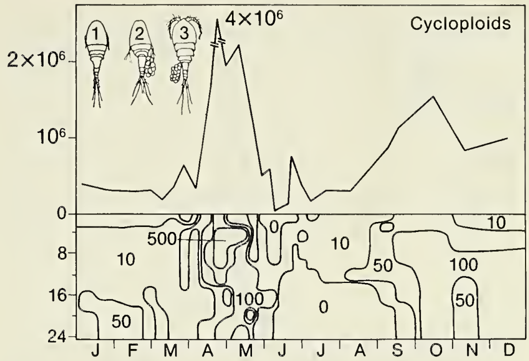

Fig. 1. Abundance, in individuals m^{-2} (upper panel), and vertical distribution in individuals l^{-1} (lower panel) of cyclopoid copepods during 1979. Depth is in meters. Adults and copepodites were pooled together. Drawings of animals are: 1, *Diacyclops bicuspidatus thomasi;* 2 *Mesocyclops edax;* 3, *Acanthocyclops vernalis. Tropocyclops prasinus* was rare most of the year.

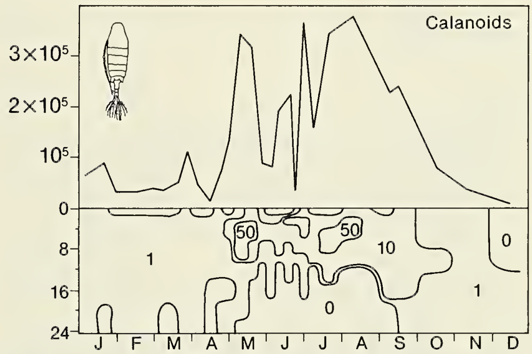

Fig. 2. Abundance, in individuals m^{-2} (upper panel), and vertical distribution in individuals l^{-1} (lower panel) of calanoid copepods during 1979. Depth is in meters. Adults and copepodites were pooled together.

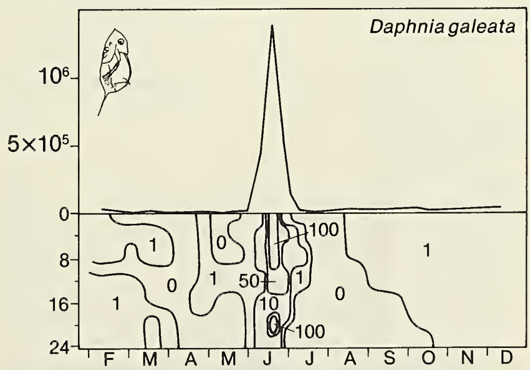

Fig. 3. Abundance, in individuals m^{-2} (upper panel), and vertical distribution in individuals l^{-1} (lower panel) of *Daphnia galeata mendotae* during 1979. Depth is in meters. Adults and juveniles were pooled together.

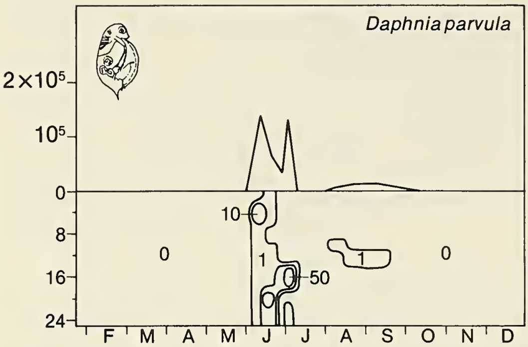

Fig. 4. Abundance and vertical distribution of *Daphnia parvula* during 1979. Symbols and units as in Fig. 1.

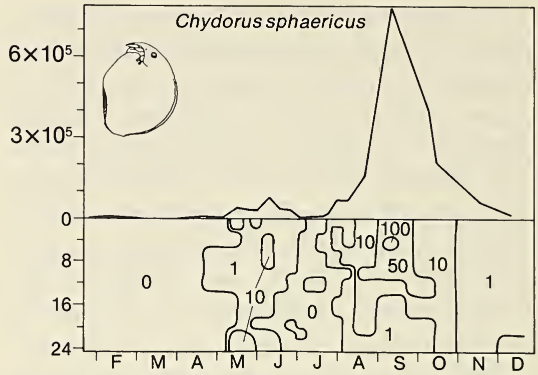

Fig. 7. Abundance and vertical distribution of *Chydorus sphaericus* during 1979. Symbols and units as in Fig. 1.

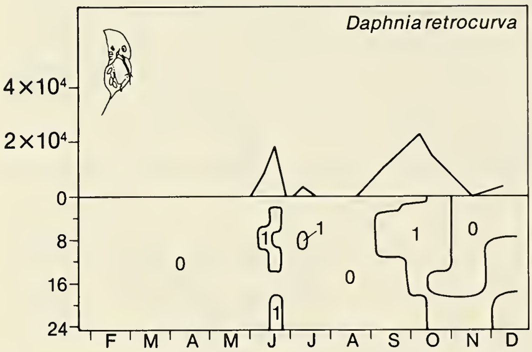

Fig. 5. Abundance and vertical distribution of *Daphnia retrocurva* during 1979. Symbols and units as in Fig. 1.

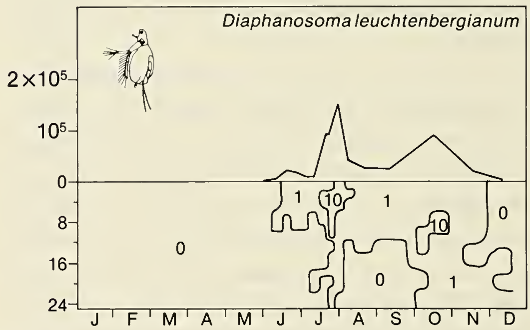

Fig. 8. Abundance and vertical distribution of *Diaphanosoma leuchtenbergianum* 1979. Symbols and units as in Fig. 1.

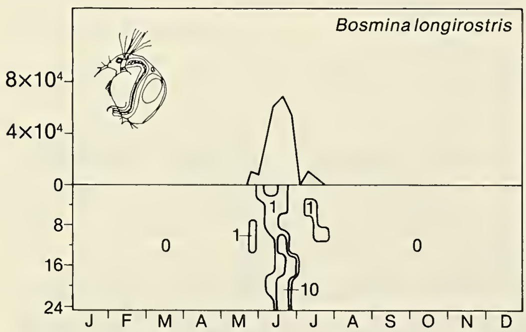

Fig. 6. Abundance and vertical distribution of *Bosmina longirostris* during 1979. Symbols and units as in Fig. 1.

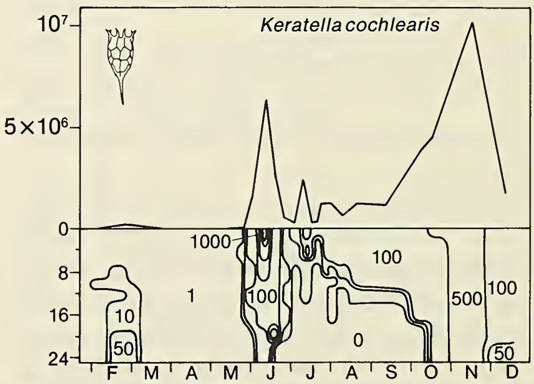

Fig. 9. Abundance and vertical distribution of *Keratella cochlearis* during 1979. Symbols and units as in Fig. 1.

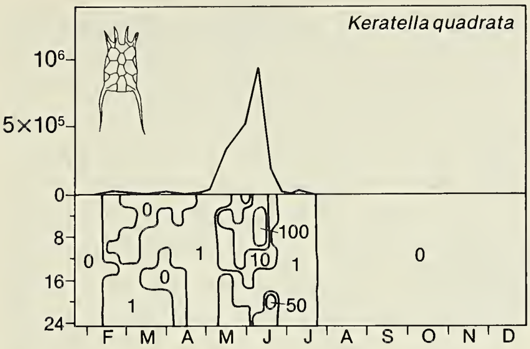

Fig. 10. Abundance and vertical distribution of *Keratella quadrata* during 1979. Symbols and units as in Fig. 1.

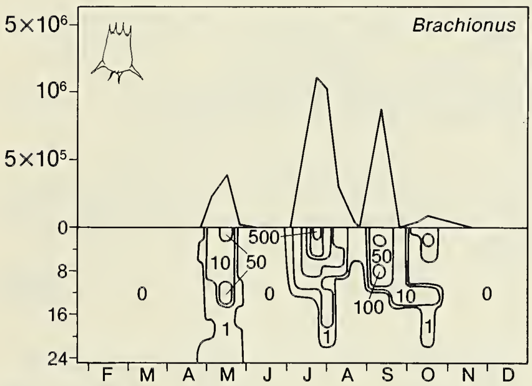

Fig. 11. Abundance and vertical distribution of *Brachionus* sp. during 1979. Symbols and units as in Fig. 1.

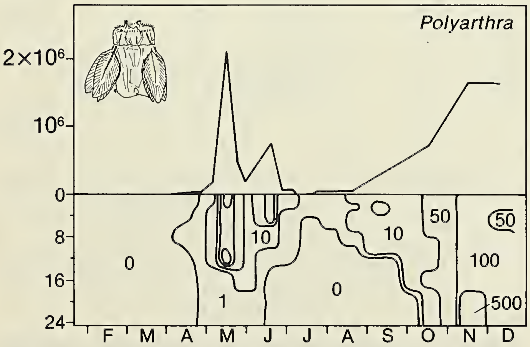

Fig. 12. Abundance and vertical distribution of *Polyarthra* sp. during 1979. Symbols and units as in Fig. 1.

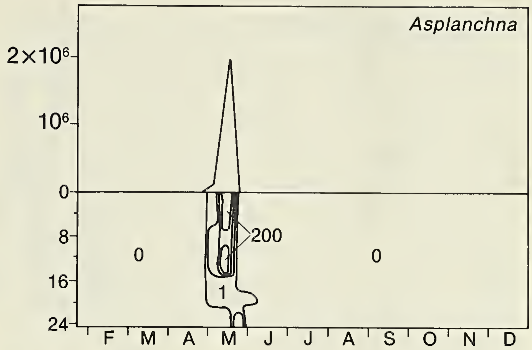

Fig. 13. Abundance and vertical distribution of *Asplanchna* sp. during 1979. Symbols and units as in Fig. 1.

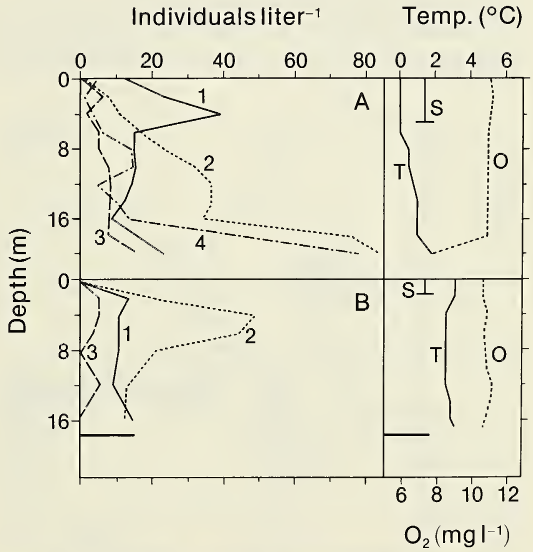

Fig. 14. Vertical profiles of zooplankton abundance (left hand panels) and physico-chemical parameters (right hand panels) for: A, February 21, 1979, and B. April 18, 1979. Symbols are: S, Secchi disk depth in meters; T, temperature in °C; O, oxygen in mg l^{-1}. The bar in panel B represents the bottom (a shallow station was sampled on this day due to inaccessibility of the central station because of ice). Organisms are: 1, Copepod nauplii; 2, Cyclopoid copepods (including copepodites and adults); 3, *Keratella quadrata;* 4, Calanoid copepods (including copepodites and adults).

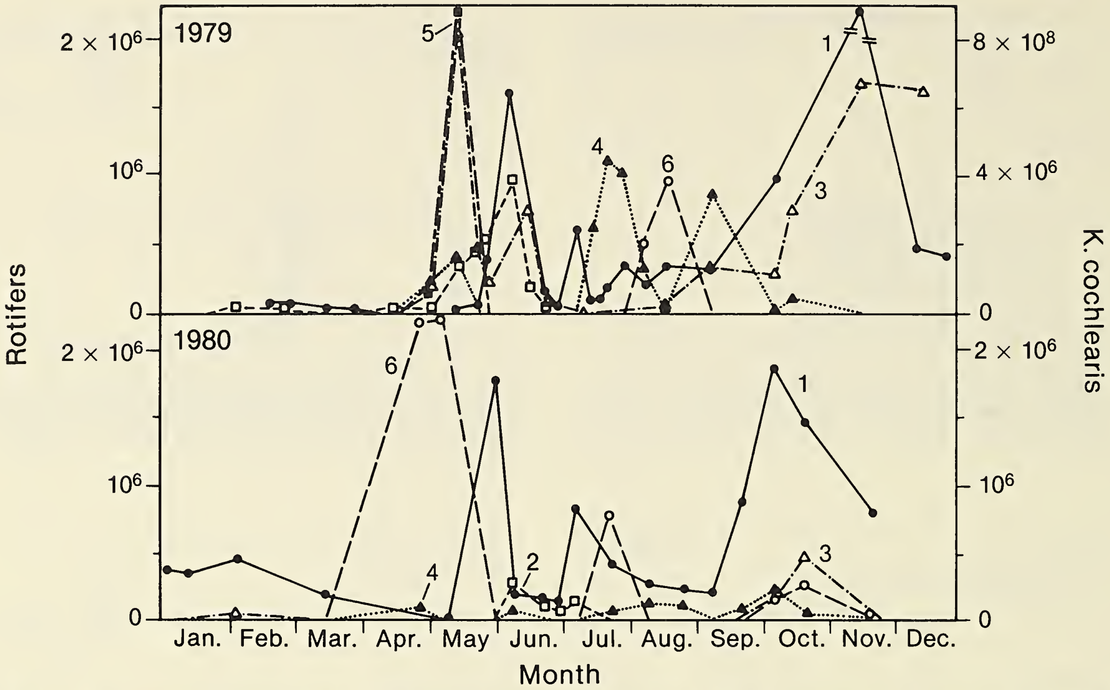

Fig. 15. Abundance in individuals m^{-2}, of rotifers during 1979, and during 1980. Animals are: 1, *Keratella cochlearis;* 2, *Keratella quadrata;* 3, *Polyarthra* sp.; 4, *Brachionus* sp.; 5, *Asplanchna* sp.; 6, *Conochilus* sp. in A and *Conochiloides* sp. in B. *K. cochlearis* is presented in a different scale.

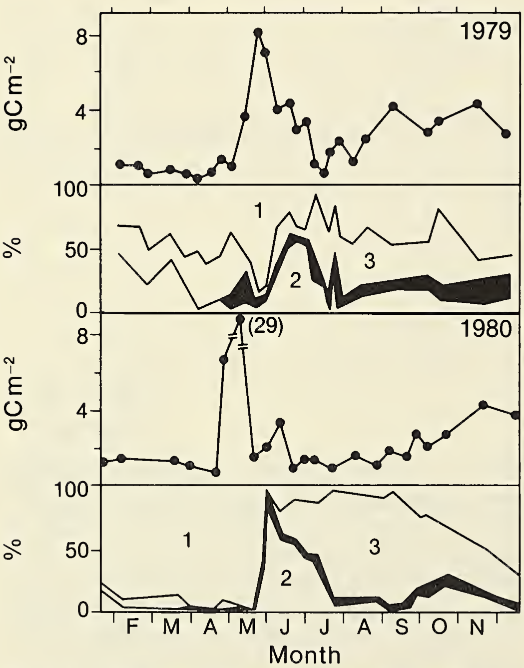

Fig. 16. Total zooplankton biomass during 1979 and 1980. A and C, Carbon weights in g m^{-2}. B and D, Percent biomass in different zooplankton groups. Rotifers are in black. Numbers are: 1, Cyclopoid copepods; 2, Cladocerans; and 3, Calanoid copepods.

