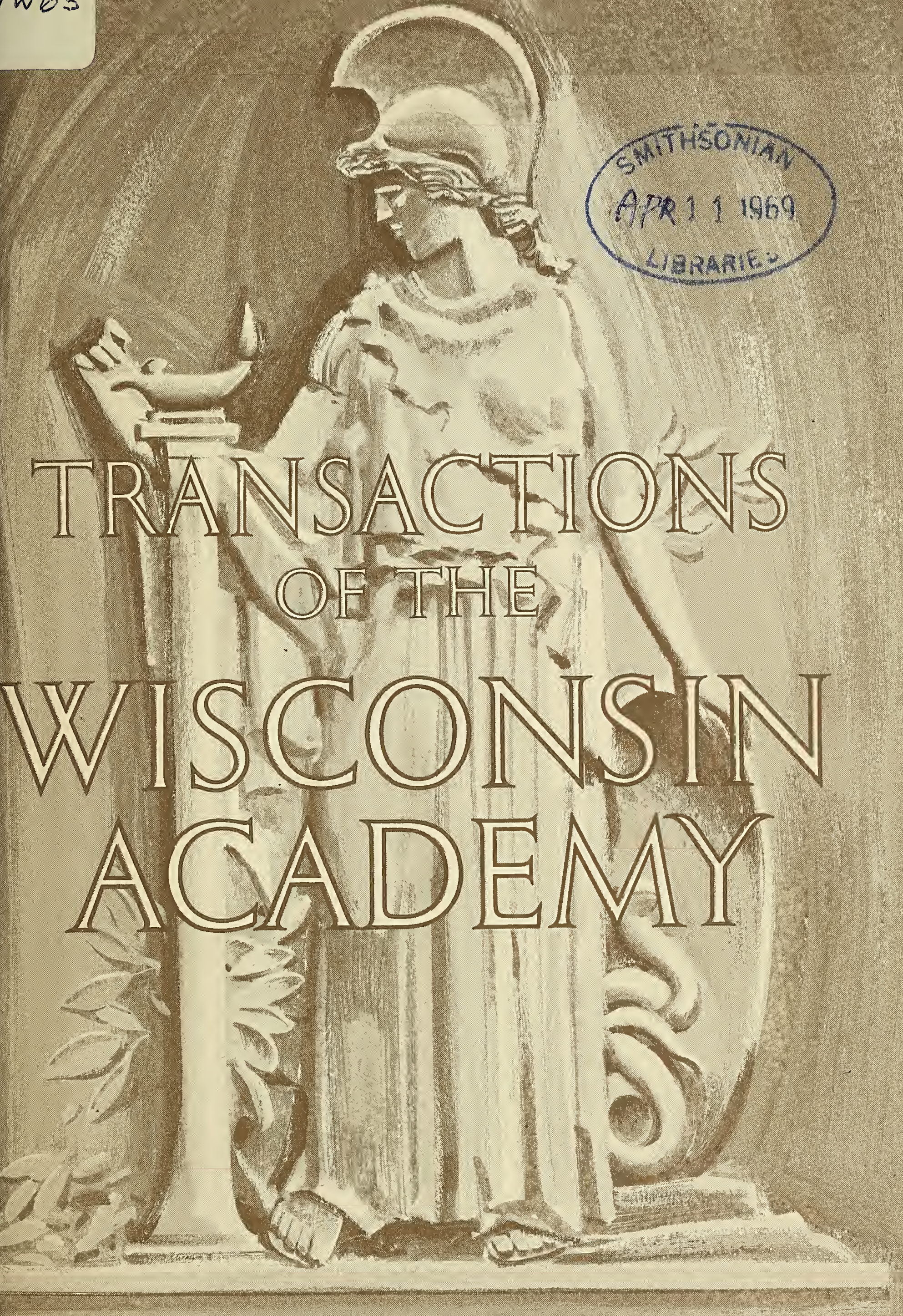


# TRANSACTIONS OF THE WISCONSIN ACADEMY

NATURAE SPECIES RATIOQUE

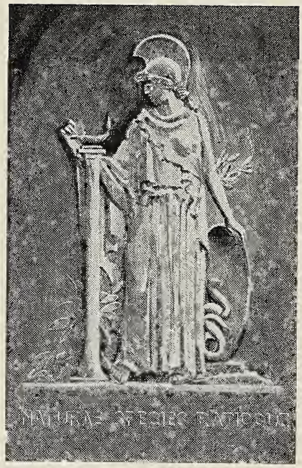
*Cover Design by Jeffrey Homar*

*Title Page Design by Gail Mitchem*

*School of Fine Arts*

*University of Wisconsin–Milwaukee*

# TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS



LVII—1969

Editor

WALTER F. PETERSON

# TRANSACTIONS OF THE WISCONSIN ACADEMY

Established 1870
Volume LVII

## EDITORIAL POLICY

The *Transactions* of the Wisconsin Academy of Sciences, Arts and Letters is an annual publication devoted to the original, scholarly investigations of Academy members. Sound manuscripts dealing with the state of Wisconsin or its people are especially welcome, although papers by Academy members on topics of general interest are occasionally published. Subject matter experts will review each manuscript submitted.

Contributors are asked to forward *two copies* of their manuscript to the Editor. The manuscript should be typed and double spaced on 8½ x 11″ bond paper. The title of the paper should be centered at the top of the first page of the manuscript and should be *typed in capital letters throughout.* The author's name should appear in capital and lower case letters, and should be *underlined* and centered directly below the title. A note identifying the author by institution or background should be placed at the top of a fresh page, immediately after the text of the article. Upper right hand page notations from the second page on should read 2—Brown, 3—Brown, 4—Brown, etc.

The cost of publishing the *Transactions* is great. Therefore, articles in excess of twenty-five printed pages will not normally be accepted. In the rare instance in which a longer paper is approved, the contributor may be asked to help subsidize publication.

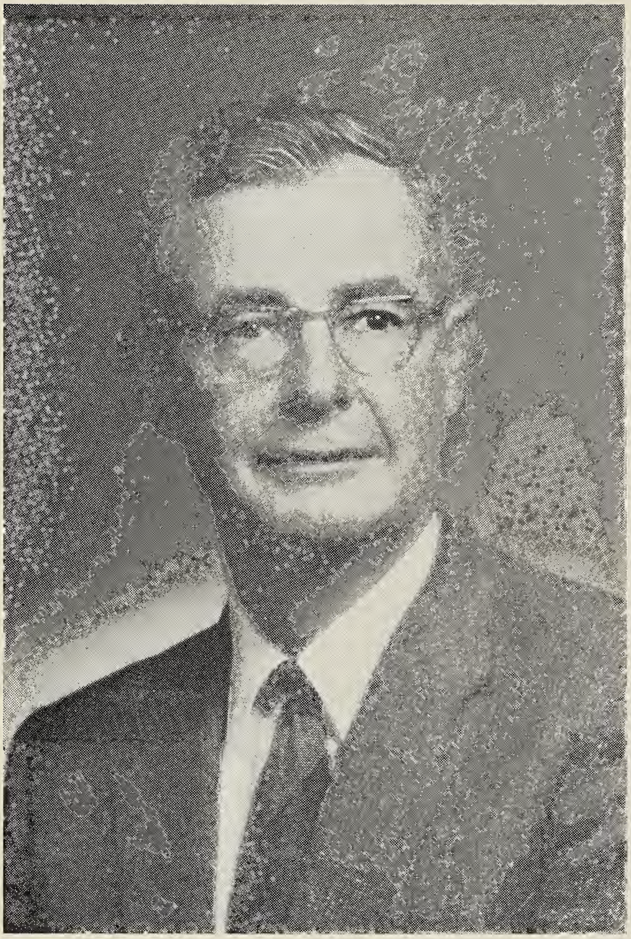
Documentary footnotes should appear at the end of the paper under the heading "References Cited." Supplementary or explanatory notes of material too specialized to appear in the text itself should be typed on a separate sheet entitled "Footnotes" and appended to the section entitled "References Cited." Contributors should avoid unnecessary documentation wherever possible. Other matters of style should be in harmony with current practice in the subject matter area.

Galley proofs and manuscript copy will be forwarded to the author for proofreading prior to publication; *both* should be returned to the Editor within *two weeks.* Papers received on or before *July 15* will be considered for publication in the current year. Papers received after that will be considered for publication the following year.

Contributors will be given five offprints of their article free of charge. Additional offprints in sets of 100, 200, etc. may be ordered at the time galleys and copy are returned to the Editor. Price will vary according to quantity desired and the length of the article.

Manuscripts should be sent to:

PROFESSOR WALTER F. PETERSON
Editor, *Transactions* of the Wisconsin Academy
Lawrence University
Appleton, Wisconsin 54911



JOHN W. THOMSON

*47th President of the*

WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

# GREEN POWER: THE INFLUENCE OF PLANTS ON CIVILIZATION

*John W. Thomson*

When considering the possibilities for this address tonight there was a strong temptation to entitle it "Flower Power". But, such a topic presented by a professor from the University of Wisconsin might perhaps be unappreciated by many of our citizens who comment upon daily life on our campus.

As a professional botanist my own field of research and teaching involves the science or art of classification and the naming of plants, a field known to the professional as plant taxonomy. In actual practise a plant taxonomist studies many aspects of the life of plants: their physiology, chemistry, ecology, cytology, uses, and many other things. Perhaps more than for any other botanist his tracing the history of the names of the plants leads him into an awareness of significant historical events which resulted from the intertwining of the life of man and the plants of his environment.

The current geologist will point out a fact based upon his solid evidence that in the earlier days of its founding, the earth was surrounded by a different mixture of gases than that with which we are familiar: The abundant volcanoes produced an atmosphere with a higher content of carbon dioxide than the 0.03% of today and less than the 20% of oxygen which sustains our life. The evolution of plants which used this high concentration of carbon dioxide gas in their photosynthetic activity, giving off oxygen as a byproduct, altered the atmosphere to the more liveable atmosphere on which we are so dependent today. The algae in the waters of the earth can take their carbon dioxide from the dissolved bicarbonates, precipitating the unused portion as carbonates, usually lime carbonates. The thousands of feet thick of limestone deposits have locked up in them the carbonates from which the ancient algae released the oxygen in their life processes. The enormous coal deposits of the world also represent such an alteration of the atmosphere in which the carbon dioxide of the air was taken out and changed into organic materials which were fossilized and the byproduct oxygen enriched the air.

For some people, the earliest relationship of man and plants was perhaps that described in the delightful tale of the use of the apple by Eve in the Garden of Eden as related in Genesis.

Studies of anthropologists tell us that man evolved as a predator, a hunter. His early weapons, his art, the artifacts of his civilization, attest to this. He had little to do with plants except when game grew scarce. Then he would gather nuts, berries, and roots of the plants which he found around him. He became a gatherer of plants as well. Probably his earliest use of plants on a consistent basis was as fuel for his fires. The early development of hand axes perhaps reflects the possibility of such use and yet these were mainly weapons. The use of fire dates back only some 20,000 to 30,000 years ago (Baker, 1965). Man may also have used plants in the making of shelters of wattle or of reeds and barks. Probably the grasses were early harvested in the wild as wild rice is still harvested in northern Wisconsin and Minnesota, or as small grains in the Sudan.

At this point I should like to bring to your attention two possible routes of the evolution or development of civilizations based upon plants. The tropics are large areas where a civilization based upon fruits and roots evolved, including products as breadfruit, the tubers of tara (corms) and "yams" of the banana type fruits or of *Dioscorea* (tubers). These are perishable foodstuffs. Furthermore their collection requires much hand labor. They cannot be laid up against starvation periods or crop failures, nor are they easily transported. A civilization based upon such foods as these is subject to periods of feasting or famine. How different is a civilization such as ours based upon the grains of grasses. The grass stores its food in a non-perishable easily handled package. Its stored food is on stems which are easily cut and processed and it lends itself to mass treatment, especially by machinery. Its product can be stored, protected from the depredations of insects for many years, circumventing the old cycle of inevitable feast and famine periods. Its ease of culture and of transport has led to a situation in which over 30 people may be supported in cities by one on a farm. This proportion, still increasing today, has made possible a civilization of immense cities in cold climates. It makes possible the feeding of one part of the world by the production in another. An equitable sharing of the products of the earth is more possible with the grains of this family of plants than with the products of any other plant family except possibly the legumes.

The story of the rise of this allegiance of man to the grasses is a long story, perhaps of three chapters achieved quite independently in three parts of the world; one based upon wheat and originating in Asia minor, one based upon corn and originating in the new world, and the third based upon rice originating in the orient.

Agriculture, according to Baker, had its inception in the Mesolithic or Middle Stone Age, a period when the glaciers were melting away in Europe. Around the communities of the "hunter-gatherers" were undoubtedly disturbed soils, midden heaps, areas rich in nitrogenous wastes. Some of the weeds may likely have developed there. They would have been derived from plants of disturbed habitats such as rock slides, cliff faces, sea shores, sand bars, cattle wallows, etc. Among these ancient weeds were species of *Triticum,* the wild wheats, three species of which are known from remains of a 7th millennium village in the Tigris–Euphrates valley. These grains were probably parched to assist in removing the husk and prepared in a gruel, as bread-making is a comparatively recent art. In any case these weedy plants became crossed with other weeds in the genus *Aegilops* and the chromosomes multiplied to give us the hexaploid bread wheats of today. The best of the progenies of these weeds were probably unconsciously selected and fell near the homes of our ancestors. Somehow, somewhere, some genius among these ancestors decided that rather than to rely on finding the grains, a better way would be to scratch the soil and thereby promote their growth. Thus agriculture and the dependence of man on a sedentary life was born.

A similar story can be told for the independent origin of indian corn or maize, in the new world. Its origin is less well known than that of wheat. It does appear to be related to teosinte *(Euchlaena mexicana)* but to also have characters derived from a weedy species of *Tripsacum.*

One of the fascinating developments of such weeds into plants upon which we depend is the series of crops which European man developed from a nondescript weed of the chalk cliffs of England and France, a mustard, *Brassica oleracea.* From this unimposing start have been derived cabbage by developing the terminal bud, brussell sprouts by developing the lateral buds, cauliflower and broccoli by developing the flower buds, and kale by developing the leaves. Would that some genius among us find such promise in the pigweeds of our garden!

One other food plant should be mentioned with respect to its influence upon our history. The potato originated in the high Andes where many varieties are grown. The conquerors of Peru introduced it to Spain during the 16th century and from there it spread to all of northern Europe. It has become one of the world's most important crops. In Britain and Ireland it was the main crop fed to the peasantry with perhaps a pig or two per family per year allowed as a source of protein by the landlords who owned the land. Such dependence upon a single crop was dangerous and when the late blight fungus (a plant of course) hit the fields of Europe during 1845–1847 millions of the peasants across northern Europe starved to death. Many others, especially from hard-hit Ireland, migrated to North America, contributing to the large populations of Irish along the eastern seaboard and affecting the destiny of the United States. A very important development of this period was the repeal of the "infamous" corn-laws of England which protected the small grain grower of Britain from competition of grains from the United States and Canada. John Peel (well known in a song) was influential in the British Parliament in securing this repeal. The increased import of grain from abroad made it necessary to secure ocean travel against privateers and pirates who then operated with "permits" from the nations, and Britain promulgated the doctrine of the freedom of the seas to all trade, and built the tremendous navy necessary to enforce this doctrine. For many decades this navy was the guarantor of the freedom of the seas, and Britain was the world's greatest seapower until the period of World War II. We must admit that this doctrine of the freedom of the seas has profoundly influenced the course of history, and the potato and potato blight initiated it.

From one of our fiber plants, cotton, we have inherited some of the most serious issues of today. Let me tell you some of its background. Cotton originated from wild plants, some of Asiatic, and some of North American origin. In India it has been cultivated for several millenia. The Asiatic strains were undoubtedly known in biblical times. The New World varieties had to await the discovery of the Americas for their introduction.

In Europe, prior to the use of cotton, the main fiber used was wool. It was a warm fiber suited for use in a cool moist climate. Its original production was largely a home cottage industry, the sheep being sheared, the wool spun by the housewife and the thread woven either by the housewife or the itinerant weaver. Cotton altered this picture of domestic tranquility. The new methods of manufacture made possible a cheaper product. The cotton gin invented by Eli Whitney made it possible to get large quantities of the fiber separated from the seed easily and the spinning machines of Richard Arkwright (1768) and enormous weaving machines made mass production possible. The Industrial Revolution had begun with all its ills and abuses. It was a revolution which altered the whole way of life of man, taking him far from the land, putting him in cities and developing the immense urbanization of whole nations. It was with the fiber of cotton that all of this began.

A further enormous sin may be laid to cotton. In the southern part of the United States a plantation system based on the production of dye indigo had evolved. An important blue dye was obtained from this plant. The system was faltering in competition with the dye indigo obtained from India where labor was even cheaper than that of the slaves the planters of the south were importing from Africa. The rise of the mills of cotton manufacturies made the demand for cotton so great that a rapid shift to cotton and tremendous expansion of the plantation system in the south occurred.

The importation of the negro slaves from Africa and their use as labor for the plantation has led to a multitude of problems for our country. We can blame the Civil War upon cotton, the exhaustion of the lateritic soils of the south, the social ills of the south, and the riots of today upon cotton. Truly this plant opened to us a Pandora's Box containing much evil.

From time immemorial the spices have been articles of trade, sometimes of use only to the wealthy as a status symbol of greater value than any commodity even the precious metals. Cloves, pepper, and cinnamon found their way from the Orient during the Middle Ages via long voyages, camel trains and arduous journeys. They were prized for their flavors, yes, but in addition for the promotion of perspiration, for aid to digestive processes, for preservatives, and because of lack of refrigeration, to cover up the flavor of partially rotting meat, and were even used as deodorants by people who believed that baths were dangerous and unhealthy. To avoid the inevitable losses and tribute attrition of profits caused by the long overland trade routes, the great voyages from Spain, Portugal and Italy were undertaken. These may have commenced with Marco Polo's epic 24 year journey in the mid 13th century and continued with those dates which every school child can recite for you: Columbus 1492, Vasco da Gama 1497, and Magellan 1519–22. Many were the wars and naval engagements fought in our history to secure monopolies of the spice trade. Portugal, Spain, England, and Holland fought for and sometimes won, sometimes lost, colonial empires whose products were the fragrant and profitable spices. Let anyone think that we have not inherited a legacy of problems from these plants and we shall let the names of Oriental and south seas trouble spots roll from the tongue—Indonesia, Macao, Ceylon, Malaysia, Hong Kong, to name a few.

The development of the overseas routes discovered during the great period of exploration led to the need for navies to keep open the routes and protect the trading vessels from piracy. That was the day of wooden vessels, for it was not until the battle of Hampton Roads in 1862 when the Monitor met the Merrimac that the era of wooden ships began to end. The need for forests of oak for the ships and of conifers for spars led to many problems as the forests of Europe became exhausted. Naval operations around the Baltic sea were necessary to insure Britain a supply of masts and spars. Naturally this type of operation became objectionable. Finally during the latter part of the 17th century North America became a source of naval timbers and supplies. During the Napoleonic Wars of the 19th century it was possible for Britain to win the victories of Aboukir Bay and Trafalgar only because she had access to the timbers of Canada for naval construction.

Lest we think that the movement of armies and navies caused by plant resources is a phenomenon of only the past, something which ended in the Victorian Period, let me hasten to call to your attention some of the strategies of World War II. These were determined in the Pacific Theatre of Operation in large part by plants. In central America and on the Amazonian slopes of the Andes and the Amazonian slopes of Colombia and Venezuela are trees from which rubber is obtained. This product remained mainly a curiosity until 1839 when Charles Goodyear discovered the process of vulcanization. This discovery makes it possible to use rubber in the manufacture of tires for vehicles including those on which our vast and mobile civilizations and armies are now completely dependent. The rubber trees were eventually imported to Ceylon, Malaya, and Indonesia where the principal plantations of the world are located.

A second plant genus of the same region of northern South America, *Cinchona,* supplies the world with quinine, the drug necessary to control malaria. Its introduction to the East Indies led to the source of 90% of the world's supplies being the plantations of Java. Without quinine, no army can effectively operate in the tropics. Without the wheels to roll upon, and quinine to protect against the scourge of malaria, our great armies would have been impotent. The strategies of Japan in the Pacific were to cut us from these vital supplies coming from the far reaches of the Pacific. Our strategies had to include campaigns to regain control of these vital plantations.

The quest for plant materials to treat the ailments of man is an old one. Probably our ancestors in testing the edibility of plants when they were in transition from hunters to hunters and gatherers sampled everything in their environment and in some cases found surprising effects; laxative, emetic, hallucinatory, soporific etc. The body of lore they accumulated was passed on as an oral tradition by their medicine men; later the first books on plants dealt mainly with their medicinal values. This traditional background of botany still finds use today although many drugs of today are now synthesized rather than extracted.

For the alleviation of pain we still may use cocaine from the leaves of the cocoa tree and morphine from the latex of poppies. Digitalin from the foxglove is important in the treatment of certain heart diseases; atropine from belladonna finds many important medicinal uses; precursors of cortisone are obtained from yams of the genus *Dioscorea;* and *Rauvolfia* yields reserpine which has proven so effective in the treatment of mental ailments. The tremendous effects on world health by the antibiotics obtained from the mold fungi such as *Penicillium* must also be recognized. Some of the extracts from plants contain addictive alkaloids as morphine or its derivative heroin in the latex of the opium poppy or nicotine in the tobacco plant. What have been the effects of such plant products on man? It is not necessary here to do more than remind one of the tremendous economic and social effects of these addictions. It is an ironic twist of events that the addiction of the nicotine user is the chief source of funds for the Outdoor Recreation Act of Wisconsin, or that a major source of revenues for the government is this same addiction. Many of us also certainly are habituated, if not addicted to the milder alkaloid caffeine contained in coffee. Sometimes too, we may be enlivened by the alcohol produced by the yeast plants when carrying on anaerobic fermentation in obtaining their energy for life processes. There are not many other plant products, or even animal products, that have not been utilized by man in seeking to harness the yeasts to his desired aims.

Tonight I have spoken of but a few of the examples of the power of plants in influencing man's course of action. I could have spoken of many more, of cacao and coffee, of tea, and of the forests and the influence of paper, other foods and fibers, things to chew, an amazing array of plants from far corners of the earth. But, I should like to conclude with some thoughts concerning our future relationships with plants. In the newspaper this past weekend was a discussion of a vast project which was proposed for South America. A dam would form an inland sea as large as western Europe. The newswriter with remarkable insight commented that he wondered what the significance could be of removing so much of an area of trees from the oxygen regeneration system of the world. This is part and parcel of the same problem in which we use the fossil fuels of the earth, coal and petroleum, taking oxygen from the atmosphere and releasing carbon dioxide by the millions of tons, a process which Prof. Reid Bryson, one of our academy members and a climatologist will tell us portends serious alterations in the climate of the earth. This too, Prof. Bryson tells us, is correlated with problems caused by the removal of the vegetation of large areas of the earth by man and his domesticated animals, especially the goat, leading to atmospheric dust pollution which causes greater reflection of the radiant energy of the sun, in turn thus cooling the earth and its climate. Continuation of this process will certainly force man to alter much of his way of life in the northern hemisphere. To reverse this process and to revegetate the large areas of the world which once were green and supported huge cities as those of the Mycenians and the Sumerians in the region of Asia Minor seems well nigh impossible. The evidence seems incontrovertible that the loss of the vegetation of these regions caused the decline of great civilizations.

A hitherto unsuspected influence of plants is only now making itself felt. Henry Thoreau's statement of it was borrowed for the title of a recent publication of the Sierra Club "In Wildness Is The Preservation Of The World". Perhaps we can say that this is an influence upon the soul of man! Man was a creature of the edge of the forest, perhaps of a savannah-like landscape. He feared the deep forest, he feared the open prairie. Does he not cut down the forest around his home to open it to sunlight? When travelling in the Dakotas does he not seek a tree under which to picnic? Can he bear the solid expanse of concrete and asphalt of the urban horrors which have arisen today? Certainly he is never happy in them, he escapes to the greener expanses of suburbia when he can and is happiest when camping in what he can call the "wilds". He has come a full circle. From a native home in a world clothed in plants, he came to a utilization of plants which led to vast cities in which man scarcely felt any relationship to plants, so far was he from the land. And now he has returned to a realization that plants are necessary not just for economic values but merely because he feels he needs them and is unhappy without them. This is the age when the pressures upon the plants are so severe that the conscience of man feels the need to grant the plants sanctuaries, when the Nature Conservancy and the Sierra Club become inner needs felt by so many people. They are an expression of the power of plants upon people, a green power whose influence will continue to be needed no matter how far we progress in achievement. When we reach for the stars, plants will ride with us, exchanging oxygen for the carbon dioxide produced by the astronauts, a cycle with which we started our thoughts tonight, the green power which is indispensable to man.

# THE RELATION OF HENRY JAMES'S ART CRITICISM TO HIS LITERARY STANDARDS

*Donald Emerson*
*Professor of English*
*University of Wisconsin–Milwaukee*

Henry James's use of the representational arts as material for fiction extends from the early "A Landscape Painter" of 1866 to *The Outcry* of 1911. In the Preface to *The Tragic Muse* he speaks of the fascination of the artist-life as "a human complication and a social stumbling-block," the conflict between the claims of art and of society being, he feels, one of "the half-dozen great primary motives."[1] He exploits this subject also in *Roderick Hudson* and in many of the short stories. Although in fiction he treats problems of the painter, the actor, and the sculptor, his art criticism and his discussions of the problems of representation deal most frequently with painting. The terms of painting enter into his criticism of literature, a great deal of metaphor is drawn from this art, and he alludes frequently to specific canvasses.

But as art critic James is an amateur, a lover of painting who could never become the rigorous professional he made himself in his proper field. Mr. John Sweeney, who has collected much of the art criticism, emphasizes James's reliance on personal impressions in his role of an attentive spectator interested in questions of representation. He delighted in "shows," and he made his investment of time and interest yield a return for his developing critical sense. As Mr. Sweeney points out, he never concealed the fact that he found literary as well as plastic values in pictures, and "*read* pictures with an eye for their possible lurking donnée."[2]

James's criticism of painting is to be found in art reviews and accounts of travel. The reviews appeared from 1868 to about 1882 and again, briefly, in 1897; the travel accounts which deal with painting were written in the early 1870's. Mr. Sweeney has collected the bulk of the reviews, and *Transatlantic Sketches* includes most of James discussion of painting in his travel writings. The great difference is that the travel accounts record personal, imme-

---

[1] *The Art of the Novel* (New York, 1934), p. 79.

[2] Henry James, *The Painter's Eye*, ed. John L. Sweeney (Cambridge, Mass., 1956), p. 12.

diate responses and discoveries which enriched James's visits to new places. The reviews are more reserved, but without being impersonal.

All the accounts of painting are best seen in relation to James's criticism in general. In his career James is at first more the reviewer and the critic than the writer of fiction, and the art reviewing begins some years later than the book reviewing. One notable difference follows: Where the reviewing of books gives place to extended critical essays in which James eventually speaks with the authority of "a man of the craft," as he later styles himself, the art notices remain always the appreciations of an intelligent observer, and eventually cease.

James disclaims interest in technical criticism of painting; this is a matter which is to be left to others.

> There is a certain sort of talk which should be confined to manuals and notebooks and studio records; there is something impertinent in pretending to work it into literary form. . . . It is narrow and unimaginative not to understand that a very deep and intelligent enjoyment of pictures is consistent with a lively indifference to this "inside view" of them. It has too much in common with the reverse of a tapestry.[3]

The "inside view" is precisely what makes James's later literary criticism uniquely valuable, yet the record of his enjoyment of pictures has its own interest, for his views on painting are related to his inseparable concerns for the role of the critic and his assessment of the imagination of the producer in all artistic performance.

In his earliest literary criticism, which antedates any of the art criticism, James takes the position that the critic must be opposed to his author, bound to consider the work within the limitations of subject imposed on him, without reference to extraneous theory or critical dogma. He distinguishes between "great" criticism, which touches on philosophy in the fashion of Goethe, and the practice of Sainte-Beuve, which at this time he considers productive of "small" criticism. It is, he maintains, the duty of the critic to "compare a work with itself, with its own concrete standard of truth," and to rely on his reason rather than his feelings.[4] He makes a Coleridgean distinction between imagination and fancy. Imagination enables the writer to present recognizably living figures, to whom the imaginative reader can respond; the merely fanciful writer seeks cheap and easy effects because he recognizes no stand-

---

[3] Review of Eugène Fromentin's *Les Mâitres d'Autrefois: Belgique–Hollande*, *Nation*, 23 (13 July 1876), p. 48.

[4] *Notes and Review by Henry James*, ed. Pierre de Chaignon la Rose (Cambridge, Mass., 1921), p. 102f.

ard of truth or accuracy. "As in the writing of fiction there is no grander instrument than a potent imagination," James declares, "so there is no more pernicious dependence than an unbridled fancy."[5] Fancy alone may convey the impression of physical surroundings; the reconstruction of feelings and ideas requires imagination.

Within a very few years James modifies this stand and takes a sterner view of the function of the imagination, which he now maintains should "hold itself responsible to certain uncompromising realities."[6] Beyond this respect for fact, the imagination, by sympathetic penetration of its subject, can convey the very color of reality. He shortly adds that the working of the imagination is connected with questions of both realism and morality; analytic imagination, presenting a scene with "hard material integrity," can leave behind a certain moral deposit.[7]

At the same time he softens the tone of critical authority and calls now for justness of characterization. The day of critical dogmatism, he holds, is over, and with it the ancient infallibility and tyranny of the critic. It now seems to him his duty as critic to detach from a work under discussion "ideas and principles appreciable and available to the cultivated public judgment."[8] At this point James begins his discussions of painting, and it is at once clear that the principles he has formulated for literature are to be applied also to painting; justness of characterization of a canvas requires, quite as much as does analysis of a novel, an estimate of the imaginative force behind its creation.

The bases of James's responses to painting and painters are: A distinction between imagination and fancy; a concern for reality; a search for justness of characterization; a fondness for the narrative or literary aspects of a canvas; and a demand for morality and taste. They all appear in one of the earliest of his reviews of an exhibition of paintings in which he begins a discussion of Alexandre Decamps by naming this painter as representative of the gifted class of artists who pursue effect without direct reference to truth whether it be in literature, music, drama, or painting. Yet he goes on to acknowledge Decamps' "penetrating imagination" as warrant for a background much resembling, so far as it relates to reality, "some first-rate descriptive titbit of Edgar Poe or Charles Baudelaire." And then James finds that, in default of reality, the somewhat arbitrary and ambiguous air of grandeur and lustre is

---

[5] *Ibid.*, p. 32.
[6] "Novels by the author of *Mary Powell*," *Nation*, 5 (15 August 1867), p. 126.
[7] Review of Gustave Droz' *Around a Spring*, *Atlantic*, 28 (August, 1871), p. 251.
[8] Review of Rebecca H. Davis' *Dallas Galbraith*, *Nation*, 7 (22 October 1868), p. 330.

the conception, rather, of "a supremely vivid fancy." In comparison, the juxtaposed canvasses of Eugène Delacroix reveal "a generous fallibility which is the penalty of his generous imagination . . . he is a painter whose imaginative impulse begins where that of most painters ends." It is not that Delacroix selects grotesque or exceptional subjects, but that he sees them rather in "a ray of that light that never was on land or sea—which is simply the light of the mind." James goes on to describe a picture of men around a campfire, and he finds great fault with the drawing; but in the picture, he feels, Delacroix has shown an eye for the "*mystery*" of a scene which fuses expression and details into the harmony of poetry. And when it comes to morality and taste, James can describe a Daubiguy canvas as "a little blank and thin; but . . . indefinably *honnête*," in the fashion of one of George Sand's rural novels.[9]

With variations this is the pattern of the early art reviewing, in which James respects the definitions and discriminations he has already made clear in his general critical effort. He deplores, in a picture admittedly painted with precision and skill, the total lack of what may be called "moral atmosphere."[10] He notes that Foxcroft Cole's pictures have rather less of "an imaginative or reflective germ" than suits his taste and finds it a pity that a painter should ever produce anything without suggesting its associations, its human uses, and its general "sentimental value." He discovers that art is thoroughness and intelligent choice, and that beauty is sincerity; that the artist who would avoid superficiality must deal with the simple and the familiar; that superficiality is the only vulgarity; and that to be broadly *real* is to be interesting.[11] Returning to Decamps, he finds that his work is rich in "skill . . . invention . . . force . . . apprehension of color . . . and *insincerity*," since his prime warrant is his fancy.[12] He feels that Winslow Homer "not only has no imagination, but he contrives to elevate this rather blighting negative into a blooming and honorable positive. He is almost barbarously simple, and, to our eye, he is horribly ugly; but there is nevertheless something one likes about him."[13] He finds an extraordinary impression of "imagination, vigor, and facility," in the work of Gustave Doré.[14]