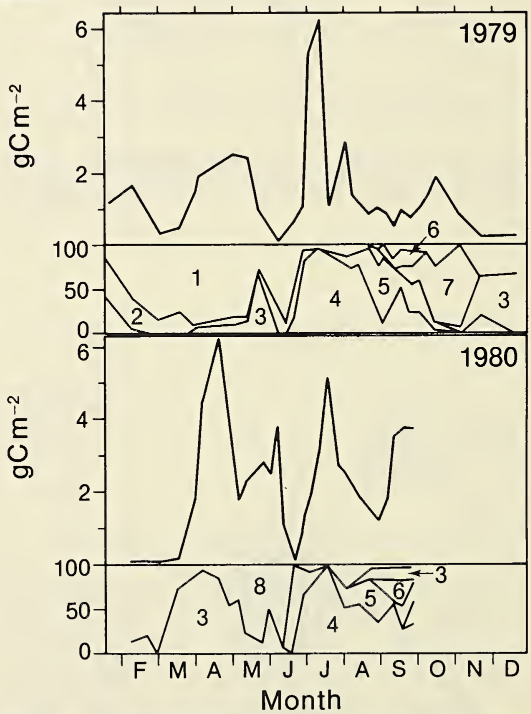

Fig. 17. Phytoplankton biomass during 1979 and 1980. Numbers are: 1, *Chlamydomonas* sp.; 2, *Cosmarium* sp.; 3, *Stephanodiscus astraea;* 4, *Aphanizomenon flos-aquae;* 5, *Lyngbya* sp.; 6, *Ceratium* sp.; 7, *Fragillaria* sp.; 8, *Cryptomonas* sp.

abundant and reproducing in the summer, and rare in the winter. *Cyclops pulchellus,* later reclassified as *Cyclops bicuspidatus* by Birge and Juday (1908), corresponds in modern taxonomy to *Diacyclops bicuspidatus thomasi.* Better information about this organism than in the 1897 paper can be found in Birge and Juday (1908), where they describe its summer diapause. Finally, *Cyclops brevispinosus* was considered to be a synonym for *Cyclops viridis* (Jurine) by Marsh in his revision of the North American *Cyclops* (Marsh, 1910). *Cyclops viridis,* in turn, is considered by Yeatman (1959) to occur only in a few cases in North America, but is referred in almost all cases to *Cyclops vernalis* Fischer, which corresponds to *Acanthocyclops vernalis* in modern taxonomy. The fourth species found in our study, *Tropocyclops prasinus,* does not appear in Birge's studies, but it had only very low numbers year-round and it could have been overlooked very easily by Birge, since most of his copepod taxonomy was done by Marsh using only a small part of his samples (Birge and Juday 1908).

Diacyclops bicuspidatus thomasi was the dominant organism during the late fall and

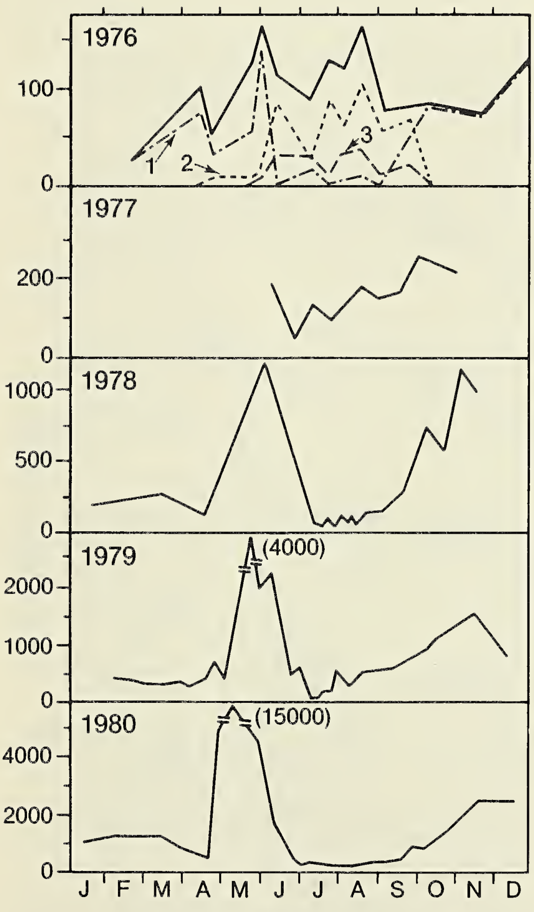

Fig. 18. Abundance of cyclopoid copepods from 1976 to 1980. Values have to be multiplied times 10^3 to obtain individuals per m^2. In 1976 individual species are also shown. Numbers are: 1, *D. b. thomasi;* 2, *A. vernalis;* and 3, *M. edax.*

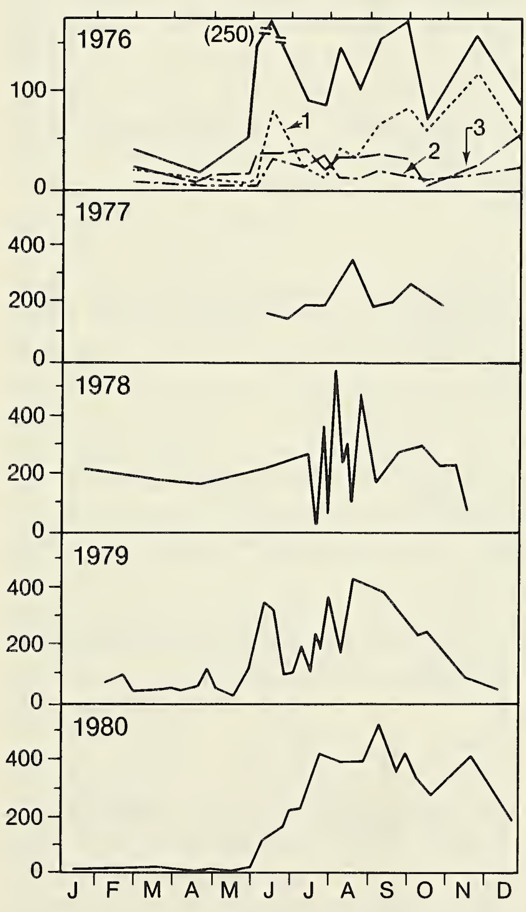

Fig. 19. Abundance of calanoid copepods from 1976 o 1980. Values have to be multiplied times 10^3 to obtain individuals per m^2. In 1976 individual species are also shown. Numbers are: 1, *L. siciloides;* 2, *L. sicilis;* and 3, *A. clavipes.*

winter, both in our study and in Birge's. Vertical distribution showed an accumulation of *D. b. thomasi* towards the bottom of the lake during this time of the year (see Fig. 1 and Fig. 14a). Temperature was one to two degrees warmer than at the surface and throughout most of the water column (Fig. 14a), and this might attract the organism. From February to March, the animals slowly rose from the bottom, establishing themselves at four meters by the end of March (Fig. 14b), and increasing from then on to produce the annual maximum in May. This peak of abundance represented the highest biomass of the whole year, with concentrations of 1.8×10^6 ind. m^{-2} in 1896 and 1.48×10^7 ind. m^{-2} in 1980, which accounted for 90% of the total zooplankton biomass (Figs. 16 and 22). The May peak appeared every single year in both Birge's and our studies, and there was a sharp crash shortly after the peak had appeared. According to Birge (1897), this crash was due to a lack of food. Fryer (1957) established the carnivorous habits of most cyclopoids, but Hutchinson (1967) pointed out that small cyclopoids, such as *D. b. thomasi,* would feed mainly by

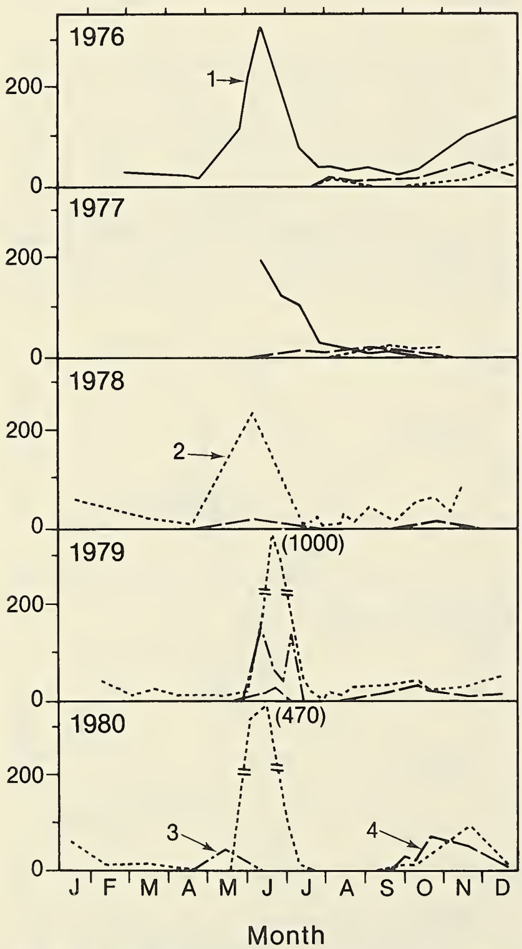

Fig. 20. Abundance of members of the genus *Daphnia* from 1976 to 1980. Values have to be multiplied times 10^3 to obtain individuals per m^2. Numbers are: 1, *D. pulex;* 2, *D. g. mendotae;* 3, *D. parvula;* and 4, *D. retrocurva.*

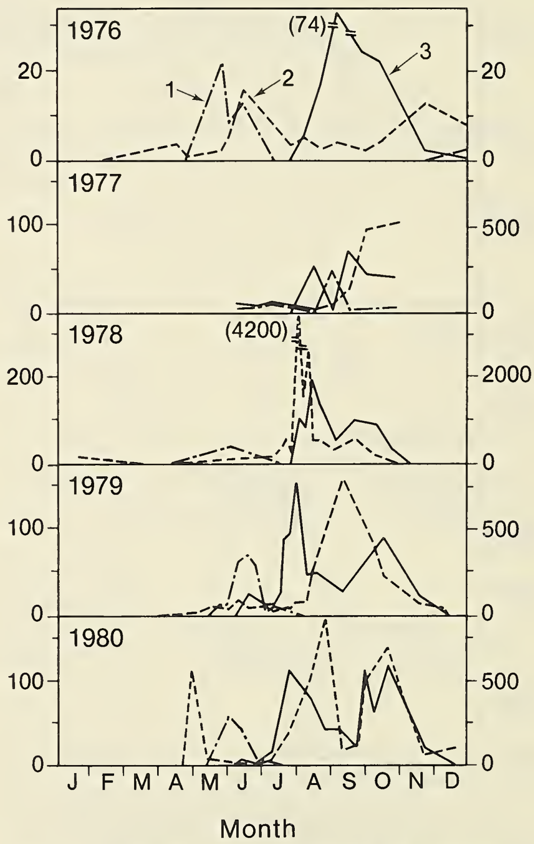

Fig. 21. Abundance of cladocerans not belonging to the genus *Daphnia* from 1976 to 1980. Values have to be multiplied times 10^3 to obtain individuals per m^2. The scale on the right is for *Chydorus* only (number 2). The scale on the left is for *Bosmina* (number 1) and *Diaphanosoma* (number 3).

grabbing algae. Our feeding experiments showed that it could also eat bacteria, although at very low rates, from 0.1 to 1.0 ml ind^{-1} day^{-1} (Pedrós-Alió and Brock, 1983). During 1979, the May peak started when the alga *Chlamydomonas* was at its maximum (Fig. 17a). The two organisms increased and disappeared following perfect "predator-prey" curves (see Figs. 16a and 17a). In 1980, there was an early peak of the diatom *Stephanodiscus* (Fig. 17b), and *D. b. thomasi* followed it at the time that the diatoms disappeared and the flagellate *Cryptomonas* reached its maximum (Figs. 16b and 17b). In both cases, the algae almost completely disappeared from the lake in mid-June, perhaps thus causing the crash of *D. b. thomasi.*

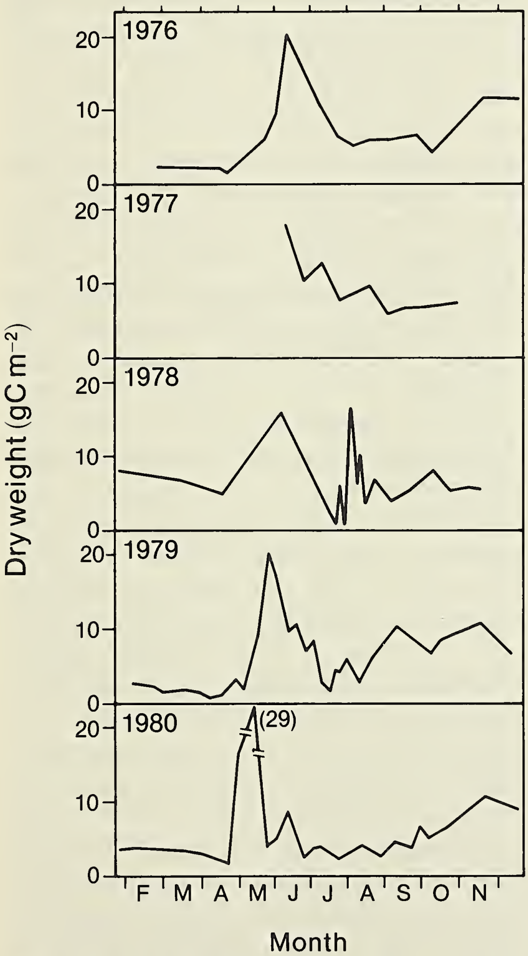

Fig. 22. Total zooplankton biomass. Dry weight in g carbon per m^2 for the five years of the present study.

Birge and Juday (1908) discovered this peak of *D. b. thomasi* to be composed mainly of immature individuals which gradually descended towards the sediment and entered diapause as the copepodite IV stage. Lack of food and rising temperatures in the epilimnion, and anaerobiosis in the hypolimnion, were the factors inducing *D. b. thomasi* to enter diapause. The same summer resting stage has been described in other lakes (Moore 1939, Cole 1953) and at least one case of winter encystment has also been described in Marion Lake, British Columbia (McQueen 1969). Sealed bottles with mud samples showed a fine layer of live, slowly-moving animals at the mud-water interface after several months of being devoid of oxygen, demonstrating the animal's ability to survive in the anaerobic hypolimnion throughout the summer.

Towards the fall, more and more copepodites left their cocoons and reached the cooler and oxygenated waters after the lake overturned, and this was reflected in the increasing abundance of the organism in the plankton starting in late September and reaching a plateau in late December, about the time the lake froze. As shown by the presence of egg-bearing females and nauplii, winter populations reproduced at a slow pace and thus were able to compensate losses and maintain more or less constant numbers under the ice until ice-out occurred, at which time the population started to produce another spring peak.

D. b. thomasi was the most abundant crustacean in Lake Mendota, a feature common to many North American lakes (Watson, 1974; Hutchinson, 1967; McQueen, 1969). However, the annual cycle of this organism in Lake Mendota, both in Birge's and in our study, was different from the cycle in other lakes such as L. Ontario (Nauwerck et al., 1972), L. Erie (Watson et al., 1973) or Marion Lake (McQueen, 1969).

There is a common alternation between

Diacyclops and *Mesocyclops* in many lakes (Hutchinson, 1967). In these cases, *Diacyclops* dominates during the winter while *Mesocyclops* is more abundant during the summer. In some cases, *M. leuckartii,* the European counterpart of *M. edax,* has been found to undergo winter diapause (Fryer and Smyly, 1954), replacing *Diacyclops* in the summer (Cole, 1955). Thus, *M. edax* in L. Mendota followed the general pattern for temperate lakes. According to Fryer (1957), *M. edax* is carnivorous, preferentially eating small cyclopoids, *Diaphanosoma* and rotifers, and thus it would find abundant prey in the summer fauna of the lake.

Acanthocyclops vernalis followed the same pattern as *M. edax,* although generally in lower numbers. Together, these species accounted for all the summer cyclopoids in the lake (Fig. 1). *A. vernalis* is also a large aestival, carnivorous cyclopoid (Cocker, 1943; Fryer, 1957). The expected competition for food between *A. vernalis* and *M. edax* might not have occurred because of their size differences. *Tropocyclops prasinus,* found at all times during the year in very low numbers, is a common constituent of the plankton in the Great Lakes and inland lakes of Wisconsin (Hutchinson, 1967).

2. *Calanoid copepods.* Birge reported only one species of calanoid copepod: *Diaptomus oregonensis* Lillj. and described a life cycle which consisted of a stable winter population with no reproduction and no change in numbers, a small peak in June, a middle summer minimum, and a second peak in September. Birge found reproduction from May to September, as shown by the presence of ovigerous females, but there were also losses due to predation by *Leptodora,* invertebrate larvae such as *Chaoborus,* and planktivorous fish, especially perch. After October, when lower temperatures developed, the population started to decrease. Some of the adults overwintered, while some produced a few nauplii which slowly developed under the ice. The same type of cycle, with two summer generations, was found by Langford (1938) for *Skistodiaptomus oregonensis* in Lake Nipissing and by Davis (1961) in Lake Erie. This suggests that *S. oregonensis* was, in effect, the most abundant calanoid in the 1890s in Lake Mendota, but that Birge did not recognize the possible presence of other species due to the amount of work necessary to differentiate species (as he states, Birge, 1897, p. 326). In our study, *S. oregonensis* was the least abundant calanoid species and this is the main difference between the crustacean plankton studied by Birge and that found by us.

We found three species occurring together in the plankton of Lake Mendota (Figs. 2 and 19). This is a common phenomenon, as Davis (1961) found three of our species and two more coexisting in Lake Erie. He found that *Leptodiaptomus siciloides* and *S. oregonensis* reproduced mostly in the summer, while *L. sicilis* did so in the winter and spring. Eddy (1930) described *L. siciloides* and *L. sicilis* coexisting in Reelfoot Lake, the first being abundant year-round and the second appearing only in November. Wilson (1955) found *Aglaodiaptomus clavipes* and *L. siciloides* living together in Boulder Dam (Nevada) and Cole (1961) found the same two species in some of the Salt River impoundments in Arizona, associated with the cyclopoid *Acanthocyclops vernalis.* It seems that different species of diaptomids can coexist due to differences in size, food requirements, vertical distribution, reproductive season, etc. In our study, *L. siciloides* was the most abundant species year-round, but *L. sicilis* and *A. clavipes* followed closely, the three species being present throughout the year. It seems reasonable that the larger the lake, the more species of diaptomids can coexist, since there are more niches available (Hutchinson, 1967), and Lake Mendota fits nicely between the small ponds in Arizona with two species (Cole, 1961) and the large lakes such as Lake Erie with five species (Davis, 1961). In summary, although the main species was different in the 1970s than in the 1890s, the pattern of abundance of calanoid copepods was very similar to that found by Birge.