A comparison of the art reviews with the reviews of books and the criticism of authors which James was multiplying at the same

[9] "French Pictures in Boston," *Atlantic*, 29 (January, 1872), p. 115–118.
[10] "Pictures by William Morris Hunt, Gérôme, and Others," *Atlantic*, 29 (February, 1872), p. 246.
[11] "Art," *Atlantic*, 29 (March, 1872), p. 372 f.
[12] "The Wallace Collection in Bethnal Green," *Atlantic*, 31 (January, 1873), p. 72 f.
[13] "On Some Pictures Lately Exhibited," *Galaxy*, 20 (July, 1875), p. 93.
[14] "London Sights," *Nation*, 21 (16 December 1875), p. 387.

time shows how closely connected are his theories of criticism and of the imagination in all fields. By 1872 he expresses a preference for the method of Sainte-Beuve, whom he once slighted as a "small" critic, over the supposedly scientific method of Hippolyte Taine. While Taine attempts to knock loose chunks of truth with a blow of his critical hammer, Sainte-Beuve rather disengages its diffused and imponderable essence by patient chemistry, by dissolving his attention in the sea of circumstances. James now considers Sainte-Beuve's provisional empiricism more truly scientific than the premature philosophy of M. Taine.[15] He begins to revise his own critical practice, and the sympathetic essay on Turgenev of 1874 reveals something of the critical empiricism he praises in the French critic. He finds Turgenev a searching observer, but even more a man of imagination, universally sensitive, who surpasses the French realists in appreciation of sensuous impressions and at the same time appreciates impulses outside the realists' scope. He discusses Turgenev's imagination, which he cannot praise too highly for its "intensity and fecundity." No novelist seems to James to have created a greater number of living figures, to have had so masterly a touch in portraiture, or to have mingled so much ideal beauty with so much unsparing reality.[16]

Thus it is hardly surprising that at very nearly the same time he can note Winslow Homer's "perfect realism" while remarking that although Homer is a genuine painter it is not his practice to think, imagine, select, refine, or compose. He goes on in the same review to say of another painter that he lacks intellectual charm, a thing which James finds precious even to its being the only thing of deep value in a work of art, since imagination or intellectual elevation cannot be studied or acquired, whereas everything else can.[17] And just as he expresses fatigue that his self-respect requires his being analytical in observing pictures, he experiences revulsion from literary criticism as he has practiced it. Examination of paintings in Italy has persuaded him that the whole history of art is the conscious expression of a single mysterious spirit. He has worked off his juvenile impulse to partisanship, and he now perceives a certain human solidarity in all cultivated effort. "There comes a time," he confesses in 1874, "when points of difference with friends and foes and authors dwindle, and points of contact expand. We have a vision of the vanity of remonstrance and of the idleness of criticism."[18] Within the year he speaks of criticism as "deep appreciation."

---

[15] Review of Taine's *English Literature, Atlantic,* 29 (April, 1872), p. 469.
[16] *French Poets and Novelists* (London, 1878), pp. 275, 318.
[17] "On Some Pictures Lately Exhibited," *Galaxy,* 20 (July, 1875), pp. 91, 93.
[18] Review of Victor Hugo's *Quatrevingt-trieze, Nation,* 18 (9 April 1874), p. 238.

During this same time he enlarges his conception of the imagination, and of the imaginative force behind artistic construction. Flaubert in *Madame Bovary* reveals what the imagination can accomplish under a powerful impulse to mirror the unmitigated realities of life.[19] Emile Montegut's "cultivated imagination" gives out in his work "a kind of constant murmur of appreciation—a tremor of perception and reflection."[20] The "true imaginative force" enables Howells to give his readers not only the mechanical structure of a dramatic situation, but also its atmosphere, meaning, and poetry.[21] James cites also such negative examples as Charles Kingsley, whose imagination died a natural death when Kingsley turned didactic historian,[22] and Bayard Taylor's, which was so cold it could not kindle the reader's.[23] When in 1875 he discusses Balzac extensively for the first time his chief concern is the quality of Balzac's imagination, and in later essays he returns to it again and again. It becomes for James the great explanatory fact behind Balzac's reality, his vividness, and his systematizing of the *Comedie Humaine.* Its deficiences explain Balzac's failures of portrayal whenever he attempts to touch the moral life.[24]

This discussion of literary matters, which deliberately departs from James's concern with painting, serves two ends: It shows the inseparable connection of his changing conceptions of the critic's role in his responses to both books and pictures, and it underscores his developing sense of the crucial role of the imagination in all artistic production. And since it deals with the formulations which are most explicit in his writings of 1872 and 1875 it encloses, as in a parenthesis, the bulk of the travel accounts subsequently collected as *Transatlantic Sketches.* It is no way surprising that these accounts reflect also, with the intensity of vivid, immediate experience, perceptions and responses to pictures which James had learned elsewhere. The travels reinforce one's inescapable sense of *connection* in everything James wrote.

He rhapsodized in 1873 on Tintoretto, before whose work he feels old doubts and dilemmas to evaporate and the conflict of idealism and realism to be practically solved. That earlier sense which led him to declare that a scene presented with hard material integrity could leave behind a certain moral deposit now makes

---

[19] Review of Gustave Flaubert's *Temptation of St. Anthony, Nation,* 18 (4 June 1874), p. 365.

[20] Review of Emile Montegut's *Souvenirs de Bourgogne, Nation* 19 (23 July 1894), p. 62.

[21] Review of William Dean Howells' *A Foregone Conclusion, Nation,* 20 (7 January 1875), p. 12.

[22] "Charles Kingsley," Nation, 20 (28 January 1875), p. 61.

[23] Review of Bayard Taylor's *The Prophet: A Tragedy, North American Review,* 120 (January, 1875), p. 193.

[24] *French Poets and Novelists,* p. 114.

him speak of Tintoretto as "the most *interesting* of painters," whose indefatigable hand never drew a line that was not "a moral line." Tintoretto's great merit, to James's mind, is his unequalled distinctness of vision: "When once he had conceived the germ of a scene, it defined itself to his imagination with an intensity, an amplitude, an individuality of expression, which makes one's observation of his picture seem less an operation of the mind than a kind of supplementary experience of life." Veronese and Titian, by comparison, seem to James to be content with much looser specification, so that to place them against Tintoretto is to measure the difference between observation and imagination. Tintoretto grasped the whole scene in his great dramatic compositions, and his work conveys the impression that "he *felt*, pictorially, the great, beautiful, terrible spectacle of human life very much as Shakespeare felt it poetically."[25]

The justness of characterization which James demands in literary criticism is again, in his observations on painters and painting, satisfied only with an account of the artist's imagination. He proceeds even by negative example with Domenichino, to him a supreme example of "effort detached from inspiration . . . school-merit divorced from spontaneity" for the production of examples of how the artist must *never* paint. The intensity of James's feeling is apparent in his introduction, into a travel account, of a fictional character, the head-master of a drawing academy who sadly leads his pupils to the disheartening examples of this painter's work and explains,

> "Domenichino had great talent, and here and there he is an excellent model; he was devoted, conscientious, observant, industrious; but . . . his imagination was cold. It loved nothing, it lost itself in nothing, its efforts never gave it the heart-ache. It went about trying this and that, concocting cold pictures after cold receipts, dealing in the second-hand and the ready-made, and putting into its performances a little of everything but itself."[26]

The same type of discrimination appears in James's discussion of Sandro Botticelli, whom he finds, in a certain way, the most interesting of the Florentine painters. Although he acknowledges indebtedness to Walter Pater he resolutely puts aside all that he considers recondite in Pater's interpretation of Botticelli and proceeds in typical fashion to conclude, "A rigidly sufficient account of his genius is that his own imagination was active, that his fancy was audacious and adventurous. Alone among the painters

---

[25] *Transatlantic Sketches* (Boston, 1875), p. 90 ff.
[26] *Ibid.*, p. 177.

of his time, he seems to me to possess *invention*." Where the glow of expanding observation sent Botticelli's contemporaries to their easels, Botticelli possessed a faculty which loved to play tricks with the actual, to sport, wander, and explore on its own account.[27]

James's individual judgments of painters or canvasses, of both which numerous critics can give more just accounts, are less interesting than the bases of his judgments and their relations to his literary criticism. Early and late examples in both fields show his conviction that the quality of imagination in a work of art is all-important. It is the power, he now feels, to conceive greatly and to feel greatly, to organize irreproachably the work of art of whatever kind, and to make it a kind of supplementary experience of life. Of literature James speaks with an authority that is wanting in his criticism of painting, for in dealing with books he can make the kind of technical analysis he eschews in his reports of painters and their work. He can thus, in 1877, condemn Whistler's work as unprofitable and uninteresting, and at the same time praise the work of Edward Burne–Jones as having, for all its faults, "an amount of imaginative force the mere overflow of which would set up in trade a thousand of the painters who are more generally accepted by the public."[28] Again, in the same year he can declare that "a picture should have some relation to live as well as to painting. Mr. Whistler's experiments have no relation whatever to life; they have only a relation to painting," while he praises the art of Burne–Jones as the art of culture, reflection, intellectual luxury, and aesthetic refinement, the art, in short, "of people who look at the world and at life not directly . . . and in all its accidental reality, but in the reflection and ornamental portrait of it furnished by art itself in other manifestations; furnished by literature, by poetry, by history, by erudition."[29]

James much later confessed to Charles Eliot Norton that he had come to find the work of Burne–Jones uninteresting,[30] but the changed view is of less significance than that James's insistence on relations in art leads eventually to his conception of criticism as in part the study of connections. Guided himself by the practice of Sainte-Beuve, in 1880 he praised the Frenchman's sense of his role: "The critic, in his conception, was not the narrow lawgiver or the rigid censor that he is often assumed to be; he was the student, the inquirer, the observer, the interpreter, the active, indefatigable commentator, whose constant aim was to arrive at just-

[27] *Ibid.*, p. 300.
[28] "The Grosvenor Gallery and the Royal Academy," *Nation*, 24 (31 May 1877), p. 320.
[29] "The Picture Season in London," *Galaxy*, 24 (August, 1877), p. 156f.
[30] *Letters*, ed. Percy Lubbock (London, 1920), I, 341.

ness of characterization."[31] Four years later he says, "The measure of my enjoyment of a critic is the degree to which he resembles Sainte-Beuve."[32]

James's experience as writer inevitably affected his criticism; he more and more cited his own authority. One such authoritative pronouncement is "The Art of Fiction," of 1884, which characterizes the novel as a direct impression of life, the value of which depends upon the intensity of the impression. The writer must work from reality and experience, but reality has myriad forms, and experience is never complete. "It is an immense sensibility . . . it is the very atmosphere of the mind; and when the mind is imaginative . . . it converts the very pulses of the air into revelations." "Imagination assisting," the artist can deal with anything, for experience is practically constituted of the gifts which are designated as imagination: "The power to guess the unseen from the seen, to trace the implications of things, to judge the whole piece by the pattern, the condition of feeling life in general so completely that you are well on your way to knowing any particular corner of it."[33]

This declaration explains why in James's criticism in all fields the imagination is so emphasized, why it is the ground of so many of his discriminations, and why he insists upon a description of the artist's imagination as part of the discussion of his work. With his enlarging view of criticism as practiced by Sainte-Beuve, James is shortly to remark that works of art grow more interesting as one studies their connections, this study being a function of intelligent criticism.[34] He goes on to insist that everything depends on the qualifications of the critic. "Curiosity and sympathy" form his equipment.

> To lend himself, to project himself and steep himself, to feel and feel till he understands and to understand so well that he can say, to have perception at the pitch and passion and expression as embracing as the air, to be infinitely curious and incorrigibly patient, and yet plastic and inflammable and determinable . . . these are fine chances for an active mind.[35]

He characterizes himself when he speaks of the critic who has no *a priori* rule but that a production shall have genuine life.[36]

---

[31] "Sainte-Beuve," *North American Review*, 130 (January, 1880), p. 56.

[32] "Matthew Arnold," *English Illustrated Magazine*, 1 (January, 1884), p. 242.

[33] *Partial Portraits* (London, 1888), pp. 387, 389.

[34] *Essays in London* (London, 1893), p. 160.

[35] *Ibid.*, p. 276.

[36] *Views and Reviews* (Boston, 1908), p. 227.

James is well known to have remarked rather testily, "Nothing is ever my last word about anything," but for a variety of reasons he gave over the criticism of painting, and one of his last words has an almost valedictory note. It is his mature expression of the importance which through his life he attached to art, the embalmer, the magician whom we can never speak too fair or whose importance overstate. For art "prolongs, it preserves, it consecrates, it raises from the dead. It conciliates, charms, bribes posterity; and it murmurs to mortals, as the old French poet sang to his mistress, 'You will be fair only so far as I have said so.' "[37]

This may belong to the realm of deep appreciation, but it is no longer criticism. Aside from the stresses of James's desperate preoccupation with the stage between 1890 and 1895, his return from defeat there to the magic of his "*own* old pen," and his disgust with all journalistic practices and activities, is there not also a partial explanation of James's ceasing to write on painting in his inability to conduct the kind of analysis which, with novelists, he increasingly made a part of his criticism, and with no one so much as himself? All the last critical essays bear a family resemblance, and the artistic problem is always the general subject, as it is in the Prefaces for the collective New York edition of James's own work.

A final illuminating statement of the office and the effect of criticism completes the perspective of James's changing views and implies his neglect, in the late criticism, of painting. Painting had been one of the great resources of his imaginative life, but he could not write of it as he could of literature, the field in which he spoke with the authority of the high title he gave himself as "a man of the craft."

> The effect, if not the prime office, of criticism, is to make our absorption and our enjoyment of the things that feed the mind as aware of itself as possible, since that awareness quickens the mental demand, which thus in turn wanders further and further for pasture. This action on the part of the mind practically amounts to a reaching out for the reasons of its interest, as only by its so ascertaining them can the interest grow more various. This is the very education of our imaginative life . . . we cease to be instinctive and at the mercy of chance."[38]

In its scope and development James's criticism reveals the growth of an artistic mind of high quality, and the evolution of his standards explains the changing estimates he made of painters and

[37] *Picture and Text* (New York, 1893), p. 134 f.
[38] *Notes on Novelists* (New York, 1914), p. 315.

writers. This itself is sufficient ground of interest, his views of the painter's art forming a long and interesting chapter in the whole volume. The early advocate of science and logic turns from judgment to justness of characterization and at last to deep appreciation, with his final word a demand that criticism promote the education of the imaginative life itself. A good deal of James's artistic education came from pictures, and he was deeply responsive; but as critic he was authoritative only in his own productive field.

# VIOLENCE AND SURVIVAL IN THE NOVELS OF IRIS MURDOCH

*Donald Emerson*
*Professor of English*
*University of Wisconsin–Milwaukee*

Iris Murdoch is a contemporary Anglo–Irish novelist and philosopher who besides writing a monograph on Jean-Paul Sartre (1953) continues to lecture and to produce papers in both her professional fields since her resignation from Oxford. Beginning in 1954 she has published eleven novels, none of which can properly be termed a philosophical novel though each is related to the problems of contemporary philosophy and to Miss Murdoch's own developing thought. She is an artist who believes that men are social creatures who confront the intractibility of a contingent world in which their concerns are not abstractions but personal relationships and the confusing, unpredictable "stuff" of human life. She writes in full awareness of the state of fictional art, with an inexhaustible inventiveness, humor, irony, and compassion; and she has a high regard for the 19th century novel of character and plot although she has attempted it less frequently than the patterned novel which tends to abstraction and symbolism.

The novel is one of the contemporary modes of philosophy, and Sartre has gone so far as to declare it a chief mode of expression for his brand of existentialism. As a form it reaches an audience indifferent to other statements, and whether existentialist or not has a persuasiveness more powerful than discursive exposition. It expresses more sensitively than other forms the motives and assumptions of men in action or, in some of its guises, the convictions, amounting to assessments of the culture of their times, of its authors. The novel is one of the chief cultural documents of the age, and Miss Murdoch considers it "a picture of, and a comment upon, the human condition."

She regularly directs her attention to the principal strategies of the novel in our time. In her criticism and her practice she distinguishes four chief modes: the journalistic novel of thin characterization and abundant detail; the realistic novel of character which is closely related to the great 19th century examples of, say, George

"Violence and Survival in the Novels of Iris Murdoch" was read at the meeting of the Wisconsin Academy in Eau Claire, May, 1968.

Eliot or Tolstoy; the symbolist, almost allegorical novel of the type of William Golding's *The Spire,* which she terms a "crystalline" form; and the fantasy-myth which she herself produced brilliantly in her first novel, *Under the Net* (1954). Although much of the best modern work has been done in the symbolist novel, she regards the form with misgivings prompted by her conviction that interest in issues rather than people is inappropriate in the novel. To her thinking the novelist proper is "a sort of phenomenologist . . . a describer rather than an explainer," whose eye should be fixed on what we do rather than on what we ought to do. She thus insists on "the stubborn irreducibility of persons" and the contingency of experience, and finds Sartre's impatience with the "stuff" of human life crippling to his work.

Miss Murdoch is herself victim of the paradox which confronts every novelist. On the one hand there is the bumbling confusion of human personalities and relationships, on the other the demands of the novel for some degree of formal coherence. The form has swung between the wonderful, lifelike record of contingency which made Henry James refer to the 19th century English novel as "the paradise of the loose end," and the contemporary tight, structured form which results in what Miss Murdoch terms "dryness". Against such dryness she argues that the novelist must portray individuals who are independent of their author and are not puppets to exteriorize some psychological conflict of his own. As she also says, "A novel must be a house fit for free characters to live in; and to combine form with respect for reality with all its odd contingent ways is the highest art of prose." She demands respect for contingency, yet she writes novels which have sometimes prompted her critics to draw diagrams. In practice she has resolved the paradox of composition with varying degrees of success in fictions which tend to be well-structured although her characters are believably unpredictable and her own sense of the ridiculous conveys a lively sense of their contingent world.

Some further preliminaries must be dealt with: Miss Murdoch's philosophical ballast; the relations between her work and that of others; and her own development as a novelist. As an unreformed academic she naturally draws upon her professional knowledge of philosophy when she works as a novelist. In an excellent study, *Degrees of Freedom,* Mrs. A. S. Byatt documents Miss Murdoch's indebtedness, sometimes in opposition, to Sartre. Wittgenstein's net of concepts furnishes the dramatic metaphor of the hero's predicament as well as the title of the first novel. Simone Weil's life and work illuminate, for example, the portrayals of suffering in *The Flight from the Enchanter* (1956) and *The Unicorn* (1963).

There are allusions to Kant and Hegel, and to the religious concepts possible to a novelist who terms herself a Protestant "Christian fellow-traveller." Yet Miss Murdoch says there is little connection between her books and her academic thinking despite the fact that their shape and moral bases owe something to philosophy.

When she published her earliest novels she was bracketed by critics with such Young Angries of the 50's as John Wain and Kingsley Amis, and her third novel, *The Sandcastle* (1957), disappointed those who expected her to continue in a single vein. *A Severed Head* (1961) was a further surprise which had even some success of scandal—How far could she go?—and was likened by critics to the Restoration drama of Congreve. *An Unofficial Rose* (1962), in which she made an ambitious attempt to regain the advantages of the 19th century novel of character led to her being categorized as a "lady novelist," a term which was repeated with all its denigrative connotations for *The Nice and the Good* (1968), whatever it may mean.

Iris Murdoch is well read in her profession of novelist as in her profession of philosopher, and awareness of the art affects her work much as does her knowledge of philosophy—there is only partial connection between the work she does and what, as critic, she approves, yet the shape of her novels owes much to her critical understanding of the art and of the developments which have brought it to its present state. She began with two novels best described as fantasy-myths, the first concerned with freedom for the individual caught in the conceptual net, the second with the meanings of power in the modern world. Both are social novels, both owe something to existentialist thinking, and both maintain a brisk pace in which respect for contingency leads at times to portrayal of wild and hilarious improbabilities. Since then Miss Murdoch has chosen to deal more frequently with inter-personal relations, an emphasis which recalls that of Henry James. Her most successful novel, *The Bell* (1958), has the solid life which Miss Murdoch praises in the great 19th century novels, for it best displays the "real apprehension of persons other than the author as having a right to exist and to have a separate mode of being which is important and interesting to themselves." Other novels of this type are *The Sandcastle* (1957), *An Unofficial Rose* (1962), *The Red and the Green* (1965), and *The Nice and the Good* (1968). *A Severed Head* (1961) is strikingly different from the other novels in style and plot, and is an apparent attempt of Miss Murdoch's to make a comic substitution of the "hard idea of truth" for the "facile idea of sincerity" with which, to her mind, both Freud and Sartre are associated; and *The Italian Girl* (1964) is a feebler example. There is one further division within the work: *The Uni-*

*corn* (1963) is a return from the realistic complexity of *The Bell* type of novel to the patterned, mythic novel, no longer fantastic in the fashion of the earliest novels, but stripped and contrived, as is *The Time of the Angels* (1966).

Mrs. Byatt has found the central concern of Miss Murdoch's novels in the question of freedom, and it is an illuminating approach; but other themes deserve analysis, among them violence and survival. Four exemplary novels will serve: *Under the Net, The Bell, An Unofficial Rose,* and *The Time of the Angels.* They happen to have appeared at precise four year intervals since 1954, but they are not strikingly better than others for illustrative purposes. They might equally be used to define such other recurrent themes as the nature of love; the relation between love and morality; the recognition of reality, especially the reality of other persons; or the conflict between reality and illusion.

Outward violence in Miss Murdoch's work ranges from simple theft to murder or suicide on the scale of action, from impulse to premeditation on the scale of intention, from accident to catastrophe within the workings of nature; but the inward violence of aggression, subjugation, and enslavement is frequently far more interesting than any outward event, as is the inward struggle for freedom. The terms of survival encompass the degrees between the unthinking safety of self-chosen ignorance, the achievement of stoic endurance, and the liberation of self-awareness. But for Miss Murdoch's characters survival is not always possible nor even, sometimes, desired.

*Under the Net* is the earliest of the three novels Miss Murdoch has attempted in the first person, and from a male point of view. It is a lively romp, wildly improbable at times, which conveys an encompassing sense of London and, in a different way, of Paris. Jake Donaghue is the ideal narrator for a piece filled with action and ideas, for the substance of his life is the private conversation with himself of a man who sees too much ever to give a straight answer. Besides, in his half-outsider fashion he is as much a philosopher as Iris Murdoch. Beneath the tumultuous action there is a seriousness which makes Jake's final grasp of a direction for his life meaningful and convincing, but there is none of the grimness of final choices apparent in some later novels, none of the sense of harried individuals pushed to intolerable limits. There is even a good-natured quality about the violence, which occurs in great variety. Why shouldn't a sensible man carry a pick-lock and take over his friends' apartments when locked out of his room for nonpayment? Why shouldn't he, when his manuscript has been stolen, steal a valuable dog which the thief has kidnapped? Or help his friend break out of a hospital? Or escape from a riot in a film studio by blowing a hole in the set? Or use a powerful detonator of the type conveniently at hand in well-furnished apartments, to blow open a wall safe? Jake's sense of the passing of time, however, at last turns him to other courses.

> All work and all love, the search for wealth and fame, the search for truth, life itself, are made up of moments which pass and become nothing. Yet through this shaft of nothings we drive onwards with that miraculous vitality that creates our precarious habitations in the past and the future. So we live—a spirit that broods and hovers over the continual death of time, the lost meaning, the unrecaptured moment, the unremembered face, until the final chop-chop that ends all our moments and plunges that spirit back into the void from which it came.

Jake turns from the hand-to-mouth survival of his first thirty years to the possibility of writing well, from the "ragged, inglorious, and apparently purposeless" life he has known to the possibility of doing better work than in his first book, with a strength and joy which make the moment "the morning of the first day." His survival is not endurance but a plunge into a life made new by being newly understood. And he achieves the understanding for himself.

Another novel filled with the odd contingencies of life followed *Under the Net,* though more sombre in tone. Miss Murdoch then turned to a less highly charged picture of domestic life and personal relations, thence to *The Bell,* her best piece thus far. The action of *The Bell* centers about an Anglican lay community and the disruptive events which lead to its closing after a public scandal. It is far too rich a novel for easy summary, but the violence of much of it indicates the direction which Miss Murdoch is taking: From the casual, almost merry violence of the first novel she has turned to more consequential acts, not because suicide is more desperate an act than safe-cracking but because all the violence is seen more meaningfully in relation to the values of religion and philosophy. There is more depth to this novel than to the first, and the study of violence in still later novels will show a progression already apparent here. Yet the two principal characters are far less intelligent than Jake Donaghue. Dora Greenfield is neither talented as an artist nor gifted with common sense even in ordinary affairs; and Michael Meade is a weak, homosexual ex-schoolteacher who fails in all relationships through fumbling attempts at tender-minded goodness. It is Miss Murdoch who is intelligent in this novel, though with that respect for her characters as having lives of their own which she considers typical of the great novelists.

Besides suicide, attempted suicide, adultery, and self-righteous bullying there is the more subtle violence, increasingly apparent in Miss Murdoch's work, of the sins against love: indifference, failure of feeling, and calculated betrayal. It is these which are destructive; the violence is their product. And the terms of survival have changed. For Dora and Michael there is no sudden life-enhancing vision such as Jake Donaghue experienced; instead, there is a slow progress and adjustment to their changed lives. Michael observes that the events at Imber Court increase Dora's substance; there is simply "more of her" after the dreadful events have passed. Michael himself, in anguish over the death of a man he might have saved, defeats thoughts of suicide by perfecting his suffering through responsibility for the dead man's half-mad sister. At last he, like Dora, turns to the hope of life when he can "experience again, responding with his heart, that indefinitely extended requirement that one human being makes upon another."

After *The Bell* Miss Murdoch produced a witty, brilliant study of sexuality in *A Severed Head,* but with *An Unofficial Rose* she returned to what she terms "the novel proper," and here there is far less of the strangeness, amounting at times to the effect of enchantment, elsewhere cast about her characters. Miss Murdoch's characters are never ordinary but they are sometimes fantastic; the figures of *An Unofficial Rose* are believable without being commonplace. More of this novel is related to the linked problems of violence and survival than any other, yet the surface is comparatively placid. There is one tumultuous scene and at least two symbolic murders, but with her shift of interest from social to personal relations Miss Murdoch here subdues violence to those crimes only possible between persons who have loved or, what is worse, have failed of love. There is Hugh Peronett, who is willing to sell a precious picture to finance his son Randall in an adultery the like of which Hugh was never bold enough to attempt. The selfishness of Randall includes a self-justifying and coldly rationalized hatred of his wife Ann, at the same time that his acceptance of Hugh's money is a joyful symbolic murder of his father. The daughter of Ann and Randall destroys her mother's possibility of happiness by ruthless deception which prevents Ann from ever enjoying the love of a good man who has waited until Randall deserted her. Even Hugh's mistress of long ago manipulates Hugh, Randall, and Randall's new mistress with devilish skill. Yet they are not monstrous, however they may seem, and they survive in their varied fashions beyond such difficulties as are always, one character remarks, solved by violence. For some there is simple forgetfulness—the young will find other interests. For Hugh and his failing mistress there is the anticipation of an early extinction which leaves Hugh thinking only that a brief interval remains: "Perhaps he had been confused, perhaps he had understood nothing, but he had certainly survived. He was free. *O spare me a little that I may recover my strength; before I go hence and be no more seen.*" Randall is simply left in a besotted state with the mistress whom he may decide, when sober, to leave. For Ann there is endurance in her ignorance of those she has never known. "She had not known them. She did not know herself. It was not possible, it was not necessary, it was perhaps not even proper. . . . Tasks lay ahead, one after one after one, and the gradual return to an old simplicity. She would never know, and that would be her way of surviving."

In her next novel, *The Unicorn,* Miss Murdoch turned more directly to the problems of suffering and endurance, but in a form radically different and equally exemplified later in *The Time of the Angels.* It has been noted that her thought can be related to that of other philosophers and her fictions to those of other novelists. *The Unicorn* suggests the strangeness of Sheridan Le Fanu while its subject is related to the anatomy of suffering diagrammed by Simone Weil. Both influences are apparent in *The Time of the Angels,* set in London but a corner of London isolated amidst bombed-out acres, and fog-shrouded into a remoteness as strange as that of any Irish coast. These two novels are departures from the realism to which Miss Murdoch feels the novel must return to recover its vitality. It is as though the modern fascination with myth-making, abstraction, and the creation of patterned fictions has some sort of irresistible appeal. Or possibly Miss Murdoch finds realism in some ways inadequate and unsatisfying and seeks somehow to get more directly to the core of reality by rejecting commonplace actuality, "a world in which people play cricket, cook cakes, make simple decisions, remember their childhood and go to the circus; not the world in which they commit sins, fall in love, say prayers, or join the Communist Party." She has moved, as has been seen, from Jake Donaghue's tumultuous social world to the portrayal of personal relationships, thence to ever-tighter sets of relationships in progressively restricted groupings of characters. This has been accompanied by a deepening of meaning as she has neglected the everyday world in which people play cricket and cook cakes for the more intense world in which, if they do not pray, they are concerned with God, man, suffering, and evil. And violence has become ever more closely identified with evil, while suffering has acquired an ultimate redemptive power. It is only fair to note that the latest novel, *The Nice and the Good* (1968), returns, with some modifications, to the realistic mode.

*The Time of the Angels* actually contrasts the commonplace world with the enclosed, fantastic rectory dominated by the mad atheist priest Carel Fisher, for into it intrude Carel's younger brother Marcus and the one-time mistress of Carel's older brother Julian, who committed suicide after Carel had seduced Julian's wife. The weird household includes Muriel, Carel's daughter by his deceased wife; Elizabeth, the daughter of that adultery, with whom Carel commits incest; and Pattie O'Driscoll, Carel's mulatto mistress and housekeeper. Other servants are a father and son, a refugee pair, of whom the son is the more interesting because he is a pathological liar. All is not the grimness of American Southern Gothic with which in subject matter this novel surely could compete; there are scenes and encounters as funny as some in Faulkner, if sometimes equally macabre. Much of the violence is in the past, and if theft, incest, and suicide are in the foreground, the meaning of violence has changed. Carel Fisher is a Dostoevskyan character sunk in debasement and at the same time a religious seeker for whom God is dead. Not even evil is real to him any longer. "There is only power and the marvel of power, there is only chance and the terror of chance." Carel's most significant act of violence is a blow to his brother's face, for he is persuaded now that only infliction of pain can prove the existence of others. When his daughters discover the truth of their relationship and when Pattie cannot remain with Carel, though she loves him, he kills himself. And now it is not a question of survival so much as of suffering. Pattie's love is to be her own torment only. Muriel, watching her father die, realizes she is "condemned to be divided forever from the world of simple innocent things, thoughtless affections and free happy laughter and dogs passing in the street." She is bound to Elizabeth, and they will be each other's damnation.

The ultimate violence and perversity of both *The Unicorn* and *The Time of the Angels* belong to the literature of extremity, the very thing which Miss Murdoch had avoided in her earlier work. She has already gone on to another portrayal of a more easily recognizable world in *The Nice and the Good,* but it is a world in which, as before, violence is a fact to which survival or destruction are alternatives. These themes will surely recur in the further work of this endlessly inventive and interesting novelist. They are centrally related to her conception of the human condition, and despite her respect for a contingent world and irreducible persons Miss Murdoch seems increasingly drawn to the symbolic novel in which emphasis on violence and suffering is greater than in portrayals in the realistic mode.

# LIFE AGAINST DEATH IN ENGLISH POETRY: A METHOD OF STYLISTIC DEFINITION*

*Karl Kroeber*
*with Alfred L. Kroeber and*
*Theodora K. Kroeber*

Our purpose in this paper is to illustrate a method of defining configurations of literary style through the study of word-choice patterns in poetry. Refined and extended, this method should make possible more meaningful analyses of poetic movements and counter-movements both within and across the conventional classifications of stylistic periods—neo-classic, romantic, modern, and the like.