3. *The genus Daphnia.* The various species of the genus *Daphnia* were the most abundant cladocerans in Lake Mendota. Four species were found in the present study, three of them the same species found by Birge: *D. galeata mendotae, D. retrocurva,* and *D. pulex.* A fourth species, *D. parvula,* which was not mentioned by Birge, appeared in the last two years of the present study. The genus *Daphnia* constituted from 80 to 60% of the total zooplankton biomass during the month of June (Fig. 16).

D. galeata mendotae was referred to as *D. hyalina* in Birge's paper (Hutchinson 1967, p. 611). Birge himself redescribed it later as *D. g. mendotae* (Birge, 1918). It behaved in 1895 and 1896 as a perennial species with a fairly variable cycle, always with a small peak in May-June of about 300 ind. m^{-2}, and either no peak (1895) or a rather large peak (1896) of 500 ind. m^{-2} in October. During the two first years of the present study, *D. g. mendotae* was found in very low numbers, mostly during the summer (Fig. 20), but from 1978 on, it replaced *D. pulex* and became the most abundant *Daphnia* species in the lake. From 1978 to 1980, *D. g. mendotae* showed a very consistent peak in June, and low, oscillating numbers for the rest of the year (see results for 1979 in Fig. 3). The June peak was much larger than any peak reported by Birge for any *Daphnia* species, reaching 1.02×10^6 ind. m^{-2} in 1979 (Fig. 3). While this maximum of abundance lasted, *Daphnia* constituted between 50 and 60% of the total zooplankton biomass (Fig. 16). This type of behavior, with a single sharp peak in the whole year, has been observed in *D. galeata* in a Swedish lake (Axelson, 1961) where temperature was never above 17°C, but in most American lakes *D. g. mendotae* always exhibits two peaks, one in late spring and one in the fall (Birge, 1897; Borecky, 1956; Hall, 1962). The different cycle in Lake Mendota is probably due to the recurrent cyanobacterial blooms during the summer. Cyanobacteria can have negative effects on zooplankton in several ways. Members of the genus *Daphnia* cannot eat the large flakes of filamentous *Aphanizomenon* (Holm et al., 1983) and, therefore, are unable to reproduce during the summer, thus giving rise to a second peak in the fall. In addition, many *Microcystis* species are toxic to zooplankton (DeBernardi et al., 1981). Moreover, daphnids are less efficient than calanoids at avoiding filamentous and other blue-green algae, and unlike calanoids, daphnids are not able to feed selectively on smaller edible algae (Richman and Dodson, 1983).

The collapse of the June daphnid peak was probably due to a combination of lack of food and predation by fishes. Fish ate large quantities of *Daphnia* when the cladoceran accumulated locally (McNaught and Hasler, 1961). *Leptodora,* on the other hand, did not play any major role in the disappearance of *Daphnia* in Lake Mendota, since it only appeared in July, when the *Daphnia* population had already declined. *Leptodora,* however, could help to maintain low summer populations once the peak had crashed, by eating the juveniles, as Hall (1962) found in Base Line Lake. The most obvious factor in the disappearance of the *D. g. mendotae* peak was lack of food. Both in 1979 and 1980 there was a dramatic reduction in phytoplankton biomass coincidental with the *Daphnia* peak (Figs. 16 and 17). At its maximum, *D. g. mendotae* had a biomass of 6.7 g C m^{-2}, while there were only 0.057 g C m^{-2} of phytoplankton and 0.203 g C m^{-2} of bacteria in the lake (Pedrós-Alió and Brock, 1982). The *Daphnia* probably eliminated the algal spring bloom formed by easily edible algal species of the genera *Cryptomonas* and *Stephanodiscus,* thus leaving the stage set for the appearance of cyanobacteria and the summer fauna in early July.

D. pulex is considered to be a cold water species with a rather variable annual cycle. It presented low oscillating peaks of population during the summer of 1895 and a sharp peak in May of 1896 (Birge, 1897). In our study, *D. pulex* had a similar large peak in early June and low numbers the rest of the year during 1976 and 1977, but disappeared almost completely afterwards (Fig. 20). The substitution of *D. g. mendotae* for *D. pulex* was rather dramatic and it probably reflected the incidence of heavy fish predation in 1978 and after. *D. pulex* was considerably larger than *D. g. mendotae,* and this would give the latter a competitive advantage when planktivorous fishes were present (Brooks and Dodson, 1965). As a matter of fact, we observed cisco *(Coregonus artedii)* appearing in large numbers as a single size class in 1979-1980, while it had been absent from 1976 to 1977.

D. parvula appeared only in 1979 and 1980. Although in 1979 it was present at the same time as *D. g. mendotae,* the two species seemed to avoid each other both in depth and slightly in time (Figs. 3 and 4), so that direct competition did not occur. *D. parvula* seems to replace *D. retrocurva* in the Southern U.S. (Hutchinson, 1967, p. 818). However, during the present study, *D. retrocurva* did not show any differences in life cycle when *D. parvula* was present from when it was absent. Thus, these two species did not seem to compete in Lake Mendota.

During the present study, *D. retrocurva* behaved in almost the same way as in 1895, being an aestival species with numbers around 5×10^4 ind. m^{-2} from July to December (Fig. 5). However, a peak such as that found in 1896, with 3×10^5 ind. m^{-2}, did not occur in any of the years of the present study.

If the genus *Daphnia* is considered as a whole, the annual cycle was almost identical to that found by Birge (1897), with peaks in spring and autumn, and variable numbers during the summer. But when individual species are taken into account, differences within years can be found both in Birge's study and in ours.

4. *Other cladocerans.* Cladocerans other than *Daphnia* in Lake Mendota could be divided into spring and summer species. During the present study, *Bosmina* and *Ceriodaphnia* appeared almost exclusively in the spring, generally coincidentally with the *Daphnia* peak and with the disappearance of the easily edible phytoplankton. This behaviour seems fairly typical for *Bosmina longirostris* (Fig. 6; Wesenberg-Lund, 1904; Patalas, 1956) and it was rather constant from 1976 to 1980. The maximum reached 7×10^4 ind. m^{-2} except in 1978 when it was less abundant (Fig. 21).

Ceriodaphnia, on the other hand, is considered to be a pond species (Hutchinson, 1967, p. 619) and its appearance in the plankton was, accordingly, erratic. It was only recorded a few times, and always in fairly low numbers, once in 1976, never from 1977 to 1978, once in 1980, with a small peak being detected in June 1979 coinciding with the peaks of *Daphnia* and *Bosmina.*

The summer species of cladocerans were *Diaphanosoma leuchtenbergianum, Chydorus sphaericus* and *Leptodora kindtii.* In the summer, after the lake had become firmly stratified, the main phytoplankton species were cyanobacteria (blue-green algae), mainly *Aphanizomenon* and to a lesser degree *Microcystis* and *Lyngbya* (Fig. 17). *Daphnia* does not eat *Aphanizomenon,* and the same seems true for smaller cladocerans and calanoid copepods. Thus, these summer zooplankters graze primarily on the smaller sized, less abundant, eukaryotic algae, which form a small percentage of the phytoplankton biomass at the time (Fig. 17). The species composition thus shifts from the relatively large *D. g. mendotae* to the smaller *Diaphanosoma* and *Chydorus.*

Chydorus sphaericus is a littoral species which appears in the plankton mainly when there are cyanobacterial blooms (Hutchinson, 1967). It has been suggested that *Chydorus,* being a littoral particle scraper, would be able to handle the larger cyanobacteria as if they were particles and somehow eat them, for example by sucking

Aphanizomenon filaments "spaghetti style." Thus, this could explain the abundance of *Chydorus* in the summer plankton (Fig. 7). Its oscillations were quite variable from year to year, presenting two peaks in 1976, one peak from 1977 to 1979, and three peaks in 1980 (Fig. 21). These peaks were found from May to November in different years. Birge found *Chydorus* in low numbers with very small peaks (100 to 300 ind. m^{-2}) in July 1895 and September 1894, and three peaks of 400 ind. m^{-2} in July, 750 ind. m^{-2} in September, and 400 ind. m^{-2} in October of 1896, thus showing the same type of variability that we found. *Chydorus* seemed not to avoid the lower depths as much as other cladocerans (Fig. 7), not even during the period when the hypolimnion was anaerobic.

From 1976 to 1980, *Diaphanosoma* changed slowly from having a cycle with only one wide peak in late August (1976, see Fig. 21) to presenting two clearly distinct peaks in late July and in September (1980, see Fig. 21). Both types of behavior have been observed in this organism (Marsh, 1893; Birge, 1897; Patalas, 1954; Wells, 1960). Birge found very low numbers in September-October of 1894 and 1895, and a sharp peak of 1.5×10^5 ind. m^{-2} in 1896. The highest concentration found in the 1970s varied in different years between 100 and 4×10^5 ind. m^{-2}. It seems a widely extended feature of cladocerans to be able to shift back and forth between cycles with one and two annual peaks. This has been observed in Lake Mendota for *Diaphanosoma, Chydorus* and *D. retrocurva* (present study; Birge, 1897). Changes in maximum abun-

TABLE 3. Comparison of two different techniques in the determination of the abundance of *Leptodora kindtii* in Lake Mendota, 1980.

Date	*Individuals per m²*	*Total individuals counted*	*Percent of sample counted*	*Sampling method*
Jan. 14	0	0	100	Van Dorn
Feb. 7	0	0	100	Van Dorn
Mar. 17	0	0	100	Van Dorn
Apr. 1	0	0	100	V. tow[a]
Apr. 22	0	0	100	V. tow
Apr. 29	0	0	100	Van Dorn
May 12	0	0	100	Van Dorn
June 2	0	0	100	Van Dorn
June 11	0	0	100	Van Dorn
June 24	0	0	100	Van Dorn
July 1	0	0	100	Van Dorn
July 8	1600	2	100	Van Dorn
July 23	1300	1	100	Van Dorn
Aug. 12	2000	2	3	V. tow
Aug. 26	3000	9	10	V. tow
Sept. 8	500	15	100	V. tow
Sept. 22	2000	55	100	V. tow
Sept. 29	2000	1	2	V. tow
Oct. 6	1000	30	100	V. tow
Oct. 20	0	0	1	V. tow[b]
Nov. 20	1000	1	4	V. tow[a]
Dec. 18	0	0	4	V. tow

[a] Vertical tow from 23 m to the surface.
[b] Vertical tow from 23.5 m to the surface.

dances of cladocerans are probably in accordance with changes in food availability, competition, and predation.

Leptodora kindtii was always present in very low numbers, appearing in the plankton in July and disappearing towards October (Table 3). The extreme rarity of this animal makes numbers in Table 3 not completely reliable, due to the few individuals counted. *Leptodora* always appeared a few weeks after the collapse of the June *Daphnia* peak, so that, contrary to what happened in Base Line Lake (Hall, 1962), *Leptodora* did not play a significant role in the disappearance of *Daphnia* in Lake Mendota. Birge also found *Leptodora* present in very low numbers during the summer, and this has been observed by several authors (Wesenberg-Lund, 1904; Findenegg, 1953; Nauwerck, 1963).

5. *Rotifers.* No comparisons are possible for rotifers, since there are no previous quantitative studies of the rotifers of Lake Mendota. Only studies of Harring and Myers (1921) considered the rotifers of Wisconsin, but they were mostly concerned with the taxonomy and distribution of the different genera and not with quantitative, ecological studies. All the genera we found appeared in their 1921 list of species (Harring and Myers, 1921). The organisms found belong to all the common planktonic genera and are widely distributed (Figs. 9 to 13, and 15). Numerically some of them were very abundant, but in terms of biomass they always constituted a very small portion of the whole zooplankton biomass (Fig. 16).

All the rotifers were extremely rare (*Keratella* spp.) or completely absent (the other genera) from the winter plankton. Both *Keratella* species, *Polyarthra,* and *Asplanchna* had one or two peaks, usually one in the spring and one in the fall, but were absent from the lake during summer stratification. *Brachionus* and *Conochilus,* on the other hand, were more abundant during lake stratification. *K. cochlearis* was the most abundant rotifer as well as the one with the most constant annual cycle. It had a peak in June, a small peak in early July, and its largest peak in October or November (Figs. 9 and 15). The other genera tended to have peaks which did not overlap (Fig. 15) and which substituted for each other from spring to fall.

Year-to-year variations: 1976-1980. Considerable year-to-year variation occurred in the general annual cycle described in the previous section. Most of the detailed changes have already been discussed. Here, we will only give a systematic summary of the changes found. The main body of data (with numbers and biomass for each species, each depth, and each sampling date of the five years of the present study) can be found in Pedrós-Alió (1981). For conciseness, the organisms have been grouped and their abundances represented in Figures 18 to 21 and total zooplankton biomass is presented in Figure 22. Three types of changes among years were found and will be discussed separately below: 1) species composition, 2) maximum abundances of certain species, and 3) timing of the maxima.

1. *Species composition.* The most dramatic change in species composition was the substitution of *D. g. mendotae* in 1979 and 1980 for *D. pulex,* which had been the dominant cladoceran in the previous years (Fig. 20). This substitution was almost complete and very few individuals of *D. pulex* could be observed after 1978. The remaining changes in species composition were due to the presence of certain species (in substantial numbers) during some years, but not others. *D. parvula* appeared in 1979, presenting high numbers in the metalimnion immediately before and after the main *D. g. mendotae* peak (Fig. 4). In 1980 there was again a small peak, but no individuals of this species were observed previous to 1979. Finally, *Ceriodaphnia quadrangula* was observed in significant numbers only in February 1976 and in June of 1979 and 1980.

2. *Maximum abundances.* It can be easily seen in Figures 18 to 21 that maximum abun-

dances of many species were different from year to year. For example, the peak of *D. g. mendotae* in June was 230 ind. m^{-2} in 1978, 1000 ind. m^{-2} in 1979, and 470 ind. m^{-2} in 1980. The May peak of *Diacyclops* reached 150 ind. m^{-2} in 1976, 1200 ind. m^{-2} in 1978, 4000 ind. m^{-2} in 1979, and 14700 ind. m^{-2} in 1980. These are only the most spectacular changes in abundance, but variations were observed in most species.

3. *Timing of species maxima.* Some of the species found were reasonably constant in their annual cycles, such as *Diacyclops* and *D. g. mendotae.* On the other hand, species such as *Diaphanosoma* and *Chydorus* were rather variable in the timing of their appearance as well as in the number of peaks per year (Fig. 21). In general, the species present during the winter and spring had very predictable peaks and cycles, while the summer species were variable.

When a statistical test was run to test for differences between our study and Birge's (Pedrós-Alió and Brock, 1985), it was found that differences among years within each study were higher than differences between the two studies. Thus, for example, 1895 was very different from 1896 and close to 1978, and 1976 differed more from 1979 and 1980 than from 1895 or 1896. Therefore, although clear year-to-year variations were found, no significant trend with respect to Birge's study could be detected, indicating that the lake has had the same conditions for the past eighty years.

Acknowledgments

Winter samples for 1978 were kindly provided by R. Lathrop from the Wisconsin Department of Natural Resources. Samples from 1976 were gathered by Dr. V. Watson, then at the Department of Botany of the University of Wisconsin. Phytoplankton biomass was measured by T. H. Gries and J. Sesing, in the Department of Bacteriology.

This work was supported by NSF grant DEB-8212459 to T. D. Brock and the Northern Lakes component of the Long-Term Ecological Research Program of the National Science Foundation (DEB-8012313). Carlos Pedrós-Alió was a recipient of a Fulbright-Hays grant from the United States-Spain Cultural Exchange Program.

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A STABLE ARTIFICIAL SUBSTRATE DEVICE (TRI-BASKET SAMPLER) FOR COLLECTING MACROINVERTEBRATE SAMPLES FROM STREAMS AND RIVERS

MICHAEL W. MISCHUK *and* DAVID L. RADES
The Institute of Paper Chemistry
Appleton, Wisconsin

The quantitative collection of aquatic macroinvertebrates for the purpose of environmental impact assessment has always presented some sampling problems. Hellawell (1968) provides a review of the major benthos sampling devices and techniques, including artificial substrate samplers. Although the utilization of artificial substrates is now widely accepted (Cairns, 1982), advantages and disadvantages to these techniques exist. Rosenberg and Resh (1982) concluded that the habitat to be sampled will usually dictate the sampling device used. The remainder of this paper describes a sampler we feel provides a durable, simple, and efficient device for collecting benthos under certain habitat conditions.

system to be used in areas where the natural habitat was composed largely of pebble and cobble (50–250 mm in diameter). Additionally, we wanted the system to withstand fluctuations in river discharge, while providing physical stability and positive direction-of-current orientation. Unlike the standard Surber sampler, the device had to be versatile enough to be used in shallow water and, with the use of S.C.U.B.A., deeper water. We also needed a sampler which would generally minimize the effect of siltation, allow for the collection of samples without loss of fauna, be relatively inconspicuous to minimize vandalism, and provide some measure of within-sampler variation.