We began by counting words sure to have significance in poetry, words such as *nature, soul, spirit,* and words referring to the emotions, the seasons, and so forth. We soon found ourselves overwhelmed by a wealth of possible directions and significances, so we settled on a pattern of life and death words as a starting point, examining four life words and four death words in thirty-five poets, both British and American, beginning with Chaucer and concluding with James Dickey, for a time span of nearly six hundred years.

Our technique is to determine the frequency of the same set of words in (where feasible) the total work of each poet. This sort of survey of course turns for its data to the standard concordances, whose value has too often been underestimated. A mass of extracted and ordered stylistic information lies shallowly buried in every concordance, and this information may be illuminating and significant in many diverse ways. For instance, Housman has much to say of the *soul,* which he mentions thirty-four times in his serious verse as against twelve mentions of *flesh.* But his concordance also shows that he does not once use either the word *spirit* or the word *body*—a fact that might easily escape the most devoted student's observation. Yet this "negative fact" is essential to our

---

* The work reported on in this article was begun by my father, the late Alfred L. Kroeber. Always interested in literature, he became especially intrigued during his later years with problems of describing literary styles. This essay represents one of the last scholarly investigations he initiated. Recent developments in techniques for using computers to compile concordances make it feasible now to carry out systematically the extensive stylistic analyses my father first envisaged nearly a decade ago.
Karl Kroeber

understanding of the function of *soul* and *flesh* in Housman's poetry.

There are as yet, unfortunately, no concordances for some major poets and still very few for minor poets. We are reluctant to base findings on a sample which will someday be superseded by a concordance: the latter is not only complete but also far more reliable. We did, however, make some counts of life and death words to give broader representation to our list. Except for Swinburne, our samples are probably adequate, covering approximately a moiety of each poet's work. But these results are strictly provisional, both because they are not based on total output, and because a running tally is almost surely less accurate than a formal concordance count.

Even these provisional findings, however, are adequate to illustrate the nature of our method and (we hope) to encourage others to undertake analogous studies. In work of this kind results are in large measure additive. Indeed, it is our premise that only through the accumulation of many investigators' findings will such quantitative discriminations lead to deeper understanding of the qualities of literary style.

We counted the nouns *death* and *life,* including of course their plurals and possessives; the verbs *die* and *live,* including conjugational forms such as *dies, dieth, died;* the participles *dying* and *living;* and the adjectives *dead* and *alive.* These eight have the merits of being simple and unescapable Anglo–Saxon, and the four of each set derive from one root. This last is not always the case—thus in German, *death* is *Tod,* but the verb for *die* shifts to *sterben,* the *Tod*-derived verb *töten* being used for *kill.*

Some features of our limitation to these four pairs are admittedly arbitrary, but we have made the limitation in the interest of avoiding complications. Thus *live* as an adjective may have been used more frequently by some poets than *alive,* but some concordances do not distinguish parts of speech, even mechanically grouping the verb *lives* with the plural noun *lives.* Too many re-orderings of concordance listings would have introduced a high degree of error into work where at best mistakes are easy. *Quick* as a synonym might also have come into consideration, especially in earlier poets. *Deadly* would perhaps have been desirable to include, but its counterpart *lively* has moved out of the range of the corresponding meaning. *Mortal* might well have been significant, and one could argue plausibly that the contrast of *birth* to *death* would be at least as meaningful as that of *life* to *death.* The terms we chose are certainly not exhaustive, but one step at a time seemed wisest as a beginning, with consideration for consistency and for equal pairing on the life and on the death side. The final goal of this method is the creation of a series of something like "semantic fields" upon which to base stylistic judgments. Our eight words, then, should be regarded as the first segment of such a field.

The results of our count of the concordances plus our sample counts are given in Table 1. Fourteen of the poets show an excess of life words, twenty of death words. Collins, whose volume is tiny, splits evenly. The general division, then, is not a half and half one, and it is not random. Before 1815, and especially from Milton on, most poets give preference to life; after 1815 death takes the lead. Although clusterings seem most significant, the inevitable individual exceptions are interesting.

The results of our counts have throughout been converted into percentages to make them comparable. The absolute numbers in the last three columns of the table are the totals of our counts, included as indication of the reliability of the percentage figures. We cannot invest with much significance the grand total. About all that can be ventured from our absolute figures is that, for the six centuries, life and death words are in approximate equality, and that the total number of poets favoring one or the other may be expected to be more or less in balance when it shall have become possible to make a complete count of all of them. The significance of variability in our count lies in periods and in individuals, not in grand totals. We have not yet attempted the other obvious "totaling" test—determining how large a part life and death words play in the total vocabulary of each poet.

The series begins with Chaucer, our only Middle-English poet. The concordance included but we excluded from his count the *Boethius* and the *Parson's Tale* as being in prose and *The Romaunt of the Rose* as being an outright translation. Their inclusion, as a matter of fact, would not very materially change his proportions—by two percent only—but it would be inconsistent with the method of our other counts. In Chaucer we discover a reasonable balance between life and death, the death words being weighted over the life ones by the small percentage of fifty-four to forty-six. Such a balance sems proper to Chaucer, robust and sanguine of temperament as he was but nonetheless a poet not yet out of the Middle Ages and their preoccupation with the after life, and writing a scant century before the addiction of popular North European art to the macabre Dance of Death, the carrying off of the damned, and their torments in hell. Chaucer's life and death word preferences lie near the presumable English poetical mean, to judge by our other counts: small but pleasantly corroboratory evidence for the view that Chaucer was already within the generic

**Table 1**

| Poet | Percent Life | | | | | Percent Death | | | | | Number of Occurrences | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Life | Alive | Live | Living | Total | Death | Dead | Die | Dying | Total | Life | Death | Total |
| Chaucer, 1340 | 30 | 1 | 13 | 2 | 46 | 18 | 14 | 22 | 0 | 54 | 586 | 681 | 1267 |
| Wyatt, 1503 | 33 | 5 | 20 | 2 | 60 | 23 | 4 | 13 | 0 | 40 | 161 | 109 | 270 |
| Spenser, 1552 | 28 | 4 | 13 | 11 | 56 | 17 | 11 | 13 | 3 | 44 | 992 | 766 | 1758 |
| Shakespeare, 1564, Sonnet | 18 | 2 | 33 | 6 | 59 | 16 | 12 | 12 | 1 | 41 | 74 | 52 | 126 |
| Narrative | 20 | 2 | 15 | 3 | 40 | 24 | 14 | 18 | 4 | 60 | 70 | 103 | 173 |
| Drama | 23 | 2 | 18 | 3 | 46 | 25 | 11 | 17 | 1 | 54 | 1654 | 1914 | 3568 |
| Donne, 1573 | 15 | 2 | 14 | 2 | 33 | 26 | 16 | 23 | 2 | 67 | 159 | 316 | 475 |
| Herrick, 1591 | 17 | 0 | 35 | 2 | 54 | 11 | 15 | 19 | 1 | 46 | 287 | 240 | 527 |
| Herbert, 1593 | 27 | 1 | 19 | 0 | 47 | 23 | 9 | 19 | 2 | 53 | 117 | 130 | 247 |
| Milton, 1608 | 27 | 0 | 19 | 8 | 54 | 31 | 4 | 9 | 2 | 46 | 266 | 223 | 489 |
| Dryden, 1631* | 25 | 2 | 18 | 6 | 51 | 22 | 7 | 16 | 4 | 49 | 573 | 568 | 1141 |
| Pope, 1688 | 29 | 2 | 16 | 6 | 53 | 13 | 9 | 21 | 4 | 47 | 225 | 203 | 428 |
| Gray, 1716 | 21 | 0 | 17 | 8 | 46 | 21 | 8 | 23 | 2 | 54 | 28 | 33 | 61 |
| Collins, 1721 | 32 | 0 | 18 | 0 | 50 | 14 | 18 | 16 | 2 | 50 | 22 | 22 | 44 |
| Goldsmith, 1728 | 44 | 4 | 11 | 1 | 60 | 13 | 7 | 19 | 1 | 40 | 50 | 34 | 84 |
| Cowper, 1731 | 44 | 2 | 17 | 2 | 65 | 13 | 4 | 15 | 3 | 35 | 295 | 161 | 456 |
| Burns, 1759 | 42 | 0 | 16 | 2 | 60 | 20 | 6 | 11 | 3 | 40 | 229 | 150 | 379 |
| Wordsworth, 1770 | 30 | 3 | 17 | 11 | 61 | 14 | 11 | 12 | 2 | 39 | 983 | 617 | 1600 |
| Coleridge, 1772, Poetry | 33 | 2 | 15 | 6 | 56 | 17 | 9 | 15 | 3 | 44 | 368 | 288 | 656 |
| Plays | 31 | 3 | 22 | 5 | 61 | 12 | 13 | 12 | 2 | 39 | 257 | 167 | 424 |
| Byron, 1788 | 30 | 1 | 15 | 5 | 51 | 18 | 12 | 15 | 4 | 49 | 1175 | 1125 | 2300 |
| Shelley, 1792 | 22 | 1 | 11 | 7 | 41 | 28 | 15 | 12 | 4 | 59 | 781 | 1106 | 1887 |
| Keats, 1795 | 23 | 0 | 14 | 2 | 39 | 23 | 13 | 20 | 5 | 61 | 185 | 284 | 469 |
| Emerson, 1803 | 40 | 5 | 20 | 6 | 71 | 8 | 6 | 14 | 1 | 29 | 137 | 57 | 194 |
| Poe, 1809 | 28 | 1 | 11 | 5 | 45 | 14 | 15 | 21 | 5 | 55 | 68 | 84 | 152 |
| Tennyson, Poetry | 29 | 1 | 14 | 5 | 49 | 16 | 13 | 20 | 2 | 51 | 896 | 942 | 1838 |
| Plays | 24 | 1 | 14 | 4 | 43 | 18 | 19 | 17 | 3 | 57 | 266 | 354 | 620 |
| Browning, 1812 | 43 | 2 | 14 | 2 | 61 | 13 | 9 | 15 | 2 | 39 | 2832 | 1774 | 4606 |
| Whitman, 1819 | 31 | 3 | 6 | 7 | 47 | 29 | 15 | 5 | 4 | 53 | 310 | 347 | 657 |
| Arnold, 1822 | 31 | 2 | 17 | 4 | 54 | 16 | 15 | 12 | 3 | 46 | 483 | 411 | 894 |
| Dickinson, 1830 | 26 | 3 | 13 | 2 | 44 | 23 | 8 | 18 | 7 | 56 | 293 | 366 | 659 |
| Swinburne, 1837 | 25 | 1 | 9 | 4 | 39 | 28 | 18 | 13 | 2 | 61 | 125 | 199 | 324 |
| Lanier, 1840 | 29 | 1 | 9 | 4 | 43 | 24 | 15 | 14 | 4 | 57 | 122 | 162 | 284 |
| Housman, 1859 | 12 | 4 | 10 | 3 | 29 | 10 | 20 | 37 | 4 | 71 | 45 | 112 | 157 |
| Kipling, 1865 | 15 | 2 | 12 | 4 | 33 | 14 | 15 | 33 | 5 | 67 | 70 | 143 | 213 |
| Yeats, 1865 | 15 | 2 | 16 | 6 | 39 | 14 | 20 | 24 | 3 | 61 | 295 | 457 | 752 |
| Eliot, 1888 | 30 | 5 | 6 | 5 | 46 | 26 | 16 | 4 | 8 | 54 | 60 | 71 | 131 |
| Thomas, 1914 | 4 | 3 | 1 | 3 | 11 | 40 | 21 | 17 | 11 | 89 | 19 | 143 | 162 |
| Dickey, 1923 | 26 | 5 | 9 | 6 | 46 | 10 | 33 | 8 | 3 | 54 | 83 | 100 | 183 |

*Figures for Dryden illustrate the slight inconsistencies produced by cumulative "rounding off." These, however, seem a small price to pay for relative legibility.

stream of preoccupation characteristic of subsequent English poetry.

Spenser, the earliest Elizabethan for whom we have a full count, shows a definite life preference, fifty-six percent life words, forty-four percent death words (it is perhaps significant that our count for Wyatt suggests his even heavier life preference). This orientation makes one think of Spenser's inclination to the charming and the pleasing and makes one recall that many early Elizabethans shared these inclinations, at least in tolerance for the pastoral, the decorative, and the allegorical in their literature, a toleration which sometimes vanishes from sight under the full flood of the tragedy and realism of the Shakespearean drama.

With Shakespeare one must decide which Shakespeare. His sonnets lie within the Spenserian life-preference with fifty-nine percent life words. But the sonnets constitute too small a part of his work to have an over-all representativeness for him. Nor are the 126 life–death words numerous enough for a surely valid statistical sample, a matter of importance because Shakespeare's sonnets show as high a bias for life as the work of any other early poet in our list, and are surpassed only in the eighteenth century by Goldsmith, Cowper, and Burns, and in the nineteenth by Wordsworth, Emerson, and Browning. This weighting toward life might be reduced by other lyrical verse of Shakespeare's which we omitted from our count, mainly because of the contested authorship of some of the poems. Shakespeare's two narrative poems, with their fatal and lamentative themes, are weighted toward death in the proportion of three to two.

The bulk of the plays is so great and so much in excess of all his other poetry that their death–life ratio, fifty-four to forty-six, must, we believe, be regarded as the ultimately significant one. There are surely some interesting differences between tragedies, histories, and comedies buried in the gross total of life and death words, but these differences we do not pursue here, since our primary problem is the trend as it finds expression in successive poets, not the variability due to theme and genre within one poet's work.

With Shakespeare's drama we enter a more "modern" world, the full Renaissance in England, attended apparently with a weighting toward death which continues until Milton, although Herricks' life-preference may not be an idiosyncratic phenomenon. Our count for Donne, a decade later than Shakespeare, shows an impressive sixty-seven percent death preference; for Herbert, two decades after Donne, the death preference drops to fifty-three percent, close to the count for Shakespeare's dramas. Not to put too fine a point on it, these ratios suggest that a sort of climax of the death-orientation was expressed in Donne, which by the time of Herbert and Herrick was lessening toward balance, evolving, finally, to the definite life-preference initiated by Milton. Donne's is a considerable body of verse and his ratio of sixty-seven percent death words is the highest for any poet until we come to the turn of the nineteenth into the twentieth century. It may well be that Donne's preoccupation with death, which is accompanied of course by remarkable intellectual sophistication, accounts at least in part for the revival of Donne's popularity in the twentieth century.

We now discover, as we go down the list, a swing back to a life preference, beginning with Milton and persisting until the full weight of the romantic impetus started a long return swing to death. During these one hundred and fifty years, Gray provides the only exception to be found amongst the English poets for whom there are complete concordances. It is indeed fitting that the author of the "Elegy" and the traditional precursor of romanticism should lean to the death side, but the total number of words, sixty-one life and death words all told, is so small as to leave the preference without much solid significance. And this block of a century and a half of life-preference is impressive. The climate of mood, the set of the culture, something beyond individual idiosyncrasy must be part of the explanation of this long preference, for the poets of this period could not have been more different in personal orientation, temperament, even in choice of subject-matter and of poetic forms.

In the second half of the eighteenth century and the first decade of the nineteenth, the life ratios run up into the sixties. Byron, born a decade and a half after Wordsworth, shows, however, the beginning of a counter-trend which fully manifests itself in Shelley and Keats according to our table. We find, beginning with Shelley and continuing as far as we go into the twentieth century, death words to be in excess of life words. This is a period already approaching in length the preceding one hundred and fifty years of excess of life words over death words. The second period, however, is not so consistently patterned as its predecessor: Emerson, Arnold, and Browning, particularly the last, are notable exceptions. Browning uses the abstract noun *life* alone oftener than all four death words together, and his total life-percentage is sixty-one, matching Wordsworth's high. It should be observed that Tennyson's death-preference is relatively slight, only the plays tilt him strongly toward death. Since the dramas belong to the latter part of his career they may be associated with the death slope that gets steeper at the end of the nineteenth century and through the first decade of the twentieth. Housman marks a trough, surely to be connected with the negativistic culmination of *fin-de-siècle* development. At any rate, the three great Victorian poets do not advance the trend initiated by Shelley and Keats, nor do they link up closely with the later nineteenth-century poets.

Housman's contemporaries and successors on our list, Kipling, Yeats, Eliot, might seem to mark a movement back toward a balance between life and death. But our sampling of Thomas, by far the most death-oriented of the poets tested, and of Dickey raises doubts as to whether that balance has been achieved in our century. Of course in the lower portion of our list a new factor enters. Our limited figures, particularly for American authors, do not permit us to judge whether the influence of time is greater than that of country. Two outstanding exceptions to the death trend since Shelley, Emerson and Browning, were born on opposite sides of the ocean but within nine years of each other. But Arnold, also with a life preference, is two decades later than Emerson. Within the trend, on the other hand, are six of the Americans (counting Eliot) whose indices run surprisingly close together. Poe, often regarded as a melodramatic seer of blackness, shows 55 percent death words—but Whitman, Dickinson, Lanier, Eliot, and even Dickey are all within two points of this percentage.

Besides the total life and death percentages discussed so far, separate consideration of each of the eight words dealt with is desirable. For instance, the percentaged frequencies in each column of Table 1 can be rearranged in rank order according to their size, instead of the time order of the poets. Thus for *dying,* Thomas 11 percent and Eliot 8 percent would head the column, Dickinson, 7, would be third, and then would come Keats, Kipling, and Poe. The small end of the list would be constituted by Chaucer and Wyatt. A long-term though somewhat wavering drift is evident here—later poets on the whole run higher in this category—whether the cause be primarily linguistic or stylistic.

The abstract noun *life* is used by the poets in our list with the greatest over-all frequency of the eight words and also with the highest maximum frequency. Cowper, Goldsmith, and Burns form a cluster at the top of the rank order, joined only by Browning and Emerson among later poets. Obviously, a very high frequency of use of the noun *life* almost presupposes a majority of life words. Consequently a rather high frequency of the noun *life* by a poet who uses more death words marks an individual peculiarity. Thus both Tennyson (29) and Whitman (31) are fond of the word *life,* although their vocabularies are moderately on the death side as a whole. Contrarily, Shakespeare tends to avoid the word *life* in his sonnets, although his sonnet vocabulary is strongly life-weighted. The prophets and lovers of mortality who come at the end of the rank-order list with percentages for *life* below twenty are Thomas 4, Housman 12, Kipling 15, Yeats 15, and, nearly three centuries earlier, Donne 15, and Herrick 17. Donne is heavily death-biassed, but Herrick, like Shakespeare in his sonnets, is life-minded: they both prefer the verb *live* to the abstract noun.

At the top of our rank-order for *death* we find Thomas 40, then Milton 31, his single high; at the bottom Emerson 8, and Housman and Dickey, 10 each. Thomas of course is overwhelmingly death-oriented, but the other poets in this sub-list are surprising. Milton is on the life side in the total count; Emerson has the highest proportion of life words (71 percent) and Housman of death words (except for Thomas) among the poets. Emerson might seem almost pathologically afraid of reference to death, but Dickey shares his pattern of shunning one abstract noun but using the other relatively frequently. Housman, however interested in death, apparently dislikes abstract nouns. Instead of *death* he favors *dead* and *die,* being behind only Dickey and Thomas and with Yeats for *dead,* and over-all first for *die.*

It is the bulk of *Paradise Lost,* five times as long as *Paradise Regained,* which puts Milton near the top for the noun *death:* the frequency in *Paradise Lost* is thirty-four percent of the eight words in question. But the fact remains that Milton was interested to write the long poem of a lost Eden and lost immortality, even though Milton initiates the long stretch of almost solid life-preference. The poets who come next after Milton in liking the word *death* are Whitman, 29, who favors nouns as such, and Shelley and Swinburne, both 28, death-oriented and in this class surpassing even Donne. The poet whose ratio for both the nouns *life* and *death* together is highest is Burns, 62. He is abnormally low in adjectives and in participles and is below average in the verbs *live* and *die.* It is indeed a special lyrical genius that expresses itself so spiritedly with abstract nouns.

*Alive* and *dead* are incomplete counterparts, *living* and *dead* being opposites also. In any case, *alive* is not a specifically "poetic" word, or has not often been so considered. Burns and Keats never use it and no one uses it as often as *dead.* The poets who use the adjective *dead* most often are, in rank order, Dickey 33, Thomas 21, Yeats 20, Housman 20, Tennyson plays 19 (poems only 13); Donne's 16 is relatively high in this category. As Tennyson's plays mostly came late in his life, it is clear that all of these high-rankers wrote within the past century; Donne shows himself once more as a forerunner of the moderns. Heavy preoccupation with death in general seems to carry with it some tendency to the more frequent use of the stark and emotion-freighted adjective *dead.*

For *live* and *die* the tallies indicate what one might expect, that use and preference are complex for verb forms. The two verbs *live* and *die* are the next most frequent of our eight words after the abstract nouns, while occasional individual rejection of one or both of them is more extreme than for the nouns. For *live* high rankings are early, the highest rankings in lyrics, Herrick 35, the sonnets of Shakespeare 33 (but plays 18). The lyrical poems of Milton, incidentally, run up to 32 percent in this class, although the percentage for Milton as a whole is 19. Dryden and the eighteenth-century poets pretty consistently run medium, with a 16–18 percent of *live,* carrying over into Wordsworth 17, Coleridge 15 in poems but 22 in plays, Byron 15, and Arnold 17. With the full- and post-romantic swing to the death side, *live* goes down further, with two exceptions: Emerson 20 and Yeats 16. Emerson is generally biased toward life, but Yeats leans the opposite way. His idiosyncrasy is rather preference for verb over noun, reflected also by his *die* 24, *death* 14.

As regards the use of *die,* two influences seem to be at work which may reinforce or counteract one another. There is the tendency for *die* to go up in frequency when death words generically are favored. But there appear to be, also, poets who like the verb *die* as such, as compared with *death* or *dead,* and others who specifically dislike it. The trio Housman, Kipling, and Yeats show a strong preference for *die* over *death;* in Housman *die* is nearly four times more frequent (37 to 10), in Kipling more than double (33 to 14), in Yeats definitely in excess (24 to 14). Poe clusters with these three (21 percent *die* to 14 percent *death*). All these poets are strongly weighted toward death in general. There is, however, a trickle of poets, and some of them major poets, who favor death only mildly or even lean toward life but who are rather fond of the particular word *die.* Such are Chaucer, 22 percent *die* as against 18 percent *death,* but contrast only 13 percent *live* to 30 percent *life;* Herrick, 19:11; Pope, 21:13; Tennyson, 20:16. What else may tie these four together we do not venture to say. Emerson, too, though he is excessively partisan on the side of life, to some degree favors *die,* at any rate it is the death word he least avoids: *death* 8, *dead* 6, *die* 14, *dying* 1.

Finally, there are a few poets who are moderate in their over-all life–death attitude, such as Milton, Whitman, and Eliot, whose *die* frequencies are abnormally low: 9 percent for Milton, 5 for Whitman, 4 for Eliot. Here a common factor is discernible, though it has nothing to do with temperament; in fact, it is formal, even grammatical. These three poets operate unusually little with verbs and heavily with nouns, at any rate within our life–death sample. Compare *life* plus *death* against *live* plus *die:* Milton 58:28; Whitman 60:11; Eliot 56:10. In fact, Eliot's two verbs are surpassed in frequency by the sum of their derived participles, 10:13. Whitman's piling up of inventories may account for his excess of nouns. In Milton it is more likely his Latin models: in Virgil *vita* and *mors* make up 59 percent of his equivalent eight life and death word occurrences. Burns joins these three in his high proportion of nouns (62:27), as already remarked, but unlike them he shows an over-all heavy life bias.

Our two participles are relatively infrequent, and their separate tallies hardly suggest configurations of period or group as do the other six words, except as grammatical usage changed. There are some marked differences, but they seem individual. Thus Spenser and Wordsworth both run up to 11 percent for *living*, Milton to 8. In each case the frequency is high relative to the verb *live* and it does not extend to *dying-die*. These are probably personal idosyncrasies of these poets' diction. They contrast markedly, for instance, with Shakespeare's 3:18 for *living-live*, with the same inclination manifest in his 1:17 for *dying-die*. We have just mentioned Eliot's opposite tendency, his participles rivalling or exceeding his verbs. It is conceivable that Eliot marks the beginning of a turn in style. Thomas runs highest in the *dying* category with 11 percent, but of course he runs very high in all death words. It seems more likely that Eliot's staticism expresses a personal peculiarity. But whether the low degree of periodic consistency in the use of participles and the high degree of variability between individual poets are functions only of our special set of life and death words, or whether they extend to the grammatical form of English poetry generally, is something that remains to be tested.

Table 2 serves as a partial summary of the most pronounced personal bents, as well as period changes of taste and usage, in the choice between the several life and death words. The poets are again listed in chronological order, but their most positive preferences are made explicit without statistics by citing for each poet which word of our eight he used most often, then next most often, finally third most often.

Although one might analyze the data in other ways, to be genuinely useful more detailed analyses should be integrated with results derived from analogous compilations (and of course a more complete representation of poets would be desirable). No single study of this type can claim to be generally meaningful, but a series of interrelated investigations to establish something like a "semantic field," as we have suggested, would permit significant advances in our understanding of the processes of literary style.

TABLE 2

| POET | WORD | | |
|---|---|---|---|
| | Favored Most | Second Favored | Third Favored |
| Chaucer | life | die | death |
| Wyatt | life | death | live |
| Spenser | life | death | live + die |
| Shakespeare, sonnets | live | life | death |
| narratives | death | life | die |
| plays | death | life | live |
| Donne | death | die | dead |
| Herrick | live | die | life |
| Herbert | life | death | live + die |
| Milton | death | life | live |
| Dryden | life | death | live |
| Pope | life | die | live |
| Gray | die | life + death | |
| Collins | life | live + dead | |
| Goldsmith | life | die | death |
| Cowper | life | live | die |
| Burns | life | death | live |
| Wordsworth | life | live | death |
| Coleridge, poetry | life | death | live + die |
| plays | life | live | dead |
| Byron | life | death | live + die |
| Shelley | death | life | dead |
| Keats | death + life | | die |
| Emerson | life | live | die |
| Poe | life | die | dead |
| Tennyson, poetry | life | die | dead |
| plays | life | dead | death |
| Browning | life | die | live |
| Whitman | life | death | dead |
| Arnold | life | live | death |
| Dickinson | life | death | die |
| Swinburne | death | life | dead |
| Lanier | life | death | dead |
| Housman | die | dead | life |
| Kipling | die | dead + life | |
| Yeats | die | dead | life |
| Eliot | life | death | dead |
| Thomas | death | dead | die |
| Dickey | dead | life | death |

So we conclude by pleading for increased recognition of the utility of some humble, often disregarded tools of literary scholarship, concordances, word-indices, and the like. Properly used, these tools can encourage the development of new kinds of critical insights. Contrarily, without such tools even theoretical criticism is to a degree handicapped. The lack of concordances for most writers of prose fiction, for example, blocks off one pertinently related area of stylistic criticism. The kind of investigation we have illustrated suggests the possibility of establishing a sector of literary scholarship in which the systematic accumulation of research findings would be feasible and rewarding. This research appears especially valuable in forcing the scholar to test the limits of conventional periodization and genre definition. Most students of literature recognize these conventionalized definitions as not entirely satisfactory conveniences, which nevertheless, like all such conveniences, finally tend to control our thinking. The technique of stylistic analysis proposed here provides one means for evaluating, qualifying, and refining the received classifications of literary style.

# JULIUS BUBOLZ FOUNDS AN INSURANCE COMPANY: A STUDY IN RURAL LEADERSHIP AND RESPONSIBILITY *

*Walter F. Peterson*
*Lawrence University*

On April 7, 1956, Julius Bubolz turned to his son and said, "Gordon, how is the business coming in from the new territory?"[1] Two days later at the age of 93 years and seven months the founder of the Home Mutual Insurance Company was dead.[2] Alert and active in the business to the very end, Julius Bubolz was born August 22, 1862, in Germany and at the age of seven emigrated to the United States, settling with his parents on a farm in Winnebago County. He attended public and parochial schools completing all the courses offered at that time. In fact, he took the eighth grade course twice as nothing was available beyond it. After clerking in a store for an uncle he worked briefly on the railroad before buying an 80-acre farm for $1,500 in 1882.[3]

This farm near Seymour, Wisconsin—a stake in a developing society—provided a basic orientation for Julius Bubolz as he began carving a livelihood out of the Wisconsin wilderness. Above all he developed a respect for the land. Neighbors sold their timber to lumber companies and thus stripped their land. Bubolz desperately needed the money to help pay the mortgage but he had a sense of ecology and conservation generally lacking in the late 19th century. Trees on hilly portions of the farm were never cut so they could protect the land from erosion. Flowers, animals, and birds only added to the enjoyment of a family walk through the woods. The farm eventually encompassed 242 acres.[4]

---

* The author was given unrestricted permission to use the files and records of the Home Mutual Insurance Company. For the complete cooperation of the officers and staff, the author is also most appreciative.

[1] On August 24, 1965, all living children of Julius and Emelia Bubolz but two, together with two grandchildren, were brought together at the Home Mutual Insurance Company where they were interviewed in depth by Professor Walter Ebling, University of Wisconsin. The author is indebted to Dr. Ebling and the Bubolz family for this extended and perceptive interview which was recorded on tape. Ebling–Bubolz Tape; Gordon, p. 30.

[2] *Appleton Post–Crescent,* April 10, 1956.

[3] *Ibid.* Also, *Capital University Bulletin,* February, 1943, p. 3. Ebling–Bubolz Tape; Gordon, p. 3, Amelia, p. 4. Card from Esther, September 12, 1965, in Home Mutual Files.

[4] Half of the land was described as "level, well drained, and suited for intensive cultivation;" About one-third of the land was good cropland but had "quite a few problems that will require good conservation practice;" and the remainder was "not suited for cultivation, but . . . for grass or trees." Letter from Vernon G. Geiger, Outagamie County Soil Conservationist, April 4, 1967. Ebling–Bubolz Tape; Gordon, p. 30–31.

Save for the purchase of the farm in 1882, 1884 was the key year in providing the basic orientation for Julius Bubolz. Civic interest led him into a variety of public offices. His first official position was that of town clerk—a post he filled for 19 years. Careers of 27 years as justice of the peace and 28 years as school clerk also began in 1884. The next year he was appointed census enumerator for the Town of Cicero.[5] These positions developed the variety of his contacts and his experience in administration and public responsibility.

Bubolz was keenly aware of the importance of appearance. Only 21 and anxious to appear older, he grew a beard. He was enormously pleased that he was chosen town clerk in preference to a clean shaven man 10 years his senior. The beard accomplished its purpose. It helped him appear older when that was needed and 25 years later when he found it desirable to look younger, he shaved it off.[6]

Emelia Jeske became Mrs. Julius Bubolz one month after Julius was appointed town clerk. Emelia was distressed when he grew the beard and equally distressed when he shaved it off a quarter century later. She converted a Wisconsin homestead into a comfortable and happy home. A warm and vital person, Emelia's pleasant exterior concealed a remarkable capacity for hard work, managerial ability, drive, and determination. Fifteen children provided the extra hands so useful on a Wisconsin farm.[7]

Shortly after their marriage Emelia said, "There is no blessing on the community without a church, a place to worship our God." Julius solicited the support of 21 neighbors to found Emanuel Lutheran Church of Cicero. As the guiding force Julius was elected secretary of the congregation, a position he held for the next 61 years.[8] A firm faith in God was coupled with a deep and abiding faith in his fellow man. The church was, as many other pioneer projects, a community venture. The farmers in the Seymour–Cicero area built the roads and helped each other build barns and harvest crops as well as build the church. Cooperation was essential for progress—it was a way of life and it worked.

Faith, cooperation, and work might have sufficed in those pioneer days had it not been for the periodic windstorms that ripped their way through the area. Cooperation could rebuild a farmstead destroyed by fire but when their fields were devastated along with barns and homes these pioneers obviously needed more than storm cellars. Moreover, the pioneer community was a debtor community.

---

[5] *Appleton Post Crescent*, April 10, 1956. *Capital University Bulletin*, p. 3. Card from Esther, September 12, 1965.

[6] Ebling–Bubolz Tape; Esther, Gertrude and Gordon, p. 5.

[7] *Ibid.;* Amelia, p. 27, Amelia, Esther and Gordon, pp. 35–36.

[8] *Ibid.;* Gordon, pp. 5–6. Also, *Capital University Bulletin*, p. 3.