The tri-basket sampler (Fig. 1) was devised to satisfy the design criteria previously stated. It is composed of three modified barbeque baskets like those described by Anderson and Mason (1968). Each basket is 18 cm (7 in.) in diameter by 13 cm (5 in.) in length.

Attached to the base of each basket is a 6 mm-(0.25 in.) thick Masonite plate 18 cm (7 in.) in diameter to give stability to each basket. Twelve, 5 cm (2 in.) in diameter unlapped porcelain balls were used as substrate material within the basket.*

The baskets are mounted on steel pipes 30 cm (12 in.) long by 3.2 cm (1.25 in.) in diameter (outside diameter). These pipes are attached to a triangular steel frame constructed of three 76 cm (30 in.) pieces of 5 cm (2 in.) angle iron welded together (60° inside angle). The configuration of the steel frame reduces standing wave effects from the lead basket on those to its sides. Small steel pipes to accept the ones supporting the baskets are welded in the corners of the frame. These pipes are 13 cm (5 in.) in length by 4.1 cm (1.75 in.) in diameter (O.D.). These pipes allow for adjustment in basket height above the frame (achieved by placement of holes in basket pipes).

The baskets can be removed from the frame at the top or bottom by releasing either one of the 6 mm (0.25 in.) clevis pins. Although the sampling device maintains location on the natural substrate well by virtue of its weight 17 kg (37 lb) and configuration, additional security is provided by utilizing a

* **Sources of Equipment:** Bar-B-Q Tumble Basket, Paramount Housewares, 4770 East 50th St., Los Angeles, California 90058. Two-inch, unlapped porcelain balls, Ferro Corporation, Porcelain Plant, P.O. Box 858, East Liverpool, Ohio 43920.

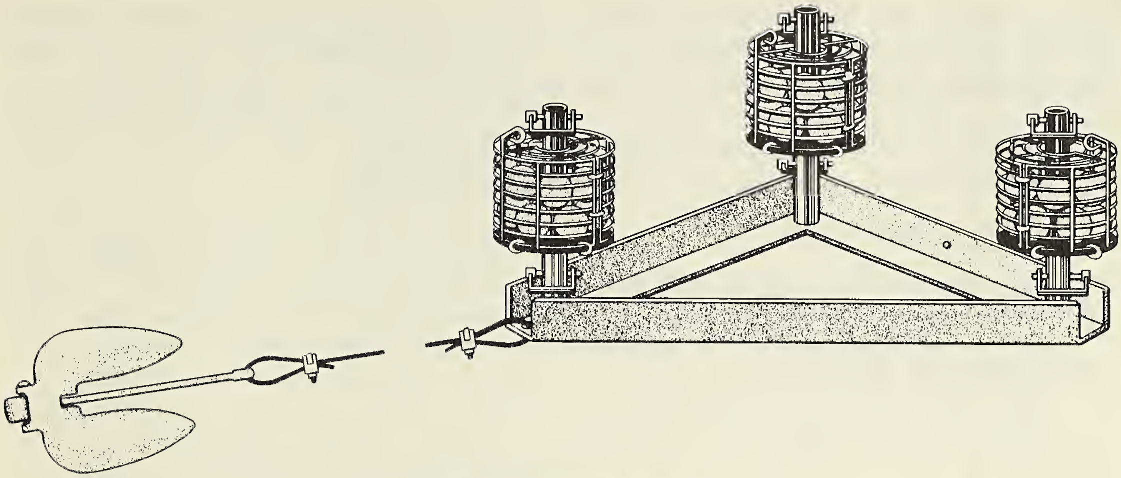

Fig. 1. Tri-Basket Sampler.

TABLE 1. A comparison of major colonizing groups (average percent comparison) and numbers of species (average number/sample) for tri-basket and natural substrate (Surber sample).

River	Substrate Type	Number of Samples	Trichoptera (%)	Ephemeroptera (%)	Diptera (%)	Oligochaeta (%)	Turbellaria (%)	Number of Species
Wisconsin River, WI	Tri-basket	18	47	4	30	9	8	31
Summer	Natural	18	49	3	22	3	16	26
Wisconsin River, WI	Tri-basket	18	45	5	18	31	1	28
Fall	Natural	18	69	2	17	3	5	23
Catawba River, SC	Tri-basket	21	67	16	10	3	2	27
	Natural	5	44	13	15	8	18	16

9 kg (20 lb) navy anchor. The anchor is attached to the sampler with plastic coated steel cable (0.5 cm) (0.38 in.) and several cable clamps. Samples are collected without loss of fauna by placing plastic or nylon mesh bags over each basket before removal from the frame.

A comparison of the faunal composition on the tri-basket sampler and the natural substrate was conducted to determine sampler biases for different groups (Table 1). In general, those taxa that were dominant on the natural substrate were also dominant on the tri-basket sampler. Likewise, within-sampler variation was looked at to determine sampling efficiency (Table 2).

The tri-basket sampler was found to be a stable sampling system to obtain benthic macroinvertebrate specimens. The weight of the sampler maintains the proper position and orientation on the stream bottom, par-

TABLE 2. A comparison of within-sampler variation (coefficient of variation) for density and number of species from four different river systems.

River	Number of Samples	Number of Species	Density
Wisconsin, WI	18	13.2%	15.4%
Escanaba, MI	7	12.9	36.9
Catawba, SC	6	16.4	21.7
Paint Creek, Scioto, OH	12	13.0	22.4

ticularly during high flow conditions. Since the baskets sit just above the bottom, siltation problems are minimal. Because of its versatility it can be used in deeper water (> 1 ft) which might preclude the use of a standard Surber Sampler.

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A HISTORY OF OLIVER LAKE #2, CHIPPEWA COUNTY, WISCONSIN, BASED ON DIATOM OCCURRENCE IN THE SEDIMENTS

RODNEY GONT *and* LLOYD OHL
University of Wisconsin-Eau Claire

Abstract

A general history of Oliver Lake #2, Chippewa County, Wisconsin, has been constructed. Interpretations were based on a diatom analysis of a vertical profile of bottom sediments taken from the deepest part of the lake using two types of coring devices. Evidence indicates that a shallow, slightly alkaline lake, moderately high in nutrient content, evolved into a relatively deep, highly acidic lake, low in available nutrients. Diatom communities of the most recent sediments indicate these trends may now be reversed.

INTRODUCTION

Techniques of interpreting changes in lakes by analyzing fossil diatom communities of the sediments are well established. Studies by Conger (1939), Andrews (1966), Charlton (1969), Florin and Wright (1969), Florin (1970), Andresen (1976) and Stoermer (1977), in the Great Lakes region; and by Patrick (1954), Round (1957 and 1961), Stockner and Benson (1967), and del Prete and Schofield (1981), elsewhere, are representative. There are many publications available outlining diatom identification which is based on the size, shape, and ornamentation of easily-preserved, glass-like walls. Many species have narrow habitat requirements, being greatly affected by temperature, available nutrients, and chemical properties of the water (Patrick 1948). There is also information available concerning their pH preferences, and even though pH is less indicative of water conditions than factors such as mineral content (Patrick 1945), it is still useful.

This study was based on a single sediment profile. Although relying on a single site increases the probability of taking a sample that does not represent the lake as a whole, there is precedence for doing so (Patrick 1954, Florin 1970, Stoermer 1977). Florin (1970) briefly discusses the problem. By using the deepest, most stable part of the lake, it seems that unnecessary effort can be eliminated while still collecting an adequately representative sample.

Only the prevalent species (relative density $> 3\%$) have been used in the majority of the analyses and interpretations. Patrick (1948) discusses the use of the largest populations as the best interpretive indicators.

Certain problem taxa were encountered but only restricted interpretive use was made of them. In a few instances identification was not possible and these were assigned numbers and recorded as such. By taking a conservative, selective approach, it is believed that the taxonomic and ecological problems have been minimized without excessive loss of information.

STUDY SITE

Oliver Lake #2, in sec 24, T31N, R8W, Chippewa county, Wisconsin, lies on an irregular terrain deposited as stagnant, ice-core moraine, just within the maximum advance of the most recent continental glaciation (Cahow 1976). This dark water, bog-rimmed, acidic (surface pH, 5.1) lake has characteristics that reduce disturbance of the bottom: 1) a small surface area of 1.6 hectares accompanied by a relatively great depth of 21 meters, 2) a wind sheltered location bordered by uplands some 6 to 12 meters above the lake surface, and 3) a bottom oxygen deficit (instrumental determination) in the winter which, as Simola (1977) points out, would eliminate large, bottom crawling animals. Lakes with these characteristics are susceptible to chemical stratification. However, with uniform conductivity throughout the water profile, and a standard, winter inverse temperature stratification, the lake was apparently not meromictic at the time of data collection.

Procedure

A vertical profile of the bottom sediments at the deepest part of the regularly shaped, slightly oblong, bowl-like basin was obtained using two different coring devices. A 195 cm long core of the uppermost sediments was taken through the ice on 5 January 1983 using a freeze-core device (Swain 1973). The upper end of the sample was marked by the clearly visible, water-sediment interface, indicating disturbance of the sediments had been minimal. This core was wrapped in aluminum foil to reduce dessication and transported on dry ice to the laboratory for storage.

On 26 February 1983 a piston-core device (Livingstone 1955) was used through the ice at the same site to remove successively deeper, 1 meter long segments, resulting in an additional 268 cm long composite core. Since 21 meters of water was above the sediment-water interface, a rigid pipe casing, slightly larger in diameter than the piston corer, was used, not only to prevent bending of the sampler thrust rod when pressure was applied to take the sample, but also to ensure that each time the sampler was lowered it entered the same hole in the sediments. Based on a subsequent comparison of diatom communities from this core to the previously-taken freeze-core sample as well as on certain trends which were continuous between the two cores—a declining number of alkaliphilic species, a constant number of acidophilic species, a rising number of *Eunotia* individuals, and constant diversity—the piston core portion began an estimated 250 cm below the water-sediment interface and continued to 500 cm.

A small cork borer was used to take 7 mm diameter by 20 mm long subsamples, spaced 50 cm apart, from the composite profile. Several mm of each end of each plug were discarded to reduce the chance of contamination from other levels. These subsamples were oxidized (van der Werff 1953) before preparing strewn-mounted microscope slides (Patrick and Reimer 1966) with Hyrax (R.I., 1.65) as the mounting medium. A slide from each subsample level was examined at 1250× with a Zeiss research microscope. Randomly selected transects were taken until a minimum of 400 diatom valves were identified and tabulated from each slide. McIntire and Overton (1971) have used information diversity measures for various diatom counts in establishing sample size adequacy for an ecological study of diatoms of similar scope.

Numerous publications were used to identify the diatoms, but those of Patrick and Reimer (1966 and 1975) and of Hustedt (1930 and 1930-66) were the primary sources. Subsamples were labelled (as levels) using their distance, in cm, below the sediment-water interface.

Results

Based on a preliminary visual inspection, only the deepest 30 cm (Level 470 to 500) of the profile had noticeable amounts of inorganic material. Wet mount examinations of this portion at a magnification of 500× before any treatments revealed: 1) both Levels 496 and 490 had small amounts of "sand" (particles $> 7\ \mu m$ diameter) mixed with organic matter, 2) Level 496 had a slightly lower proportion of "sand" than Level 490, 3) Level 480 was "gravel" comprised of sand and pebbles (up to 20 mm diameter) with very little organic matter, and 4) Level 470 was almost entirely a reddish clay ($< 7\ \mu m$ diameter). The 1250× study of subsamples prepared for diatom identification also showed: 1) Level 490 had a very diverse diatom flora devoid of pelagic and terrestrial species, 2) Level 480 had many diatoms and a wide array of species (based only on a cursory inspection), and 3) Level 470 had an insufficient number of diatoms to cven count. All other levels consisted primarily of organic material interspersed with diatom valves and fragments. Figure 1 summarizes these observations.

Twenty eight prevalent species were found in one or more of the 11 sediment levels examined. The relative densities and distribution of these species are shown in figure 2.

Many techniques are available to group data into more interpretable groups. Although the efforts to condense seemed to fail, they were valuable in showing that each sediment level was unique. The following examples are representative.

The degree of association between species was measured using Cole's Index (Cole 1949) with signficance tested by Chi square. Among the 28 prevalent species there were only three significant ($P < .05$) relationships: 1) *Asterionella formosa* Hass. and *Fragilaria pinnata* Ehr. were negatively associated, 2) *Eunotia paludosa* Grun. and *F. pinnata* were negatively associated, and 3) *Eunotia flexuosa* Breb. ex Kutz. and *E. paludosa* were positively associated. A subsequent cluster analysis (Williams and Lambert 1959), which uses a Chi square distance measure, resulted only in one significant ($P < .05$) division—those levels with *F. pinnata* present (the 7 deepest levels) and those with it absent (the 4 shallowest levels).

Bray and Curtis (1957) used a $1\text{-}2w/a+b$ index to objectively measure the degree of dissimilarity between samples. The indices calculated for Oliver Lake #2 were high, indicating high level to level dissimilarity.

Curtis (1959) proposed a ratio of prevalent modal species to prevalent species for detecting hybrid communities. A comparable ratio, disregarding prevalence, could also be used to give more weight to the rare species.

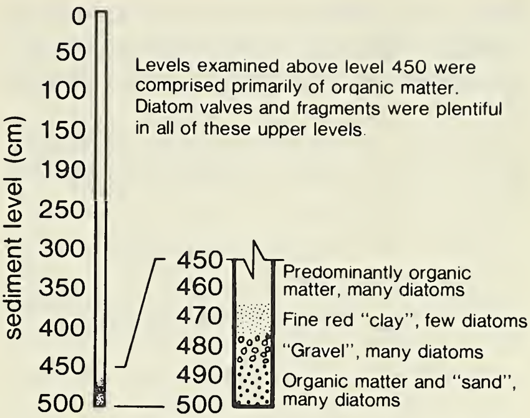

Fig. 1. Characteristics of the bottom 50 cm of the sediment profile taken from Oliver Lake #2. The proportion of "sand" at Level 496 was slightly lower than at Level 490.

Fig. 2. Percent relative densities of the prevalent fossil diatoms for each sediment level examined from Oliver Lake #2. Relative densities less than 3% are shown as 0.

Low ratios indicate a lack of uniqueness. Figure 3 shows that these two indices are simultaneously low only at Levels 50 and 350.

In effect, the species present at various times in the history of Oliver Lake #2 have varied greatly, with little continuity between adjacent levels. This is not as unusual as it first appears to be. Even in an unchanging environment, the kinds of diatom species can fluctuate greatly while the number of species and the relative sizes of the popula-

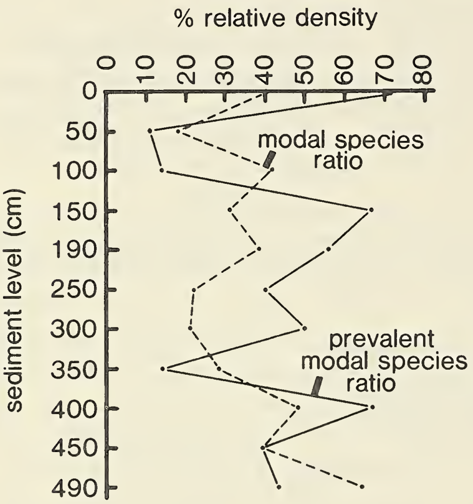

Fig. 3. Modal and prevalent modal species ratios for each sediment level examined from Oliver Lake #2. Low values indicate that the diatom community at that level has a hybrid composition. Only Level 50 and Level 350 have simultaneously low values.

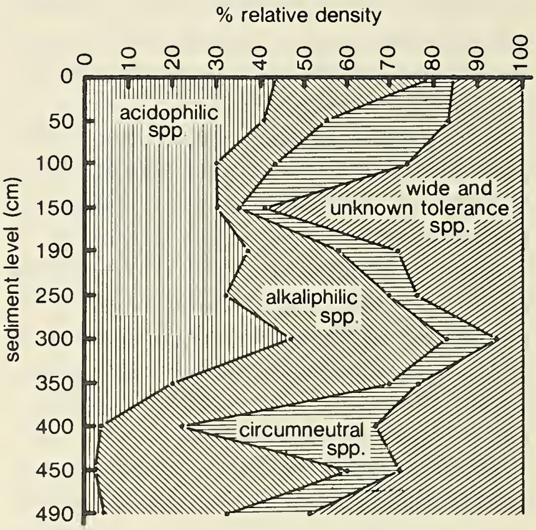

Fig. 5. Distribution of individuals when classified by their pH preferences for each sediment level examined from Oliver Lake #2. Acidophilic: pH preference < 6.5. Alkaliphilic: pH preference > 7.5. Circumneutral: pH preference 6.5 to 7.5.