Mortgages were not cancelled by a tornado and it was a very long year between harvests. In 1883 an August tornado destroyed Julius Bubolz' first crop when he had the grain cut and in shocks. The Cicero area survived another tornado in 1888.[9] News of the great cyclone that struck New Richmond, Wisconsin, on the evening of June 12, 1899, filled the Cicero residents with dread. 115 people were killed, 500 injured, 100 homes completely destroyed, and property damage was well above $750,000.[10] Julius Bubolz knew that something could be done to spread the risk. He didn't know just how, but he would find out.

The answer was found in mutual insurance but there were no mutual windstorm companies operating in this part of rural Wisconsin—only mutual fire insurance companies. Windstorm insurance was unheard of in the Cicero community and many farmers wondered whether such a company could operate successfully. Mutual insurance simply means that it is owned by the policyholders of the company. In this democratic arrangement the policyholders elect directors who, in turn, elect officers who manage the business, collect small sums as premiums, and pay the losses of policyholders who have agreed to mutual protection. Management includes setting up reserves for safe operation and then returning what is left over as dividends to the policyholders. The mutual handles insurance at cost, it is a cooperative project. Mutual insurance was not a new idea having been put into practice in London in 1696. Benjamin Franklin brought the idea to America and established the "Philadelphia Contributorship" in 1752. For the next century the idea grew slowly but by 1900 over 1,100 mutual companies had been formed. With such rapid growth many mistakes were made and poor management resulted in many failures. It was the task of Julius Bubolz to determine the principles for sound management to insure survival.[11]

Through reading, inquiry, and some experience Julius Bubolz was able to translate his thoughts into action. His stature as a church and civic leader stood him in good stead for here was one man in the Cicero community who could be trusted for honesty and judgment. Early in 1900 he invited a group of his neighbors

---

[9] *50th Anniversary Bulletin*, p. 3. In 1883 Julius Bubolz almost lost his farm as a result of crop loss to wind. He was able to keep it only because he took a 12 per cent second mortgage with the farm as security. This experience left an indelible impression on his mind. Ebling–Bubolz Tape; Gordon, pp. 20–21.

[10] *The Milwaukee Journal*, June 13, 1899. The headline followed by decks of subheads read: "A TORNADO KILLS AND MAIMS HUNDREDS OF WISCONSIN PEOPLE: Hundreds of Dead, Dying and Injured; Tornado Strikes New Richmond and Fire Completes Work of Destruction; Men, Women and Children Crushed to Death by Flying Debris Without a Second's Warning."

[11] John Bainbridge, *Biography of an Idea; The Story of Mutual Fire and Casualty Insurance*, (New York, 1952), pp. 20–21, 28. Also, *Semi-Centennial History of the Northwestern Mutual Life Insurance Company of Milwaukee, Wisconsin, 1859–1908*, (Milwaukee, 1908), pp. 25–29.

to his home and explained his plan to them. Based on this interest others were canvassed during the next 60 days until 135 members comprised the original charter group. The plan of operation was simple. Each member had an equal voice in the management. Each promised to assume his share of the losses and expenses. These men took care of themselves by helping each other. After the fashion of the day, the original name was Farmers Home Mutual Hail, Tornado and Cyclone Insurance Company of Seymour, Wisconsin—since Seymour was the nearest town. The first policies were not the multi-claused documents of today but merely simple memoranda with most of the contract written between the lines. The company that was to be the Home Mutual Insurance Company was chartered March 1, 1900.[12]

Charles Ploeger, the largest dairy farmer in the county, was the first president and held that office until 1916.[13] The president, however, was little more than a figurehead whose sole responsibility was to preside over meetings. As stipulated in the by-laws the real power and responsibility resided in the secretary, Julius Bubolz, who

> "shall keep a record of proceedings of all meetings of the members and Board of Directors of the Company, preserve all Applications for Insurance, draw and countersign all orders on the Treasurer and prepare and keep all proper books for the business of the Company, under the supervision of the Board of Directors, and all Applications, Policy Registers and other Books, Contracts and other Instruments as are required to be kept at the home office and in his custody. He shall prepare and countersign all Policies of Insurance, Contracts of Agencies, answer all business communications of the Company, prepare and render a statement of the affairs of the Company for its annual meetings, and such other purposes as may be required by law, to collect all dues and premiums or advance assessments, pay all moneys belonging to the Company to its Treasurer and take his receipt therefore, and perform all other duties usually pertaining to the office of Secretary in similar corporations."[14]

However great his powers Secretary Bubolz did not have much to exercise them on. At the end of the first year the premium income was only $235.24.[15] Company growth was slow as it involved only one line of insurance and was initially sold only to farmers in the immediate area. By December 1902, assets came to only $316.92 with cash from premiums at $544.42 for a total of $861.34.[16]

Growth continued, however, because Bubolz' management was based on integrity rooted in his faith, his close knit family, and

---

[12] *50th Anniversary Bulletin*, p. 3. *Capital University Bulletin*, pp. 3, 15.

[13] Data in Home Mutual Files.

[14] Section 3, *By-Laws of the Farmers' Home Mutual Hail, Tornado and Cyclone Insurance Company of Seymour, Wisconsin*, March 1, 1900.

[15] *50th Anniversary Bulletin*, p. 13.

[16] *Fourth Annual Report*.

his interest in his fellowman. The company earned a reputation for fair and honest dealing, the proof of this being found in the settlement of losses. During 1902, seven farmers whose barns were damaged by cyclones in Outagamie and Shawano counties had settlements of from $2 to $69 for a total of $163. These losses and claims paid as stated in the report, were "scaled down and compromised."[17] Severe hailstorms in 1905 resulted in a small special assessment of $79 on policyholders.[18] But the frugal secretary found that the annual expense of $20 for examination of the company by the Insurance Commissioner would be waived if he brought the books to Madison. In the future he did just that.[19]

During 1906, 401 policies were written or renewed increasing the total to 1,800 covering $1,593,901 in risks.[20] Since there were only 13 losses the financial picture improved. By the close of 1914 the total number of policies in force had increased to 4,007. Risks had increased to $7,666,443 and assets of $6,251.93.[21] By the close of 1919 the policies numbered 6,398 with 147 "losses and claims paid and scaled down and compromised during the year."[22] After 20 years the company had paid out $42,192.88 in losses. Secretary Bubloz had run it with such frugality that since 1900 the company had never made a cyclone assessment and only three assessments because of hail. In this respect it had the best record of all mutual companies in Wisconsin and proudly boasted that it was "a company of the people, by the people, and for the people."[23] In an interview in 1943 Julius Bubolz candidly ascribed his success to a combination of morality and practicality when he said, "Aside from the ethics involved, it always pays more than it costs to be honest."[24]

If the integrity of Julius Bubolz provided the basis for public recognition and more business, it was the managerial and social skills of Emelia Bubolz that made much of this success possible. Emelia became the manager of the farm and together with the children virtually ran it so that Julius could devote more time to the growing business for he solicited applications, kept the records, and issued the policies. When this became too great a burden he

---

[17] *Ibid.* In 1911 Julius Bubolz was elected Secretary–Treasurer. *50th Anniversary Bulletin,* p. 5.

[18] *Sixth Annual Report.* The discrepancy between the *Fourth Annual Report* rendered in December of 1902 and the *Sixth Annual Report* in 1905 was resolved in the period 1903 and 1904. Continuity was maintained from the *Sixth Annual Report* on.

[19] Julius Bubolz, "Address Commemorating the 40th Anniversary of This Company," MS in Home Mutual Files.

[20] *Seventh Annual Report.*

[21] *Fifteenth Annual Report.*

[22] *Twentieth Annual Report.*

[23] Julius Bubolz, "Address Commemorating the 40th Anniversary of This Company," MS in Home Mutual Files.

[24] *Capital University Bulletin,* p. 15. Also, *40 Years of Service, 1900–1940; Convention Program and Life Story of the Progressive 'Home Mutual',"* p. 6.

drafted the children into the enterprise. Esther later recalled how diligently she had to practice her penmanship so that she could write well enough to help write policies.[25] It wasn't until 1914 under pressure of increased sales and extraordinary losses that the secretary employed two office girls at $5.00 a week plus board. The two day annual meetings were gala events.[26] Although the formal meetings were held in the Seymour Hotel the directors ate and slept in the large Bubolz farm home for reasons of economy and because they enjoyed the gracious hospitality of the hostess. It might also have been because of the small director's fee for they received only $2.00 for attending a meeting plus train fare until 1924 when they were voted $3.00 per meeting.[27]

Economy was the watchword. For the first twenty years the company made no contribution toward the rent, fuel, or light in the Bubolz home. Then the directors allowed $50.00 a year until 1926 when it was raised to $100.00.[28] Such economies in operation saved the company enough money so that for the first 25 years the premium charges were only 25¢ per $100 for five years. When the State Insurance Department required larger reserves the company raised its rate to 30¢ per $100. However, this was not sufficient to take care of the large wind and hail losses of the late 20's and also build up a surplus so the rate was raised to 50¢ per $100 for five years in 1930. This rate was sufficient to meet all losses, build a substantial surplus and make the company the largest and strongest of its kind in Wisconsin. Through economy of operation and strength of purpose Julius Bubolz served the interests of his fellow farmers in Wisconsin.[29]

The decade of the 20's was the heyday of big business. In this period when men thought only in terms of profits and the key to success was the stock market, the virtues of cooperation that were part of the pioneer society and basic to mutual insurance came under heavy attack. Reports of the annual meetings cast light on this as Julius Bubolz and others briefed the agents on how to handle attacks on the company. A rumor was circulated that the company was in debt and ready to collapse. A careful review of the financial report provided adequate rebuttal.[30] Stock insurance companies disseminated the report that mutual insurance companies across the country were failing. Charts were presented to

---

[25] *50th Anniversary Bulletin,* p. 4. Ebling–Bubolz Tape; Esther, p. 8.

[26] *40 Years of Service,* p. 4.

[27] *Ibid. 50th Anniversary Bulletin,* p. 5. Ebling–Bubolz Tape; Esther and Amelia, pp. 36–37.

[28] *40 Years of Service,* p. 4.

[29] *Ibid.* Ebling–Bubolz Tape; Gordon pp. 13–14.

[30] Julius Bubolz, "Secretary's Annual Message," *Thirtieth Anniversary Bulletin,* p. 17.

indicate that the rate of failure for stock and mutual companies was approximately the same.[31]

The primary criticism of mutual companies during the period was that of socialism as the stock companies wrapped themselves in the American flag and stood on a platform of capitalism. At the annual meeting which celebrated the 30th anniversary of Home Mutual, Henry Straight of Grand Rapids, Michigan, appealed to history to vindicate mutual insurance. He pointed out that Ben Franklin brought the mutual insurance concept to America and that Thomas Jefferson and John Marshall had stock in mutual companies—these the founding fathers. "Talk about socialism!" said Straight. "Why, if this is socialism let us have a little more of it."[32]

To have more of it was distinctly possible, Straight added. The mutual companies had a built-in advantage—they paid no dividends to stockholders. Their stockholders were the mutual policyholders. From 1919 to 1924, 19 stock companies paid $93,036,096 in dividends to their stockholders.[33] In mutual companies this would have gone to policyholders. All that was needed was a sound company, leadership, and able, hard working agents. By 1930 the company had developed a number of agents of this caliber. Anton Matheson of Manitowoc County, for example, wrote 400 policies in 1929 totalling $2.25 million.[34]

Nineteen thirty-one marked the end of an era for the company and opened new horizons. It shed the vestiges of its pioneer beginning when in 1931 it moved its headquarters from the Bubolz farm to modern offices in the Zuelke Building in Appleton.[35] Constantly increasing business and the desire to give all agents and assureds the most rapid service possible made this move imperative. A change of name was in keeping with the spirit of the time. "The Farmers' Home Mutual Hail, Tornado and Cyclone Insurance Company of Seymour, Wisconsin" had shortened its name in 1926 to "Home Mutual Hail–Tornado Insurance Company." In 1932 it was streamlined to its present form "Home Mutual Insurance Company." Perhaps the greatest tribute to the company's record of safety, service and low cost insurance protection occurred at this time when four smaller windstorm companies in Wisconsin after thorough investigation voted to join with Home Mutual rather than one of the 17 other Wisconsin mutual

[31] Henry Straight, "Comparative Strength of Mutual and Stock Insurance," *Thirtieth Anniversary Bulletin*, p. 28.

[32] *Ibid.*, p. 31.

[33] *Ibid.*

[34] *Ibid.*, p. 9.

[35] *The Story of Home Mutual*, 1933, p. 2.

windstorm companies.[36] The accent on change was also seen in personnel. Gordon Bubolz, son of the founder and a recent graduate of law school, became assistant secretary on September 10, 1926.[37] A new generation was now on the scene to cope with a new era of history which saw the U.S. plunged into depression and world war.

At the annual meeting celebrating the 30th anniversary, Julius Bubolz said, "This year the Home Mutual will be 30 years young. I say it will be 30 years young because I believe the company has not yet reached maturity, it has not reached the point where it will no longer progress. To the contrary, I believe the Home Mutual has reached a point where it has successfully gone through the most dangerous period of its life, which is the period of infancy. The Home Mutual has reached a point where it may anticipate a great era of expansion."[38]

He was absolutely correct. The assets in 1930 were $150,902 and in 1967, $9,334,778. The surplus in 1930 was $19,645 and in 1967, $1,884,346. At the end of three decades Home Mutual offered one insurance line (windstorm and hail coverage) in one state (Wisconsin). In 1967 it wrote nine lines of insurance and was licensed in 17 states.[39]

Extensive and intensive studies have been made of Carnegie, Rockefeller, and Morgan. There is no question but that they deserve such attention for they helped build urban, industrial America. In insurance we have the Bulkeley family, sole owners of AEtna Life Insurance Company which, at the end of its Centennial Year, 1953, had admitted assets of $2,370,717,579.[40] But these leaders of American industry and finance did not have a personal or direct effect on Cicero and Seymour in the period 1882–1930. Julius Bubolz did. As a leader in his community he played an important role in the development of rural Wisconsin. In recognizing the need for hail and windstorm insurance and acting to fill that need, he exercised responsibility of the highest order. His ambition was not wealth or fame but service to his fellow man. We have here a study in rural leadership and responsibility.

---

[36] *Ibid.*, p. 8. The companies were the Wrightstown Morrison Mutual Cyclone Insurance Co. of Greenleaf, Wisconsin, the North Wisconsin Farmers Mutual Cyclone Insurance Company of Poskin, Wisconsin, the Buffalo County Mutual Storm and Cyclone Insurance Company and the Windstorm branch of the Price County Farmers' Fire Insurance Company. Also, *40 Years of Service*, p. 8.

[37] *50th. Anniversary Bulletin*, p. 7. Also, *Who's Who in Insurance*, (New York), 1968, pp. 104–105. *Who's Who in the Midwest*, vol. 10, (Chicago, 1966), p. 143.

[38] *Thirtieth Anniversary Bulletin*, p. 16.

[39] Data supplied by Albin Bevers, Vice President, Home Mutual Insurance Company, April 23, 1968. The foundation was laid. The Home Mutual Group by 1968 was capable of handling a customer's complete financial plan—his fire and casualty insurance, life insurance and his investment program.

[40] Richard Hooker, *Aetna Life Insurance Company; Its First Hundred Years*, (Hartford, 1956), p. 224.

# ANTI-GOLD RUSH PROPAGANDA IN THE WISCONSIN MINES

*Watson Parker**

Gold rushes are made, not born. They do not spring to life immediately upon the discovery of gold in far-off places, but arise, instead, from the publicity given to such discoveries by a variety of interested parties. Such propaganda, falling upon minds which are naturally receptive to it, or upon those ears made preternaturally attentive by unhappiness or misfortune, can have volcanic effects and move both men and mountains.

The rush to California received its most compelling impetus when, on December 5, 1848, President James K. Polk proclaimed that "the accounts of the abundance of gold in that territory are of such extraordinary character as would scarcely command belief were they not corroborated by the authentic reports of officers in the public service who have visited the mineral district."[1] Thus did Polk confirm the many rumors already widely prevalent concerning the riches of the land so recently ceded to the United States as a result of the War with Mexico.