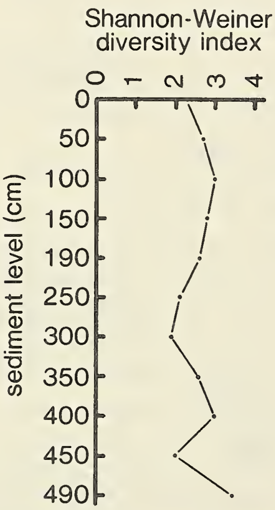

Fig. 4. Shannon-Weiner diversity index for each sediment level examined from Oliver Lake #2. Level to level variation is much greater in the older sediments.

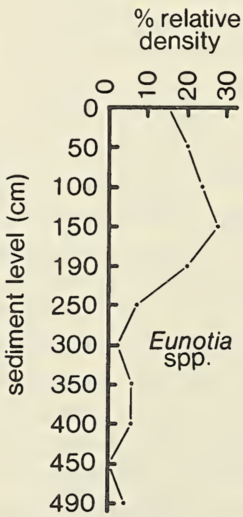

Fig. 6. Percent relative density of the genus *Eunotia* for each sediment level examined from Oliver Lake #2. This genus is much more common in the younger sediments.

tions of the species remain quite constant (Patrick 1962, 1963). There are so many diatom species available that any one of a number of these, in the right place and time, can reproduce rapidly enough to fill niche openings. The Shannon-Weiner diversity index (Shannon and Weiner 1963) uses just these two criteria (number of species and sizes of populations). Remaining constant, it would then indicate relatively stable ecological conditions. As shown in figure 4, the index fluctuates erratically in the earliest stages of lake development but dampens considerably in more recent times.

Species can be grouped by their pH preferences (Foged 1981). As shown in figure 5, acidophilic species are absent from the deepest sediments but become prominent in the more recent sediments. A comparison with fig. 6 shows that the genus *Eunotia* roughly parallels this trend and in fact contributes to it. This would be expected since *Eunotia* taxa are virtually all acidophilic. *Eunotia* genera peak at Level 150. Figure 5 also shows that the combined alkaliphilic-circumneutral pH species are at a minimum at Level 150.

Discussion

Level to level diversity has fluctuated more in the older fossil communities studied than in the recent ones. Since Richardson (1969) has correlated stratigraphic variability to low water levels, this may well mean that Oliver Lake #2 was shallower than at the present. To account for the later stability, a subsequent increase in depth is proposed which provided extra volume to better absorb the effect of factors that influence lake ecosystems. The analyses at each individual level support this contention as well as indicating that conditions became more acidic and more dystrophic.

Level 490 (oldest sediments)

At this time, Oliver Lake #2 was apparently mildly eutrophic. Of the prevalent diatoms, *F. pinnata, Gomphonema parvulum* Kutz and *Fragilaria brevistriata* Grun. are usually found in such water, while only *Pinnularia biceps* Greg. prefers water of low mineral content. The marked lack of acidophilic species indicates somewhat alkaline conditions.

Although shallow water species can exist in deep water if the water is clear enough to allow sufficient light penetration (Conger 1939), only an oligotrophic lake would likely be clear enough. As discussed above, Oliver Lake #2 was apparently mildly eutrophic at this time, so that the abundance of shallow-water species would indeed imply shallow water. Since pelagic species normally abound in deep, mildly eutrophic water, but not in shallow water, their absence here further supports the shallow water proposal.

Diatom diversity is particularly high. Water chemistry apparently had not greatly changed for a long time and an abundance of available niches due to an extended period of favorable habitat development seems probable. However, it is unlikely that the situation was totally static. Maximum diversity may well occur when there is some intermediate disturbance (Huston 1979, van Dam 1982). Presence of some sand at this level further substantiates a somewhat dynamic situation.

It is speculated that the lake at this time was located above a large block of buried glacial ice. Florin and Wright (1969) have proposed the melting of buried ice blocks to be a common means of lake basin formation in glaciated regions. Cahow (1976) felt that most of the lake basins in the area resulted from the melting of buried ice blocks. The gradual deepening of the shallow lake, indicated by the fossil diatom community at this level, to the present day depth of 21 meters, fits well into this buried ice block concept.

Level 480 and 470

These levels were not a part of the diatom analysis, but were included because of their obviously different physical appearance when the entire sediment core was visually inspected. The "gravel" layer of Level 480 would have required a powerful earth-moving force for its transportation to this location. It is conceivable that glacial events—large volumes of swift-flowing water, rafting via chunks of ice, or landslides—provided the impetus. Diatoms in this "gravel" may have been transported from reworked, upstream sites.

On the other hand, subsequent deposition of the easily suspendible clay particles of Level 470 would have required greatly reduced flows. Glacially fed runoff may have been depleted due to recession of the glacier. The insufficient number of diatoms present at this level to even count is consistent with Round's proposal that deposition of clay dramatically reduces diatom populations (Round 1956).

Level 450

Apparently, organic deposition in a shallow lake was renewed. Extensive amounts of the benthic *F. pinnata* and a lack of pelagic species once again indicate shallowness. Sand and clay are no longer present, so that material being transported overland appears to be trapped by some sink surrounding the lake. The establishment of emergent and submergent vegetation at the periphery of the lake may have been that sink. Retarded water movement would cause a dropping of sediment loads before the lake was reached. The organic matter of the sediments would then have come only from production within the lake and from wind-blown sources (e.g. leaf litter).

With acidophilic species still rare, the water was probably somewhat alkaline. Diversity at this level is low and the widely tolerant and benthic *F. pinnata* is very abundant, implying that conditions were harsh for diatom growth. Warm water may have been one of those conditions. Benthic species would have been scarce in a cold, shallow lake (Patrick 1948).

Level 400

An increase in the proportion of circumneutral species, a decrease in alkaliphilic ones, and a concurrent slight rise in acidophilic ones indicate a pH decline. The presence of *Fragilaria crotonensis* Kitton, a pelagic species, would have required some deeper, open water—presumably provided by the sagging of the lake bottom as the buried ice block slowly melted. With *F. crotonensis, F. brevistriata* and *G. parvulum* present, the lake was probably still mildly eutrophic.

Level 350

The lake apparently continued its pH decline. Although alkaliphilic species (*F. pinnata* in particular) still were abundant, acidophilic species such as *Melosira distans* var. *lirata* Ehr. had also become prevalent. Water depth and nutrient content were apparently sufficient to support pelagic species such as *Melosira italica* subsp. *subarctica* O. Mull. and *A. formosa* in small numbers. The lower diversity might be attributed to acidic conditions "weeding out" less tolerant species. A small bog may have developed at the perimeter—not only increasing acidity, but also donating water-darkening humic substances that would be resistant to breakdown in the more acidic conditions.

Level 300

As indicated by the dissimilarity indices and the proportion of modal species, this was a hybrid level, showing some similarities to both Level 350 and Level 250. Acidophilic species peaked here due to the high proportion of *M. distans* var. *lirata*, but the alkaliphilic *F. pinnata* was still present in large numbers. Diversity was low indicating a major transition, presumably from alkaline to acidic water, was taking place.

Level 250

The increase in individuals within the genus *Eunotia* implies that pH had dropped and that dystrophic, bog-like conditions were likely established. Most of the species of *Eunotia* indicate soft, somewhat acid water (Patrick 1977). This has been consistently confirmed, particularly in deep lakes (e.g. Ford 1982). A floating bog that covered shallow water and contributed humic material which would prevent sufficient light for photosynthesis from reaching the bottom, may have caused the decline of benthic species. None of the prevalent species were indicative of eutrophic conditions, implying that nutrient levels were low, possibly due to unavailability in acidic conditions rather than to an absolute deficiency.

Level 190

The relative proportion of *Eunotia* individuals was high and acidophilic species were plentiful. A well developed bog is proposed and the lake was likely dystrophic. High humic content and low available nutrient levels determined the biotic composition. Increased diversity might have been caused by a stable period of dependable resources. A wider array of specialist species could then have gained a competitive advantage, reducing the numbers of the more extensive generalist species (Smith 1980).

Level 150

The high proportion of *Eunotia* individuals and low proportion of alkaliphilic species indicate that by this time Oliver Lake #2 was a prime example of a dystrophic acid-bog lake. Although pH and calcium content of the water may be the most important factors in diatom distribution, proper substrate may have been the primary reason certain attached species were present (Bruno and Lowe 1980). The bog would have provided such a specialized habitat. This could also explain the rarity of benthic species as well as the commonness of littoral ones such as *Synedra rumpens* Kutz. Although *A. formosa* was present, it and other planktonic species were scarce. This could still have been due to a nutrient tie-up under the acidic conditions.

Level 100

The proportion of *Eunotia* individuals declined, but the density of acidophilic individuals had remained constant. Alkaliphilic species were still rare. Although still a dystrophic, acid-bog lake, it appears that bog expansion had stagnated. With the relatively high diversity, water conditions were apparently in a stable phase with only slight disturbance.

Level 50

The proportion of modal species and a low dissimilarity index indicate that this was a hybrid level which resembled Level 100. A surrounding bog continued to provide living space for littoral species such as *Synedra tenera* W. Sm. Hints of new, rather surprising, changes were also found here. The proportion of alkaliphils increased while that of *Eunotia* individuals decreased.

Level 0

The increasing alkaliphil and decreasing *Eunotia* trends became more marked. It becomes tempting to propose that lake acidity was decreasing and the dystrophic, bog-like conditions were being altered. Recent personal observation and instrumental measurements do not support such an interpretation. Oliver Lake #2 is still a highly acidic, dark water, dystrophic lake with low conductivity and depleted winter oxygen supply.

However, the great abundance of *A. formosa* (36.9% r.d.) cannot be totally ignored. There are some variations in the literature concerning its ecological preferences but it is usually considered an alkaliphilic species that is normally best developed in somewhat nutrient-rich water. If these qualities are truly not artifacts, the diatom analysis has been able to detect trends—decreasing acidity and increasing nutrient availability—that were not apparent in the restricted instrumental analyses. These same trends have been found in certain Swedish lakes and have been related to agriculural development of the drainage basin (Renberg 1976).

Summary

Immediately following the most recent glaciation, Oliver Lake #2 was apparently a shallow, slightly alkaline, mildly eutrophic lake. As uplands weathered and became vegetated, nutrient inputs were altered. A huge ice block buried beneath the lake slowly melted and a bog developed at the periphery. Several trends became apparent: 1) increasing depth, 2) increasing acidity, 3) increasing dystrophy, and 4) reduced availability of nutrients—so that the lake has become deep, acidic, and dystrophic, with very dark water. However, there are now indications that acidity may be decreasing and nutrient availability rising, possibly as a result of cultural modification of the drainage basin.

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THE AQUATIC MACROPHYTE COMMUNITIES OF TWO STREAMS IN WISCONSIN

JOHN D. MADSEN *and* M. S. ADAMS
Department of Botany
University of Wisconsin-Madison

Abstract

The aquatic macrophyte communities of two streams, Black Earth and Lawrence Creeks, were examined using the line intercept method from May through August, 1981. The data were analyzed using multivariate statistics. The seasonal succession of species was significant in both streams. Differences within and between their plant communities were also examined, as well as the distribution of the plant species in relation to environmental factors.

INTRODUCTION

Aquatic macrophytes are an important, but neglected, component of stream communities. Macrophytes contribute a large portion of the energy budget in some streams (Minshall 1978). In addition, they stabilize the stream bed and provide food and shelter for macroinvertebrates and small fish (Dawson 1978; Haslam 1978). In some instances, eutrophication has caused large growths of macrophytes that are deleterious to fish habitat and undesirable for human recreation. For these reasons, a greater understanding of stream macrophytes is necessary to an understanding of stream ecosystems as a whole.

Plants living within the stream ecosystem have to contend with an environment that is entirely different from that of lentic ecosystems. The stream environment is complex and heterogeneous, having many habitat patterns superimposed on each other at varying scales. There is a gradual change in character from the headwaters to the mouth (Vannote *et al.* 1980) with local variation in habitats primarily due to geology, geomorphology and a patchy distribution of microhabitats (Hynes 1975; Dawson, Castellano and Ladle 1978). All of these factors create environmental differences that affect the distribution and abundance of aquatic macrophyte species.

The macrophyte communities of temperate streams respond to a complex array of environmental factors in a definite seasonal pattern as well. During the year, various environmental events in the watershed affect the stream, giving one species a competitive advantage over another. Along with seasonal changes of temperature and photoperiod, seasonal rainfall and intermittent flooding cause dramatic changes in microhabitats, sediment contours, and current regimes. One intense flood may scour a stream so intensely as to effectively remove a large proportion of plant biomass and change the contours of the stream bottom (Bilby 1977; Westlake 1975; Wetzel 1975). Flooding at one stage may remove more propagules of one species than another, or may occur at a time when one species is more susceptible to disturbance than another. Therefore, different species may dominate from one period or year to another (Dawson, Castellano and Ladle 1978; Kimmerer and Allen 1982).

Terrestrial plant ecology has used quantitative methods for many years. These methods have been applied only recently to aquatic systems. Swindale and Curtis (1957) used the quadrat method in developing their index of aquatic plant associations in Wisconsin. Lind and Cottam (1969) used the line intercept method of McGinnies (1952) to quantify the changes in macrophyte composition which resulted from the eutrophication of Lake Mendota, Wisconsin. Lind and Cottam found this method preferable to the quadrat method in measuring aquatic plant cover.

In stream environments, quantitative methods are even less commonly used. Haslam (1978) used presence/absence data in her study of the stream vegetation in England. Other studies which used this method were those of Holmes and Whitton (1977) and Smith (1978). The presence/absence method is adequate for large-scale investigation across many sites, such as in the case of whole riverine systems or provinces, but is not intensive enough for the study of one or two streams. A method for study on a smaller scale has been to measure biomass (Kullberg 1974; Hannan and Dorris 1970), but this method requires much time and a large number of samples due to variability.

We have chosen to measure cover using the line intercept method, for several reasons. First, no problem arises with quadrat size affecting the measure of cover. Second, line intercept is a rapid method that does not require cover estimation (McGinnies 1952). Third, reliance on cover alone avoids the difficulty of counting or estimating the number of individuals. Fourth, with the cross-channel transect we were able to measure vegetation along the entire cross-section of the stream, not just a small segment, as with the quadrat method (Grieg-Smith 1957).

We studied the macrophyte communities of Black Earth and Lawrence Creeks to examine the successional trends within the streams as well as quantitative differences within and between the streams. By measuring environmental data, we correlated these trends to measureable environmental factors.

Materials and Methods

sites

Black Earth Creek

Black Earth Creek is a class-one trout stream in Dane County (Figure 1). The study area was near the Village of Cross Plains. The average stream gradient is 1.96 m/km, and the stream drains 116.78 km^2 (Dane County Regional Planning Commission DCRPC 1979). The area surrounding Black Earth Creek has a variety of land uses. Most of the land directly along the banks is in a public fishing easement, fenced off to maintain the streambank. In many places, arboreal vegetation has returned. The drainage basin as a whole is mostly agricultural, with 38% in pasture and 15% cultivated. The remainder is largely composed of wetlands (DCRPC 1979).

The average yearly water flow for Black Earth Creek is 0.879 m^3/s; however, this is not evenly distributed over the year (USGS

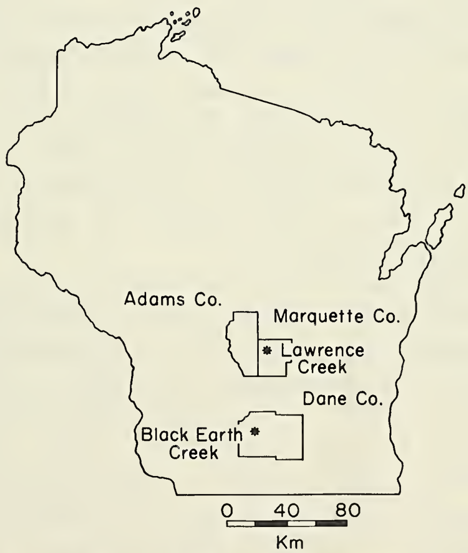

Fig. 1. Location of Black Earth and Lawrence Creeks within the State of Wisconsin.

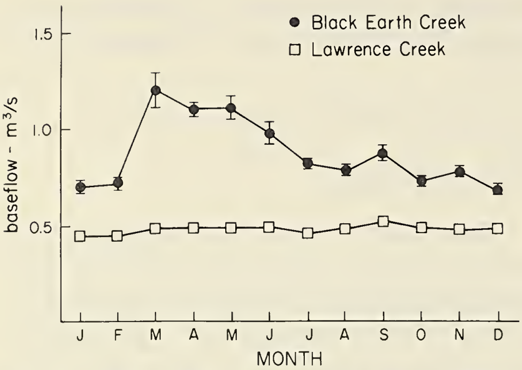

Fig. 2. Water flow for Black Earth and Lawrence Creeks (data from USGS). Bars indicate ± standard deviation; standard deviation smaller than square for Lawrence Creek data.

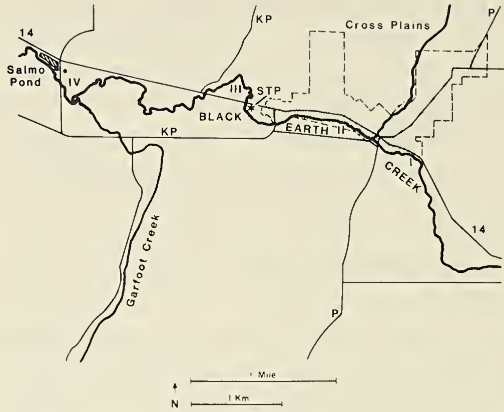

Fig. 3. Map of study sections on Black Earth Creek. Roman numerals indicate section numbers.

1973b; Figure 2). Flow is low in early winter when precipitation is low and in a solid form (snow or frozen rain). Black Earth Creek has a tendency to flood in late winter or early spring (DCRPC 1979). The average flow is also highest during this period. Flow generally decreases over the summer, probably due to increased transpiration and flow resistance caused by plants. However, in August of the sampling year, heavy rains caused a spate with a maximum flow of 3.059 m^3/s on 27 August 1981 and 4.816 m^3/s on 1 September 1981 (U.S. Geological Survey (USGS), personal communication, 1981). Although Black Earth Creek receives a base flow of artesian spring water and ground water, high flows commonly occur from heavy surface runoff of adjacent agricultural land.

Black Earth Creek is a "rich" limestone stream. High concentrations of nutrients support high productivity of plants and other aquatic organisms (Brynildson and Mason 1975). This is largely due to the parent limestone material surrounding the stream, which provides a needed high inorganic carbon source for high primary productivity. A moderately high amount of suspended solids is present. The major pollution problems are coliform bacteria and phosphorus, due to both surrounding agriculture and the sewerage plant (DCRPC 1980).

The stream flows through a variety of land use categories in the four study sections (Figure 3). Above County Highway (CTH) P, Section I, it flows through a wetland area. Section II, below CTH P, flows through a city park area behind the Village of Cross Plains. It then passes a light industrial area and the Cross Plains sewerage treatment plant. Section III, the "horseshoe," flows through a residential area in the lower half. Section IV flows through agricultural fields and pastures. Along most of its length in II through IV, the Wisconsin Department of Natural Resources (WDNR) has a streambank easement where trees, mostly cottonwood and willow, have grown back, along with some planted red cedar.

Lawrence Creek

Lawrence Creek is a class-one trout stream located in western Marquette and eastern Adams counties near Westfield (Figure 1). Most of the 6.5 km stream and a significant portion of its 16.4 km^2 drainage basin lie within the 338 ha Lawrence Creek Public Hunting and Fishing Area (Hunt 1966). The basin is predominantly wooded with red oak forests and several pine plantations. Cattail and sedge marshes lie along the stream

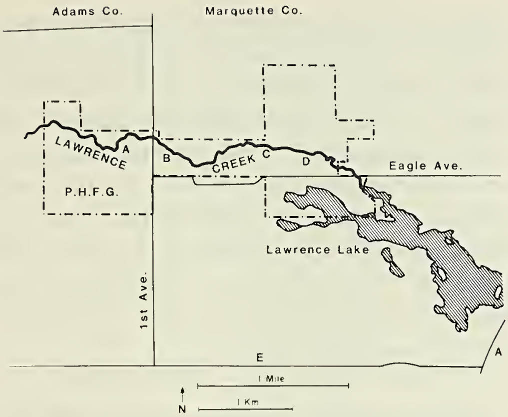

Fig. 4. Map of study sections on Lawrence Creek. Letters indicate sections.

course. This gives the basin the characteristics of a forested watershed. The runoff and groundwater lack significant anthropogenic inputs.

The yearly water flow for Lawrence Creek is regular, varying slightly throughout the year (Figure 2). Largely due to its forested watershed and the high percentage of groundwater and springs that constitute its flow, it is not subject to flooding (USGS 1973a). The annual average flow is 0.473 m^3/s. The elevation drop is about 8.8 m for an average slope of 1.62 m/km.

Lawrence Creek is also divided into four sections (Figure 4). The upper section, A, is characteristic of headwater streams with shallow depths, a few riffles and a predominantly gravel substrate. It is largely surrounded by forested land. Section B is much slower and deeper, but also has a significant amount of gravel. It flows through a marsh. Section C and D also flow through marshes, but differ in having an almost total absence of gravel. The predominantly sand substrate greatly influences the character of the lower portion of the stream.

Field Methods

Each of the streams was divided into four arbitrarily determined study sections approximately 1 km in length (as discussed above). Once per month (May through August 1981) we sampled 20 transects in each section. The transect site was selected using a stratified-random system. At each site we measured the following environmental data: width, water temperature, light extinction, canopy and substrate. The transect was constructed with a plastic-coated wire clothesline (Lind and Cottam 1969) with 1 dm and 1 m graduations indicated. Width was determined using the transect. In the middle of each 1 m interval, depth and current were measured. Depth was measured with a meter stick. Current was measured using an orange as a float for a distance of one meter following the method of Hynes (1970). Water temperature was recorded with a Yellow Springs Instruments thermistor-thermometer #44. Light (photosynthetically active radiation, or PAR) was measured with a Lambda quantum sensor 3LI-17Q and submersible probe; and light extinction was calculated using an equation from Nichols (1971; Hutchinson 1957). Canopy, although part of the terrestrial biotic community, is most conveniently considered with the physical environment. Canopy was estimated as the total percentage of overhead tree or shrub cover to the nearest 10%. The substrate type for the site was classified as either gravel, sand or silt.

The transect was also used to measure the cover of plant species as points of line interception. Each species that was present under a 1 dm segment was considered to "cover" that 1 dm segment. In addition to percent cover, relative cover was calculated to assess plant species composition. Relative cover is calculated by dividing the percent cover of a species by the sum of cover for all species, or

$$\text{relative cover} = \frac{X_i}{\sum_{i=1}^{n} X_i} \times 100$$

where X_i is the cover for species i and n the total number of species. Relative cover indicates the percentage of the plant community represented by an individual species, and so the sum of relative cover for all species is 100. Relative cover is a measure of dominance in the plant community.

Species identification was based initially on Fassett (1957), although taxonomic names were used after Gleason and Cronquist (1963). Voss (1972) was especially helpful in identifying species of *Potamogeton.*

The U. S. Geological Survey (USGS) provided water flow data for Lawrence and Black Earth Creeks from October, 1967 to September, 1973 (1973a,b). Water flow data for this six year period was averaged for each stream to indicate mean base flow, as shown in Figure 2.

Water chemistry data for Black Earth Creek came from two reports by the Dane County Regional Planning commission (DCRPC 1979; 1980). Water quality data from Hunt (1966) and Mason (unpublished) were used for Lawrence Creek.

SEDIMENT SAMPLES

In July, five sediment samples were taken from each section of both streams. Sample sites were determined using a stratified-random sampling procedure. The sample was obtained from the thalweg of the stream course using an Eckman dredge. The sediment samples were transported in polyethylene bags to the laboratory where they were refrigerated in polyethylene containers with sealing tops. Particle Size Analysis was performed using the Bouyoukos Hydrometer method (Foth 1978; Love, Corey and Gilmour 1977). The U. S. Department of Agriculture (USDA) system of particle classes was used (Foth 1978).

Crucibles for analysis of organic and $CaCO_3$ content were first heated to 950 C for 24 hours and then cooled under dessication for taring. Dry weight, organic matter, and $CaCO_3$ were determined using the Thermolyne muffle furnace F-A1740 after Wetzel (1970) and Adams, Guilizzoni and Adams (1978b) on wet samples from 50 to 100 grams. Organic matter composition was determined by combustion at 550 C, as compared to oven dry weight (105 C). Percent $CaCO_3$ was measured by conversion of CO_2 lost at 950 C to % $CaCO_3$ present in the sample (Adams, Guillizzoni and Adams 1978b).

STATISTICAL ANALYSES

Average cover values were entered along with environmental data for 600 transects in

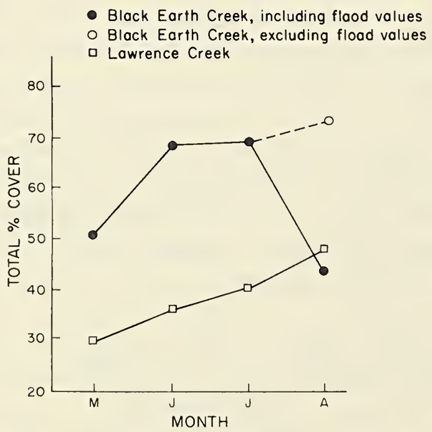

Fig. 5. Total percent cover of macrophytes for Black Earth and Lawrence Creeks over the growing season (M, May; J, June; J, July; A, August).

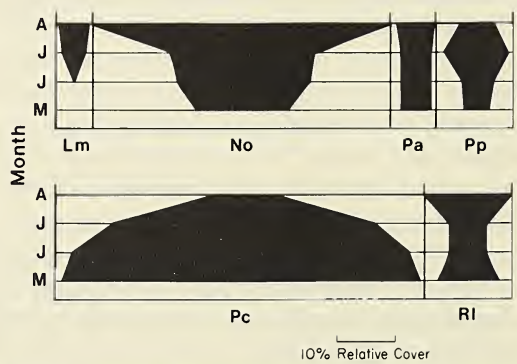

Fig. 6. Seasonal succession as indicated by relative cover for Black Earth Creek (Lm, *Lemna minor;* No, *Nasturtium officinale;* Pa, *Phalaris arundinacea;* Pc, *Potamogeton crispus;* Pp, *Potamogeton pectinatus;* Rl, *Ranunculus longirostris;* M, May; J, June; J, July; A, August).

order to perform statistical analyses on a Sperry-Univac 1100 at the University of Wisconsin-Madison Academic Computing Center (MACC). Descriptive statistics were computed for each section and sampling period. Descriptive statistics, one-way analysis of variance (ANOVA) and Discriminant Analysis were performed using the Statistical Package for the Social Sciences (SPSS; Nie *et al.* 1975). Discriminant Analysis was also performed using the BMDP Statistical Package (BMDP; Dixon *et al.* 1981).

Analyses for seasonal succession were performed by grouping the data from all sections for each month. Differences between sections were examined by grouping data for all months for each section. Therefore, each month or each section has data for eighty transects, which is an adequate sample size for these analyses. Examination of the differences between the two streams used all data for each stream, or the data for 320 transects.

Results and Discussion

Succession

Black Earth Creek

The total cover of Black Earth Creek increases rapidly from May to June (Figure 5).

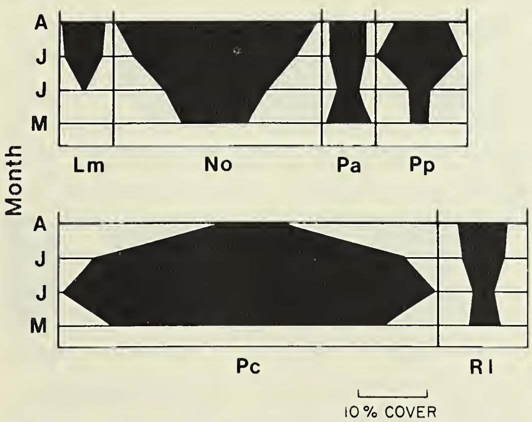

Fig. 7. Seasonal succession as indicated by percent cover for Black Earth Creek (Lm, *Lemna minor;* No, *Nasturtium officinale;* Pa, *Phalaris arundinacea;* Pc, *Potamogeton crispus;* Pp, *Potamogeton pectinatus,* Rl, *Ranunculus longirostris;* M, May; J, June; J, July; A, August).

By June, total cover peaks and senescence of *Potamogeton crispus* begins (Figure 6). Due to a large amount of rain over a two week period, a large flood occurred on Black Earth Creek in August after sampling sections I and II, but before sampling sections III and IV. This flood greatly reduced total cover, leaving vegetation only along the banks and a few protected sites. The data for Black Earth Creek are presented both including and excluding values affected by the flood.

Potamogeton crispus has its highest relative cover in May when it is nearly full grown due to overwinter growth (Figure 6; Haslam 1978). Dominance continues through June, when *P. crispus* literally fills many stretches of the stream from bank to bank. In June *P. crispus* senesces, with large mats of it floating downstream and lodging around obstructions. Although cover is still fairly high, biomass was observed to be down significantly by July. A sparse, though continuous, cover of *P. crispus* is then maintained through the rest of the summer. However, the flood removed most of the stems remaining, explaining the sudden decrease in cover in the lower two sections.

Nasturtium officinale increases steadily in cover throughout the summer. Its high relative cover for August is due to the absence of other vegetation after the flood (Figure 7). The flood apparently did not affect *N. officinale* due to its protected streambank habitat.

Phalaris arundinacea is fairly constant in relative cover throughout the summer, starting growth early from rhizomes. The flood did not affect it due to its stable gravel and stream bank habitats.

Potamogeton pectinatus increases in dominance after the senescence of *P. crispus,* apparently replacing it. However, the flood in August removed this species also from the lower stretches of the stream.

Ranunculus longirostris steadily increases in cover throughout the summer. Being tolerant of spates, it is second in importance to

N. officinale for August. Its dominance in May is due to overwintering evergreen stems.

Lemna minor appears later in the summer, probably due to its need for warm waters to initiate vegetative reproduction.

For most temperate stream communities, several species share dominance over the season as environmental conditions change in the stream. In this respect, the phenology of *P. crispus* shows an interesting ecological adaptation. Turions germinate in late autumn, with growth occuring all winter. Maximum development is achieved in late spring, with flowering and fruit formation in late May or in June. Turions then develop on the stems or rhizome during this period and are dormant until autumn, and the majority of the above-ground biomass senesces. Dormancy is broken by cold temperatures (Sastroutomo 1981). *Potamogeton crispus* is adapted to grow rapidly in early spring to compete with other species in a eutrophic environment. It then dies off in midsummer, allowing other species to grow, especially *N. officinale* and *P. pectinatus*. However, the flood in August removed most of the plants in the mid-stream area, especially the remaining *P. crispus* and *P. pectinatus*. This left the streambank macrophytes *(Nasturtium* and *Phalaris)* and the more spate-tolerant vegetation, such as *Ranunculus*, to dominate. Such floods are fairly common on Black Earth Creek, and are an important factor in plant distribution. The seasonal succession of species in Black Earth Creek was highly significant (at the $p = 0.01$ level) as determined by Discriminant Analysis, with significant changes occuring in *Lemna, Nasturtium, P. crispus,* and *P. pectinatus*.

Lawrence Creek

The total cover for Lawrence Creek increases regularly throughout the summer, as expected in a situation without disturbance (Figure 5). However, the underlying change in species is more complex. *Elodea canadensis* and *Nasturtium officinale* have overwintering stems that allow rapid growth in the spring. *Elodea* is the dominant species for all but the month of May, when *P. pectinatus* is more common due to its early phenology. *Elodea canadensis* grows rapidly from overwintering stems (Figure 8). Cover values increase throughout the summer, but relative cover decreases due to increased emergence of other species (Figure 9).

High overwintering cover of *Nasturtium officinale* allows it to have high relative

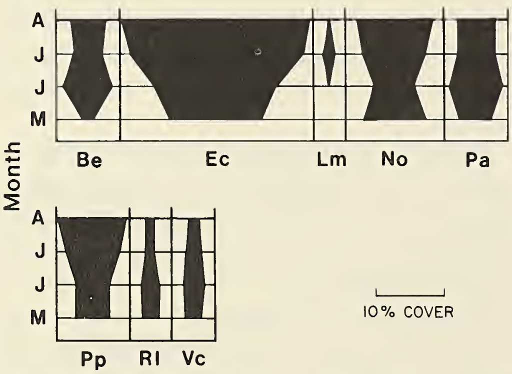

Fig. 8. Seasonal succession as indicated by percent cover for Lawrence Creek (Be, *Berula erecta;* Ec, *Elodea canadensis;* Lm, *Lemna minor;* No. *Nasturtium officinale;* Pa, *Phalaris arundinacea;* Pp, *Potamogeton pectinatus;* Rl, *Ranunculus longirostris;* Vc, *Veronica catenata;* M, May; J, June; J, July; A, August).

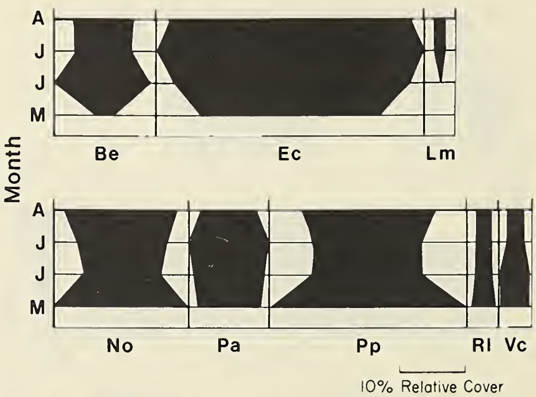

Fig. 9. Seasonal succession as indicated by relative cover for Lawrence Creek (Be, *Berula erecta;* Ec, *Elodea canadensis;* Lm, *Lemna minor;* No, *Nasturtium officinale;* Pa, *Phalaris arundinacea;* Pp, *Potamogeton pectinatus;* Rl, *Ranunculus longirostris;* Vc, *Veronica catenata;* M, May; J, June; J, July; A, August).

cover due to the relative scarcity of other species. Percent cover increases throughout the summer, with an increase in dominance. *Potamogeton pectinatus* has high relative cover compared to percent cover due to wide distribution and occurrence where other species are lacking. The cover values of *Phalaris arundinacea* are slightly affected by man. One section was mowed in July, removing some of the cover. However, flowering and seed set also occur at this time, with ensuing senescence reducing cover (Sculthorpe 1967).

Berula erecta grows from underground rhizomes during late May and early June. *Veronica catenata* and *Ranunculus longirostris* also have an early period of outgrowth. *Lemna minor* is late in appearing, and at low levels due to the fast current of this stream. Few refugia exist for the growth of *Lemna minor* in Lawrence Creek, such as backwaters and slow-moving pools.

For Lawrence Creek, relative cover is high in early spring for those plants with high overwintering cover and rapid growth from dormant perennial parts. This is especially true of *Elodea canadensis, Nasturtium officinale,* and *Potamogeton pectinatus.* These three plants are dominant throughout the year. Discriminant Analysis found seasonal differences, to be highly significant, with *B. erecta, E. canadensis, L. minor,* and *P. pectinatus* to be significant elements in this seasonal change (at the $p = 0.01$ level). Late in summer or early autumn, most of the plant biomass senesces, returning to low overwintering levels. Limited waterflow records for Lawrence Creek seem to indicate that spates are extremely infrequent and are therefore less important in plant community regulation than observed in Black Earth Creek.

Temperate stream communities tend to exhibit a cyclic relationship between cold and warm temperature plants. Several species dominate during the winter and early spring due to a tolerance of colder water and/or lower light regimes (e.g., *N. officinale* and *E. candensis*). As spring and summer progress, total cover and diversity of macrophytes increase. After this period of growth, plants begin to senesce. *Potamogeton crispus* senesces early in the summer, allowing other species to replace it. As winter approaches, there is rapid senescence of the remaining species. Although a few plants remain intact throughout the winter, most are protected in dormant vegetative propagules. Some propagules, such as tubers, roots, and rhizomes, may be under the sediment; others are above the sediment, as in the case of turions and hibernaculae. Such structures allow rapid germination for the next growing season. The actual pattern found in the plant community depends on environmental factors affecting the watershed. Some factors, such as flooding, may be randomly occuring historical events. In some streams, such as Lawrence Creek, the watershed has few floods so that this factor is of little importance to the plant community. In others, such as Black Earth Creek, occasional floods alter species pattern and result in different dominant species than in non-flood years.

INTRASTREAM DIFFERENCES

Physical Environment

Black Earth Creek

The sediment of Black Earth Creek is largely gravel mixed with silty alluvium. The highest proportions of gravel and sand occur in II and III (Table 1), the areas with higher current velocity. The largest silt deposits occur in I and IV, the areas of lower current velocity. All sections are high in organic matter and $CaCO_3$. The $CaCO_3$ may be from three causes: silt material, marl ($CaCO_3$) formation on plants in the stream, or gravel material of limestone origin. The latter appears to be the major cause, as the highest percentages of $CaCO_3$ appear in samples with a high percentage of gravel. In general, the appearance of these substrates in I and IV are a covering of silt over a gravel or sand substrate. Riffles are commonly free of silt.

The water temperature of the headwaters

TABLE 1. Sediment composition of each section and stream averages for Black Earth and Lawrence Creeks.

Stream Section	% Gravel	% Sand	% Silt	% Clay	% O.M.	% $CaCO_3$
Black Earth Creek						
Ave.	17.9	66.0	24.8	9.2	9.2	21.0
I	12.0	52.7	30.9	12.1	12.3	12.4
II	30.3	74.5	16.6	8.9	2.7	24.0
III	29.2	73.2	20.4	6.4	7.0	31.4
IV	0.0	59.1	31.3	9.6	14.8	15.8
Lawrence Creek						
Ave.	0.8	97.5	1.4	1.4	0.5	0.6
A	0.7	97.3	1.2	1.5	0.5	0.6
B	0.0	97.7	0.9	1.4	0.4	0.6
C	0.0	97.7	1.1	1.2	0.4	0.7
D	0.0	97.2	1.3	1.5	0.6	0.6

TABLE 2. Environmental data for stream sections and averages for each stream, including standard error (S.E.), for Black Earth and Lawrence Creeks.

Section	Water Temp (C)	Canopy %	Light Extinc	Depth (m)	Current (m/s)
BLACK EARTH CREEK					
I	12.2	15.5	1.4	0.52	0.12
(S.E.)	0.53	4.0	0.24	0.02	0.01
II	12.1	18.9	1.34	0.32	0.23
(S.E.)	0.38	4.2	0.11	0.01	0.01
III	13.5	59.2	1.81	0.40	0.25
(S.E.)	0.54	4.6	—	0.01	0.01
IV	16.2	20.5	2.56	0.45	0.20
(S.E.)	0.45	3.8	0.29	0.02	0.01
AVERAGE	13.5	28.7	1.88	0.42	0.20
(S.E.)	0.29	2.3	—	0.01	0.01
LAWRENCE CREEK					
A	12.8	10.1	1.15	0.45	0.25
(S.E.)	0.34	3.0	0.19	0.02	0.01
B	12.8	4.74	1.95	0.51	0.22
(S.E.)	0.31	2.2	0.18	0.02	0.01
C	15.8	3.6	1.24	0.35	0.26
(S.E.)	0.39	1.4	0.21	0.01	0.01
D	13.0	9.6	1.29	0.39	0.26
(S.E.)	0.40	2.9	0.33	0.01	0.01
AVERAGE	13.5	7.0	1.37	0.43	0.25
(S.E.)	0.22	1.2	0.12	0.01	0.01

region is low and fairly constant, with progressive warming below the sewerage plant in III and IV. Water temperature in IV is statistically different from that of sections I and II (Table 2,DCRPC 1979).

Section III has a significantly higher overhead canopy of trees than the other sections, according to a one-way ANOVA (Table 2).

The current velocity in I and IV is less than in II and III. No significant difference exists between II and III at the $p = 0.05$ level (Table 2).

Lawrence Creek

The sediment of Lawrence Creek is composed largely of sand (Table 1), due to its parent material, Potsdam sandstone. The sediment is low in both organic matter and $CaCO_3$. The lower sections of Lawrence Creek, C and D, lack any gravel beds and are mostly sandy and sinuous in character. The upper two sections, A and B, have large areas of gravel (Hunt 1977; Table 1; Figure 4).

In a section-by-section comparison, C, being more shallow, had a much higher average water temperature. Continuous influx of ground water and increased water depth led to a temperature decrease farther downstream. (Table 2).

Since most of the stream is bordered by marshy vegetation, the canopy over Lawrence Creek is quite sparse (Table 2). This allows a great deal of light to reach the stream.

The current velocity in B is significantly lower than in C and D. The average depth of B may explain this difference (Table 2).

VEGETATION

Black Earth Creek

The graph of total cover for each section shows that macrophyte cover is much higher in I and IV than in II and III (Figure 10). The major environmental difference between these sections are the siltier substrates in I and IV (Table 1). Both Kullberg (1974) and Hannan and Dorris (1970) report that macrophyte production is much higher on silty substrates than gravel or sand, within a given stream system. Silty sediments absorb more nutrients, especially phosphorus, that are then available for plants. Higher levels of available nutrients may therefore encourage macrophyte growth in these types of sediments (Barko and Smart 1980; 1981).

Potamogeton crispus is the dominant species in all but the upper section. The relative

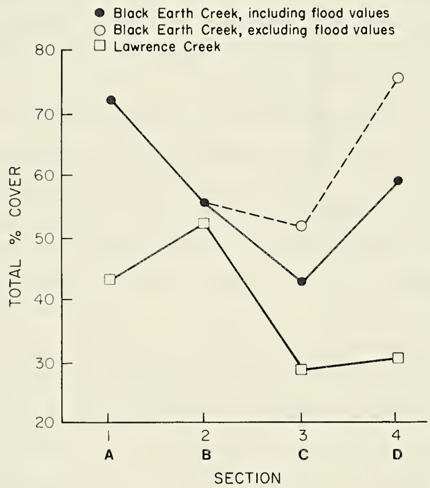

Fig. 10. Total cover of sections of Black Earth and Lawrence Creeks.

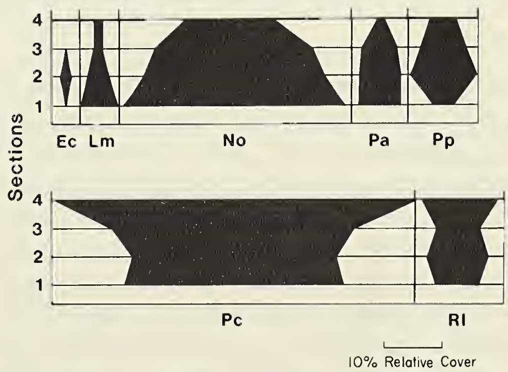

Fig. 11. Relative cover of species for sections in Black Earth Creek (Ec, *Elodea canadensis;* Lm, Lemna minor; No, *Nasturtium officinale;* Pa, *Phalaris arundinacea;* Pc, *Potamogeton crispus;* Pp, *Potamogeton pectinatus;* Rl, *Ranunculus longirostris*).

cover of *P. crispus* decreased in II and III, due to higher current and increased gravel. The increase in relative cover for IV corresponds to the increased silt (Figure 11). The environment of Black Earth Creek is ideally suited to *P. crispus:* a small layer of silt over a layer of gravel or hardened limestone (Haslam 1978), with areas of overhead shade and moderate turbidity.

The relative cover of *Nasturtium officinale* in each section corresponds inversely to the width of the stream. This downstream decrease in the dominance of *N. officinale* may also be related to shade, increased pollution, and increased water temperature (Figure 11, Table 2).

The relative cover of *Potamogeton pectinatus* is directly related to the amount of sand in the substrate (Figure 11, Table 1). Sand is a difficult medium in which to root and remain, and *P. pectinatus* is better adapted to this substrate than the other macrophytes.

Ranunculus longirostris is common in the upper two sections, being found in the gravel areas. The relative cover decreases in the lower sections, possibly from pollution (Figure 11). The increase in dominance in IV is due to its survival of the August spate.

Phalaris arundinacea is fairly common in the upper three sections, growing out into shallow gravel runs (Figure 11). This habitat disappears almost entirely in IV, explaining the absence of *P. arundinacea.*

Lemna minor is found in sheltered areas throughout the stream but is most common in the upper two sections (Figure 11). In I, many water areas occur in which *L. minor* can reproduce. This upstream sanctuary provides a continuous supply of *L. minor* to the lower sections, explaining the relatively high concentration in II.

Elodea canadensis was found exclusively in II, probably due to the silt substrate without the pollution of the lower sections. This section is mesotrophic, with an environment most similar to that of Lawrence Creek. This similarity may explain why both *Elodea* and *V. catenata* were found in only this section of Black Earth Creek.

In summary, the dominant cover of *P. crispus* is directly related to a silty substrate and increased width. *Nasturtium officinale* decreases in cover as the width of the stream increases. Discriminant Analysis shows this sectional difference to be significant at the $p = 0.05$ level, with *Lemna, Nasturtium, Phalaris, Potamogeton crispus, P. pectina-*

Fig. 12. Discriminant Analysis plot for sections of Black Earth and Lawrence Creeks as based on vegetation composition (numbers-sections of Black Earth Creek; letters-sections of Lawrence Creek).

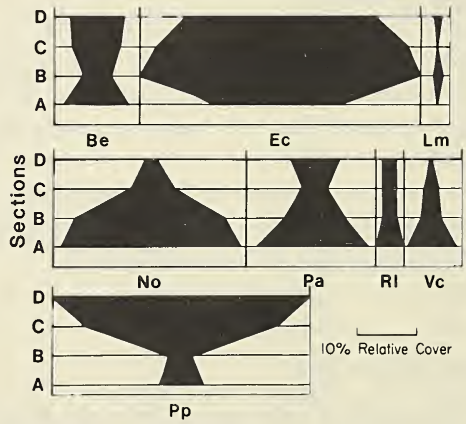

Fig. 13. Relative cover of species for sections of Lawrence Creek (Be, *Berula erecta;* Ec, *Elodea canadensis;* Lm, *Lemna minor; No, Nasturtium officinale;* Pa, *Phalaris arundinacea;* Pp, *Potamogeton pectinatus;* Rl, *Ranunculus longirostris;* Vc, *Veronica catenata*).

tus and *Ranunculus* being a significant part of this difference (Figure 12).

Lawrence Creek

When inspecting Lawrence Creek, it is immediately obvious that the lower sections (C and D) are quite different from the upper ones (A and B). A graph of total macrophyte cover shows that the lower sections have significantly less cover than the upper sections (Figure 10). This is due to a combination of less stable sandy substrate, shallower depths (which bring vegetation in contact with faster current, as the area of highest current velocity is near the surface), and unsupported banks (Haslam 1978; Kullberg 1974). These factors allow the channel to wander, providing poor conditions from macrophyte establishment and growth. Many species cannot root in this unstable environment.

In relative cover for each section (Figure 13), *N. officinale, P. arundinacea,* and *E. canadensis* are the three most important species for A and B (N. officinale dominant in A, *E. canadensis* in B); whereas *B. erecta, E. canadensis,* and *P. pectinatus* are the three most important species in C and D (*E. canadensis* dominant in C, *P. pectinatus* in D).

The dominance of *N. officinale* in section A is due to cold water from many springs and proportionately more bank habitat required for growth (Figure 13). This area is narrow, with bank-type vegetation predominating (e.g., *N. officinale, B. erecta,* and *P. arundinacea*). *Nasturtium officinale* is unable to root adequately in the unstable substrate of the lower sections.

The importance of *Phalaris* is inversely related to the width of the stream (Figure 13, Table 2). As it only invades the stream by vegetative growth from the banks, it should decrease in importance with increased stream width. It is also unable to root in the sand of the lower sections and is relinquished to the more stable banks.

Elodea is common in the quiet, deep pools of A and B (Figure 13, Table 2). As this habitat is more common in B, it is dominant here. Its cover is sharply reduced in section C. However, *Elodea* is still a dominant in C due to the low total cover of all species.

Berula erecta decreases in importance from A to B, presumably for the same reason as *N. officinale.* However, it increases again in the lower sections due to the open habitat with a sandy substrate (Figure 13; Haslam 1978).

Ranunculus longirostris and *Veronica catenata* do best in A, where the highest current and proportion of gravel occur (Figure 13, Table 1). Personal observations of these species indicate that they tend to occur together in this type of habitat and thrive best under these conditions. However, they are represented in the other sections in isolated areas of higher current velocities and stable substrates, such as submerged logs or large rocks.

Potamogeton pectinatus is infrequent in the upper stretches but is a dominant species in the lower sections (Figure 13). It is the only plant that is able to grow in the middle of the shallow sandy channels in these lower sections, where growth is extremely sparse. This macrophyte is probably a case of being the only species "available" to fill this habitat, as is often the case with macrophytes: their distribution may be limited (Haslam 1978).

Several less important species occur in Lawrence Creek, and two deserve special comment. *Lemna minor* was found along the whole stream, but in small quantities. It requires still waters. However, a continuous source of *L. minor* comes from the marshes surrounding the stream. A *Potamogeton richardsonii* colony existed in one 100 m area of section D, which could represent either a new introduction or a remnant of a large population. Haslam (1978) indicates that this species grows in silty areas of rocky streams. This colony was attached to several contiguous submerged logs and silt beds adjacent to the bank.

In summary, the most remarkable aspect of the vegetation of the stream is a pronounced shift from *N. officinale* as a dominant in the upper sections (A and B) to *P. pectinatus* in the lower two sections. The shift in dominance is due to the unstable nature of the sediment in the lower sections where *N. officinale* cannot root. *Potamogeton pectinatus,* however, cannot coexist in the upper sections with those plants which have lower nutrient requirements. *Elodea canadensis* is common throughout the stream and is predominant in the slower, deeper section B. A Discriminant Analysis between sections A through D showed a highly significant difference between the sections based upon all of the major species, with the exception of *Lemna minor.* In this analysis, A and B were similar and grouped as significantly different from sections C and D (Figure 12).

The community compositions of contiguous sections within the two streams were significantly different in most cases. These differences correlated well with changes in environmental factors, such as sediment type, depth and current. In Lawrence Creek a shift from a dominance of *Nasturtium, Phalaris,* and *Elodea* in the upper two sections to *Elodea* and *P. pectinatus* in the lower sections correlated with a shift to shallow, sandy and sinuous conditions in the lower sections. For Black Earth Creek, *Nasturtium* decreased with an increase in water temperature and width. Habitat types for each species derived from this study compared favorably with those observed by other authors.

Environmental Amplitude of Macrophyte Species

As a result of the extensive amount of data collected in this study, it is possible to obtain a quantitative evaluation of the optimal en-

Table 3. Relationship of species with environment. 0: no observed relationship −: negative relationship, +: positive relationship, numbers indicate optimal value or limits.

Species	*Width (m)*	*Water Temp (C)*	*Canopy %*	*Substr.*	*Light Extinc.*	*Depth (m)*	*Current (m/s)*
Berula erecta	−	0	0	gravel	0	0	+ .25
Elodea canadensis	0	0	−	sand, silt	turbid 1.40	+ .50	− <.20
Lemna minor	0	+ >15.00	− 0.0	0	0	+ >.40	− <.10
Nasturtium officinale	− <4.5	−	0	0	− 1.25	0	− <.20
Phalaris arundinacea	0	0	− <30.0	gravel	− 1.25	− <.30	0
Potamogeton crispus	0	0	0	silt on gravel	+ 1.80	+ .50	− <.30
Potamogeton pectinatus	0	0	0	silt, sand	+ 1.80	+ .50	− <.30
Ranunculus longirostris	− <4.0	0	0	gravel	0	− <.30	+ >.30
Veronica catenata	− <4.0	0	− <30	gravel	0	− <.30	+ >.40

vironment for each of the species (Table 3). Ideally, these optima should be constant wherever the species is found. However, the plant responds to such a large range of variables that it is difficult to be entirely sure which factor is limiting or encouraging success. For each species we will compare optima from the literature (Table 4) with those derived from our data (Table 3). References used were Fassett (1957), Gleason and Cronquist (1963), Haslam (1978), and Sculthorpe (1967). A full list of macrophyte species found in the two streams is given in appendices I and II. A complete discussion of these species can be found in Madsen (1982).

Berula erecta was not found in the sandy substrates discussed in the literature due to the extreme instability of this substrate in Lawrence Creek. Other discrepancies occur with turbidity and depth.

Elodea candensis is found in sandier substrates than that mentioned in the literature, due to the sandy nature of Lawrence Creek. *Elodea* was also found under a broader range of turbidity in Lawrence Creek because it was found in marshy areas of the stream that produce high amounts of organic matter.

The distribution of *Lemna minor* was consistent with the literature, considering that increased depth is usually associated with slower currents. *Nasturtium officinale* is also consistent in distribution with literature reports. *Nasturtium officinale* is most commonly associated with cold spring waters; therefore, it is associated with smaller tributaries.

Phalaris arundinacea was only found in the stream in fast, shallow areas with gravel substrates or along the banks. This differs from literature reports.

Potamogeton crispus is shade and turbidity tolerant. The optimal substrate is silt over a gravel or hard substrate. *Potamogeton*

TABLE 4. Relationship of species with environment, as determined from literature review. 0 = no observed relationship; − negative relationship; + positive relationship.

Species	*Width (m)*	*Water Temp (C)*	*Canopy %*	*Substr.*	*Turbidity*	*Depth*	*Current*
Berula erecta	−	−	0	gravel	−	−	+
Elodea canadensis	0	0	−	silt	−	+	−
Lemna minor	0	+	0	0	0	0	−
Nasturtium officinale	−	−	0	0	−	−	−
Phalaris arundinacea	0	0	0	0	0	−	0
Potamogeton crispus	0	0	+	silt	+	+	−
Potamogeton pectinatus	0	0	+	silt	+	+	−
Ranunculus longirostris	0	0	−	gravel	−	−	+
Veronica catenata	0	0	−	0	−	0	0

pectinatus is found in similar environments, except for preferences for sandy or silty environments.

Ranunculus longirostris was consistent with literature values. However, the distribution of *Veronica catenata* does vary significantly from literature reports. This discrepancy is due to the association of *Veronica* with *Ranunculus. Veronica* is often associated with clumps of other plants. This tendency has altered its usual distribution pattern (Haslam 1978).

Interstream Differences

Physical Environment

The light extinction of Black Earth Creek is significantly higher than that of Lawrence Creek (Table 2). This is due to higher turbidity from erosion, siltation and sewage effluent. Black Earth Creek also has greater canopy cover. These factors reduce potential macrophyte productivity (Krause 1977; Dawson and Kern-Hansen 1978; Dawson 1978, 1981). Whereas nutrients or substrate may limit growth in Lawrence Creek, light must be the limiting factor for growth in some stretches of Black Earth Creek.

SEDIMENT

The sediments of the two streams differ significantly (Table 1). In the predominantly sandy sediment of Lawrence Creek, little organic matter and $CaCO_3$ are present. Black Earth Creek sediment has significantly higher percentages of gravel, silt, clay and organic matter. It is highly calcareous as well. These factors make the sediment of Black Earth Creek a better medium for rooting and for retaining nutrients.

WATER CHEMISTRY

Differences in geology, soil, and land use patterns result in important differences in water chemistry (Table 5). Significantly higher levels of ammonia and reactive phosphate occur in Black Earth Creek, probably from the application of fertilizers on adjacent agricultural fields and output from the sewage treatment plant. This is a recognized pollution problem (DCRPC 1980) and may account for the higher productivity of trout

Table 5. Summary of water chemistry data from Black Earth and Lawrence Creek with p-value from a Mann-Whitney two sample nonparametric test used to compare the two streams.

Test	*Black Earth Creek*	*Lawrence Creek*	*Mann-Whitney P-Value*[a]
pH	7.95	8.04	0.122
Ammonia (ppm)	0.29	0.03	0.013*
Nitrate (ppm)	1.56	1.85	0.225
Organic N (ppm)	0.33	0.57	0.153
Total N (ppm)	2.76	2.45	0.762
Reactive P (ppm)	0.26	0.07	0.100*
Total P (ppm)	0.31	0.08	0.110
Conductivity (mhos/cm)	465.5	304.7	0.011*
Alkalinity (mg $CaCO_3$/1)	281.6	158.9	0.006*
Turbidity (JTU)	4.60	1.57	—

[a] an asterisk (*) indicates significance at the p = 0.10 level.

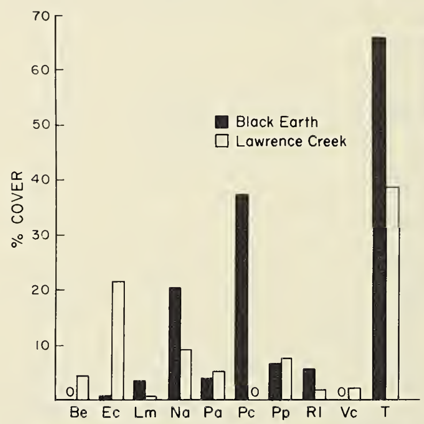

Fig. 14. Average percent cover of species and total macrophyte cover for Black Earth and Lawrence Creeks (Be, *Berula erecta;* Ec, *Elodea canadensis;* Lm, *Lemna minor;* No, *Nasturtium officinale;* Pa, *Phalaris arundinacea;* Pc, *Potamogeton crispus;* Pp, *Potamogeton pectinatus;* Rl, *Ranunculus longirostris;* Vc, *Veronica catenata;* T, total cover).

and aquatic macrophytes (Brynildson and Mason 1975). Higher alkalinity and conductivity in Black Earth Creek results from watershed soils and bedrock. Greater amounts of total dissolved inorganic carbon are available for photosynthesis, resulting in higher productivity in Black Earth Creek compared to Lawrence Creek (Adams *et al.* 1978a).

VEGETATION

One aim of this study is to compare quantitatively the differences in the vegetation of the two streams. This was achieved using Discriminant Analysis. The separation of the two streams by BMDP Discriminant Analysis was highly significant ($p < 0.001$) with a correct classification of 92.5% (86.9% for Black Earth Creek and 98.5% for Lawrence Creek; Figure 12). This analysis selected *P. crispus* and *R. longirostris* as representative of Black Earth Creek, with the higher cover values of *N. officinale* as somewhat representative of Black Earth Creek. *Berula erecta, E. canadensis* and *V. catenata* were chosen to represent Lawrence Creek, with *P. pectinatus* somewhat less important in discriminating the two streams on the basis of cover values. We then performed a BMDP Discriminant Analysis on the sections of each stream. This was also highly significant ($p < 0.001$), with a correct separation to each section of 93.0%. *Potamogeton crispus* and *R. longirostris* were selected again as representative of Black Earth Creek; *Berula erecta, E. canadensis* and *V. catenata* represented Lawrence Creek. *Nasturtium officinale* represented the upper sections of both streams, and *P. pectinatus* was indicative of the lower two sections of Lawrence Creek.

In general, growth is more luxuriant in Black Earth Creek. Total cover of macrophytes in Black Earth Creek averaged 75.2%, whereas in Lawrence Creek it was 49.5% (Figure 14). Ecological differences may also be seen from the species composition in each stream (Figure 14). The presence and success of *Potamogeton crispus* in Black Earth Creek indicates that the stream is mesotrophic or eutrophic, polluted and silted. The dominant species in Lawrence Creek is *Elodea canadensis,* which prefers quiet, clear waters and silt banks. This species is rare in Black Earth Creek, probably due to its intolerance of turbidity. The second most common plant in both streams is *Nasturtium officinale.* However, it covers twice the percentage of area in Black Earth Creek that it does in Lawrence Creek (Figure 14). This macrophyte is most common in the upper portions of both streams, due to cooler water temperatures. The third most common macrophyte in both streams is *Potamogeton pectinatus.* In each, it appears to fill a gap in stream habitat. In Lawrence Creek this is a spatial habitat of shifting sand in which other macrophytes cannot become established. In Black Earth Creek *P. pectinatus* occupies a temporal microhabitat left open after the mid-summer senescence of *P. crispus.* Other macrophytes are not as successful in the combination of pollution, turbidity and silt.

Ranunculus longirostris is also found in both streams, but achieves cover in Black Earth Creek five times that in Lawrence Creek (Figure 14). The limiting factor for *R. longirostris* in Lawrence Creek seems to be gravel substrate; it cannot root well in sand or silt. More than five times as many sites with appropriate gravel substrates occur in Black Earth Creek (Madsen 1982).

Both *Berula erecta* and *Veronica catenata* were found commonly only in Lawrence Creek; in the case of *B. erecta,* its absence in Black Earth Creek is due to its intolerance of siltation, pollution, and spates. *Berula* also prefers either fine sand or silt substrates. Less is known about *Veronica catenata.*

There is no significant difference in the occurrence of *Phalaris arundinacea* in the two streams. As it is generally a streambank species, this is an expected result.

Lemna minor is much more common in Black Earth Creek than Lawrence Creek, possibly due to a headwaters refuge and reproductive area, as well as many areas of slack water for habitation.

SYNTHESIS

In comparing the differences in vegetation between stream sections or two entire stream communities, confusion may occur. In studying sections or "reaches" of a given stream, slight differences in the environment or other factors may result in a slight difference in the community composition of those two sites. However, these differences are small when compared to the differences between the two streams, as in the case of Black Earth and Lawrence Creeks. Using Discriminant Analysis, this relationship can be seen (Figure 12). The differences between all sections except C and D are significant at the $p = 0.05$ level. The separation between the streams is significant at the $p = 0.01$ level. These relationships may be thought of in a hierarchical fashion, with the differences between sections or reaches being local and variable, and the differences between streams being of a larger scale and due to environmental differences characteristic of the streams.

ACKNOWLEDGMENTS

We thank Carolyn Madsen for her assistance in preparing and reviewing this manuscript, and the Davis Fund Committee (Department of Botany, University of Wisconsin-Madison) for providing travel funds for this project. An anonymous reviewer provided constructive comments.

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Appendix 1

Species observed in Black Earth Creek.

1. *Batrachospermum* sp. (Rhodophycophyta)
2. *Callitriche verna* (Callitrichaceae)
3. *Cladophora glomerata* (Chlorophycophyta)
4. *Draparnaldia* sp. (Chlorophycophyta)
5. *Elodea canadensis* (Hydrocharitaceae)
6. *Fissidens fontanus* (Muscopsida)
7. *Lemna minor* (Lemnaceae)
8. *Nasturtium officinale* (Brassicaceae)
9. *Phalaris arundinacea* (Poaceae)
10. *Polygonum* sp. (Polygonaceae)
11. *Potamogeton crispus* (Najadaceae)
12. *P. foliosus* (Najadaceae)
13. *P. pectinatus* (Najadaceae)
14. *Ranunculus longirostris* (Ranunculaceae)
15. *Sagittaria brevirostra* (Alismaceae)
16. *Solanum dulcamara* (Solanaceae)
17. Typha angustifolia var. *elongata (glauca?)* (Typhaceae)
18. *Veronica catenata* (Scrophulariaceae)

Appendix 2

Species observed in Lawrence Creek.

1. *Alnus rugosa* (Betulaceae)
2. *Amblystegium riparium* (Muscopsida)
3. *Berula erecta* (Apiaceae)
4. *Caltha palustris* (Ranunculaceae)
5. *Cladophora glomerata* (Chlorophycophyta)
6. *Drepanocladus* sp. (Muscopsida)
7. *Elodea canadensis* (Hydrocharitaceae)
8. *Lemna minor* (Lemnaceae)
9. *Machantia* sp. (Hepaticopsida)
10. *Mentha arvensis* (Labiaceae)
11. *Nasturtium officinale* (Brassicaceae)
12. *Phalaris arundinacea* (Poaceae)
13. *Polygonum* sp. (Polygonaceae)
14. *Potamogeton pectinatus* (Najadaceae)
15. *P. richardsonii* (Najadaceae)
16. *Ranunculus longirostris* (Ranunculaceae)
17. *Solanum dulcamara* (Solanaceae)
18. *Symplocarpus foetidus* (Araceae)
19. *Veronica catenata* (Scrophulariaceae)

ADDRESSES OF AUTHORS: *Transactions* Wisconsin Academy, 1985

ADAMS, MICHAEL S.
Department of Botany
University of Wis.-Madison
Madison, WI 53706

AHMED, SAAD N.
Apt. 106, 200 Elm St.
West Haven, CT 06516

AWEN, THOMAS J.
230 Washburn Avenue
Oconto, WI 54153

AYER, PETER F.
University of Wisconsin
Center-Washington County
400 University Drive
West Bend, WI 53095

BRINKMAN, WALTRAUD A. R.
Department of Geography
Science Hall
University of Wis.-Madison
Madison, WI 53706

BROCK, THOMAS D.
Department of Bacteriology
University of Wis.-Madison
Madison, WI 53706

COPPEL, HARRY C.
Department of Entomology
University of Wis.-Madison
Madison, WI 53706

DRENNAN, WILLIAM R.
Route 3, Box 349
Reedsburg, WI 53959

FLEMING, CHARLES M.
7312 Edgemont Avenue
Greendale, WI 53129

FOUST, J. B.
Department of Geography
University of Wis.-Eau Claire
Eau Claire, WI 54701

GONT, RODNEY
Route 1, Box 170
Jim Falls, WI 54748

JACKSON, MARION L.
Department of Soil Science
University of Wis.-Madison
Madison, WI 53706

JAEGER, JAMES
Department of Zoology
University of Wis.-Madison
Madison, WI 53706

KUENZI, F. M.
Department of Entomology
University of Wis.-Madison
Madison, WI 53706

LI, CHANG S.
Director, Institute of
Environmental Chemistry
Academia Sinica
P.O. Box 934
Bejing, People's Republic
of China

LINDBORG, HENRY J.
Department of English
Marian College
of Fond du Lac
Fond du Lac, WI 54935

LUCKHARDT, VIRGINIA
4122 Council Crest
Madison, WI 53705

MADSEN, JOHN
Department of Botany
University of Wis.-Madison
Madison, WI 53706

MINOCK, MICHAEL E.
Department of Biology
University of Wis.-Fox Valley
Midway Road
Menasha, WI 54952

MISCHUK, MICHAEL W.
Aquatic Biol./Chem. Sci. Div.
The Institute of
Paper Chemistry
P.O. Box 1039
Appleton, WI 54912

OHL, LLOYD
Department of Biology
University of Wis.-Eau Claire
Eau Claire, WI 54701

PEDRÓS-ALIÓ, CARLOS
Department of Microbiology
Facultad de Ciencias
Universidad Autónoma
de Barcelona
Bellaterra (Barcelona), Spain

PIEHL, CHARLES K.
Campus Box 110
Mankato State University
Mankato, MN 56001

PRIBECK, THOMAS
English Department
University of Wis.-La Crosse
La Crosse, WI 54601

PUTMAN, DANIEL A.
Department of Philosophy
University of Wis.-Fox Valley
Midway Road
Menasha, WI 54952

RADES, DAVID L.
Aquatic Biol./Chem. Sci. Div.
The Institute of
Paper Chemistry
P.O. Box 1039
Appleton, WI 54912

STEFFEN, JAMES F.
920A North 16th Street
Manitowoc, WI 54220

TISHLER, WILLIAM H.
Department of Landscape
Architecture
University of Wis.-Madison
Madison, WI 53706

TOMLINSON, THOMAS
Medical Humanities Program
Michigan State University
East Lansing, MI 48824

WALASEK, RICHARD A.
Department of Geography
University of Wis.-Parkside
Box No. 2000
Kenosha, WI 53141

WHITFORD, PHILIP C.
2625 North 62nd Street
Wauwatosa, WI 53213

WILSON, RAYMOND
Department of English
Loras College
Dubuque, IA 52001

WOOLSEY, E.
Department of Zoology
University of Wis.-Madison
Madison, WI 53706

ZHANG, JI Z.
Soil Scientist
Anhui Agricultural College
Hefei, People's Republic
of China

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Wisconsin Academy of Sciences, Arts & Letters
Steenbock Center 1922 University Avenue
Madison, Wisconsin 53705
Telephone 608 263-1692