The Wisconsin lead mining region, which lies mainly in southwestern Wisconsin, but includes parts of Illinois around Galena and the Iowa mines around Dubuque, was peculiarly susceptible to news of a new bonanza. The Walker Tariff of 1846 had permitted Spanish lead to enter the United States at ruinous prices, while the Wisconsin lead mines themselves, after nearly a generation of productivity, had begun to penetrate below the ground water level, and had become increasingly difficult and expensive to operate. A lead mining population already made restless by declining prices and increased costs of production was all too eager to seek its fortune in the new mines of the far west.

The interest which the Wisconsin miners and their neighbors took in California gold is perhaps best indicated by the large amount of information which the Wisconsin newspapers of the time found it advisable to print, quite evidently in response to a considerable demand for news of the developing gold fields. "It is

---

* Watson Parker is an associate professor of history at Wisconsin State University—Oshkosh. His special field of interest is the Trans-Mississippi West and its mining frontier. His publications include *Black Hills Ghost Towns and Others* (privately published 1964), and *Gold in the Black Hills* (University of Oklahoma Press, 1966), as well as several articles and reviews on western subjects.

[1] James D. Richardson, ed., *Messages and Papers of the Presidents* (Washington, 1900), IV, 636.

not our intention to foster anything like a mania with regard to the California Gold Mines," said the editor of the Galena *Gazette*, "but our readers have a right to know the current reports, and we have no desire to withhold them."[2] This equitable attitude was reflected in the widespread publicity given to the President's December 5 address, the frequent printing of advice on how to equip oneself for the trip to California, and on how to choose the best route by which to go there, and in a multiude of published letters from those who were on the way to, or who had at last reached, the mines of California. News of the rush was in demand, and few editors had sufficient fortitude to withhold it from their readers.

The editors of the mining region, however, were thoughtful and perspicacious men who realized that if favorable news and publicity could begin a gold rush, adverse propaganda could probably slow one down, and retain in the lead mines at least some of those sturdy citizens who might otherwise depart for California. These editors began their campaign subtly by putting forward general economic arguments against gold mining and inflation, by pointing out that all is not gold that glitters, and that happiness and comfort at home might in many cases be preferable to suffering and riches on the Pacific coast. As news came back from those rushers on the way to the mines the editors seem to have sought out tales of difficulties, sickness, and privation on the routes, by either sea or by land, that led to California. Disappointment in the mines, too, was a frequent topic, and reports of disillusioned miners were often prefaced by some sort of hortatory editorial "I told you so!" to make sure that the Wisconsin readers got the point. This is not to say, of course, that all the California news printed in the mining region papers was hostile to the gold rush; that was far from the case. Rather, the effort seems to have been to print all of the news, both good and bad, but to give undue prominence to the bad news, while publishing the good without comment. The editors apparently knew that they could not shut off the gold rush, but they seem to have hoped that they could slow it down.

The first point of attack against the rush lay in editorial statements about the undesirability of gold rushes in general. "The fatal dowry of gold which that new territory has brought to the Union is already producing its wonted effects. In the country itself all the usual occupations of industry—all the ordinary pursuits of life, are abandoned in the insane and insatiate thirst for treasure," cried the Galena *Gazette*.[3] "Is the discovery of the Gold mines of

[2] Galena *Weekly North-Western Gazette*, 27 December 1848.

[3] *Ibid.*, 17 January 1849.

California a blessing?" asked the Oshkosh *True Democrat.* "We say that it is not; we go farther, we think it is an injury. It is drawing men from producing to non-producing industry. There is already money enough in the country, and more is only injurious."[4] The burning question of slavery in the new territories was quickly raised by the Janesville *Gazette* which predicted that if the new lands should "resound, like Mr. Polk's plantation, with the crack of the overseer's lash and the groans of unrecompensed, hopeless Toil then far better for us and for all had they been left to the bear and the savage for ages to come."[5]

Individual miners, as well as the nation as a whole, cautioned the editors, would suffer from a gold rush. The mines would attract "the most degenerate class of foreigners in the territory," "the refuse population more than the good population" herded together with "no law, no government, no means of protecting life or property,"[6] a population composed of "desperate ruffians" among whom the honest miner might lose his life, if not his reputation. Indeed the Galena *Gazette* laid great stress upon this latter attribute, pointing out that "a man's character is worth considerably more than all the gold of California," and that conditions in the diggings might well "drive even a tolerably firm will and watchful conscience from the line of moral propriety."[7]

The editors also hoped that appeal to sentiment would deter the tender-hearted or weak-willed from attempting the trip to the mines. "What recompense would all the gold in the world be," queried the Lancaster *Herald,* "for the burial of one of your dear children . . . in the sands of the Great Desert?"[8] "Money can never make good the deep distress, suffering, and death which will ensue"[9] warned the Janesville paper. Poetry, a feature more popular in newspapers then than it is now, was used to discourage the gold seeker. A touching "Father's Advice to His Son, Leaving His Home for California," cautioned the prospective emigrant to make his peace with both his God and his family before departing for the mines:

> Then, if beneath the evening star,
> Beside the great Pacific's wave,
> Thou find'st an early tomb afar,
> His grace will there thy spirit save.

---

[4] Oshkosh *True Democrat,* 23 February 1848.
[5] Janesville *Gazette,* 28 December 1848.
[6] Galena *Gazette,* 17 January 1849.
[7] *Ibid.,* 26 December 1848.
[8] Lancaster *Herald,* 24 February 1849.
[9] Janesville *Gazette,* 11 April 1850.

Or if upon thy safe return,
Thou find'st no more thy father here,
Pay one sad visit to his urn,
Drop on his dust one filial tear.[10]

More deliberate humor, generally in the form of parodies of California news, or instructions, was frequently employed in the attempt to make the prospective gold-rusher repent of his decision. A "Treatise on the Yellow Fever (Golden Fever)" written in imitation of the many columns of medical advice then common in the news pointed out that in the early stages of the gold mania "the disease might be easily counteracted by a small dose of common sense" but that in more advanced cases "a pill composed of five grains fear of Cholera, four grains of want of ready funds and two grains of reason will frequently produce a decided improvement." Inveterate cases, however, could be helped only by "an emollient embrocation of the comforts, ease and enjoyment of the patient at home . . . applied to his mind by his wife or some other female attendant."[11]

The editors soon concluded that appeals to morality, sentiment, or laughter would not long deter the westward rush of Wisconsin miners; they quickly turned to arguments addressed to the pocketbooks rather than the hearts of their readers. A Whig paper, for example, pointed out that President Polk's information about the new territory might well be highly suspect, for Polk, said the editor, "looks upon California as his bantling, and is extremely anxious to have it settled."[12] Stories of gold were claimed to be "exaggerated if not idle tales, calculated to draw the imaginative, the restless and improvident away from their regular employment."[13] Speculators who had California lands to sell were also blamed for much of the favorable propaganda, for "persons having lots in that region which at this time sell at the rate of $2,000 for one 36 by 160 ft, desire to see a rush for gold."[14] Even if there was gold in California, the editors agreed, a gold field some 150 miles long by 40 miles wide would not be quickly exhausted, and the gold rusher had no need to participate in any hasty or ill-considered emigration in order to get his share. The propaganda which had a generation earlier produced a rush to the Wisconsin mines was held up as an example of the disappointments which the rushers might expect in California. One editor reminisced that when the lead miners had come to Wisconsin "we found that it was indeed true that some had made from $100 to $200 per day . . .

[10] *Ibid.*, 26 April 1849.
[11] Lancaster *Herald*, 13 January 1849.
[12] Galena *Gazette*, 2 January 1849.
[13] Janesville *Gazette*, 28 December 1848.
[14] Mineral Point *Tribune*, 29 December 1848.

but . . . for every individual that had met with such good fortune there were nine hundred and ninety-nine who barely eked out a subsistence." [15]

News from emigrants on their way to the mines was also a common item in the papers of the lead region. One gold-seeker, writing from Chagres on the Isthmus, reported that "it rains in these latitudes ten months a year" and that even during the dry season the thunder and lightning were so terrific that they shook the ground and left the rattlesnakes and alligators glassy eyed.[16] During the *wet* season he implied things were a good deal worse. Cholera and smallpox were reported to be prevalent on the Isthmus, where they wrought havoc among the weary miners waiting interminable weeks to catch a northward ship to San Francisco. "Under these circumstances," said the Janesville *Gazette,* "nothing but infatuated recklessness is evinced in encountering such hazards, and the safe return of the adventurers is a thing more to be hoped than expected."[17]

The Overland Trail to California, in spite of its hardships, was both quick and cheap and thus attracted the greatest number of gold rushers and produced a correspondingly large number of letters-to-the-editor in the Wisconsin papers. One editor, summarizing reports from the various routes to the mines concluded that "Those who have taken the overland route generally advise their friends not to come that way, while others, taking the isthmus route, give the same advice. For the present we are inclined to consider the advice of each as good."[18]

Many a letter reiterated this editorial conclusion. One emigrant reported that St. Joseph, Missouri, the starting point of the Overland Trail, was "filled with gamblers, thieves, swearers, and others no better" and that "the most abandoned and iniquitous city in the world would turn away with disgust from the exhibitions of demoniac knavery and wickedness of St. Joseph."[19] Pressing westward into the desert, a correspondent reported that "not one man in a hundred at home can imagine so poor and awfully wretched a country as the valley of the Platte" and went on to assure his readers that even this wilderness was "very rich indeed compared with the remainder of the journey, from Fort Laramie to the base of the California mountains."[20]

The newspapers of the 1850's seem to have devoted an immense proportion of their space to advertisements for patent medicines and nostrums reputedly good for the ills of man or beast.

[15] *Ibid.,* 20 February 1849.
[16] Prairie du Chien *Patriot,* 14 March 1849.
[17] Janesville *Gazette,* 22 March 1849.
[18] Mineral Point *Tribune,* 1 March 1850.
[19] Janesville *Gazette,* 16 May 1850.
[20] Galena *Gazette,* 6 February 1850.

Possibly this lively interest in diseases and their cure may have led the editors to suppose that reports of the prevalence of sickness on the road to California might dissuade some of their readers from making the journey. The steamer *Mary,* for example, was reported to have begun a trip to Council Bluffs with four hundred Mormon emigrants aboard, only to bury fifty-eight of them along the way, victims of the dreaded cholera. Epidemics of both cholera and smallpox swept the entire nation, but the editors stressed that they seemed to strike with peculiar severity upon the plains where privation and exhaustion made the emigrants especially susceptible to their deadly ravages. "Not a day passes," said an early letter to the Galena *Gazette,* "that we do not meet with the graves of those who but a month since left home with buoyant hopes and light hearts."[21] Soon, however, the editors found it necessary to abandon this particular line of argument, for the cholera struck so vigorously in the lead mines that Galena in a single week lost one per cent of its entire population, and the citizens may well have begun to believe that even the plains might be healthier than Wisconsin.

Strangely enough the threat of Indian attack on the Overland Trail received very little mention. Only a few items on this subject made their way into the newspapers, and these, in the light of modern-day TV massacres, seem to have been minor and inconsequential scuffles. This lack of stories of Indian attacks, however, was compensated for by the striking and gruesome quality of the *one* story which did circulate widely—the tale of a "Horrible Revenge" which was visited upon the son of a Mr. Green, of Green's Woolen Factory at Fox River:

> It is reported while passing through a tribe of Indians, this young man, naturally full of mischief, killed a squaw. The tribe, having become well advised of the fact, hastened after the company and overtook them and demanded the murderer. At first the demand was resisted but after the Indians had informed them that they would destroy the company if their request was not granted, the youth was surrendered into their hands. They then stripped him and in the presence of his father and the whole company, skinned him from his head to his feet.[22]

The story, of course, appears to be apocryphal, for it is attached to a wide variety of western localities, and the name of the unfortunate victim is variously given as Green, Wasson, Picket, or Esterbrook. Nevertheless, as an invention designed to slow down migration to California it was certainly a triumph of editorial ingenuity. Even though it later had to be repudiated by the various papers which had published it, the tale has become firmly

[21] *Ibid.*,, 26 September 1849.

[22] Council Bluffs (Iowa) *Frontier Guardian,* 1 May 1850, exchanged from an earlier issue of the Galena *Jeffersonian.*

fixed in western folklore. To this day a "Rawhide" pageant is annually given by the townsfolk of Lusk, Wyoming. Each year they find it necessary to get a new man for the "lead."

A less painful problem, but one which was frequently mentioned, was the lack of good food, and the consequent indigestion to be encountered on the plains. One correspondent cautioned his hungry readers against eating too many prairie dogs, for this "causes considerable noise in the lower regions, about the time one wants to sleep, but cannot, for the barking of the dogs." He further pointed out that "as wild meat is of a running breed, and you of a tame one, you needn't be surprised to find yourself running the day after eating it."[23]

Such experiences on the Overland Trail taken all together caused many an emigrant to write back to his home-town paper that "nothing on earth would ever induce me to undertake the trip again," or "had I known, or could I have had the slightest conception of the discomfort of the route by land, I would certainly never have started. No one, not experienced, can form the slightest idea of the privation and suffering to which the traveller over these plains is subjected."[24]

Once in the mines, the emigrant was faced with a problem of making ends meet. Some correspondents said that "California and its gold mines are a perfect farce"[25] and that there was hardly any gold to be had. Others allowed that there was gold to be dug, with the most onerous labor, but that the cost of living, with flour $100 a barrel and other expenses in proportion, made it impossible to save enough to make the trip worth the effort. The thought of buying California whisky at $50 a gallon must have seriously discouraged a good many hard-drinking Cornishmen from ever leaving Wisconsin. The California rainy season, too, when no man could work at all, but living expenses went on just the same, was said to reduce the amount of gold a miner could lay by against his return to the states when he had seen the "bullefant." Even if a miner worked for others and got paid in gold for his labors, the chances were good that he might be given a spurious gold dust made of sulphuret of iron, for the Mineral Point *Tribune* mentioned that a New York manufacturer had "received an order for 700 lbs. of this worthless compound" for the San Francisco market.[26]

With such conditions reported in the mines, it is small wonder that many correspondents wrote, and editors happily printed, letter after letter urging the lead miners not to come to California. "Any

[23] Galena *Gazette*, 17 January 1849.
[24] *Ibid.*, 26 September 1849.
[25] *Ibid.*, 24 October 1849.
[26] Mineral Point *Tribune*, 16 February 1849.

person doing a fair business had better remain at home,"[27] said one. "My advice is, to every one, to stay at home and be content with whatever lot may befall him there, rather than risk health and comfort,"[28] wrote another. "Tell all those who are in good circumstances at home not to come here, for they will surely repent it,"[29] said a third. It may have been good advice, but print it as they would, the editors of the lead region could not substantially diminish the rush of Wisconsin miners to the Pacific coast. By 1850 over two hundred men from Mineral Point alone, including 17 percent of the town's leading citizens, had left for the mines, and it was estimated that adjoining towns had been similarly depopulated. Even the newspapers appear to have suffered, for as a general thing 1850 shows a marked decline in both press and editorial work, indicating that some of the newspapermen, at least, may have departed for the California diggings.

The editors had done their best. Judicious selection of the news from California and diligent editorial comment upon it, alike had failed to stem the tide which flowed westward from the Wisconsin mines. Once started, the California rush had been too big for the editors to stop.

---

[27] Galena *Gazette,* 1 May 1850.
[28] *Ibid.,* 20 March 1850.
[29] *Ibid.,* 6 February 1850.

# OSHKOSH GRADUATES VIEW PUBLIC SCHOOL TEACHING IN LETTERS TO RUFUS HALSEY FROM 1905 TO 1907

*Edward Noyes*
*Professor of History*
*Wisconsin State University—Oshkosh*

To Rufus Halsey, president of the State Normal School at Oshkosh from 1899 to 1907, student welfare was a matter of primary concern. As a consequence, Halsey stressed close professional association with the student body. He fostered an informal sociability between faculty and pupils, and his administration witnessed a great increase over that of his predecessor in establishment of student academic and social organizations. Above all, Halsey believed there was no substitute for personal relationships on campus, and he considered a normal school whose enrollment exceeded five hundred students to be approaching a danger point at which such contact would be lost.

It was from the view of ensuring success in greater achievement of student welfare that Halsey stressed a program of pupil guidance which included counseling on the presidential level. Halsey not only wished the student on campus to have full benefit of presidential guidance, but also believed that if the institution were to serve the "highest interests of the state," its graduates should have the privilege of like counseling. Moreover, he thought it essential that the alumni have proper professional placement, especially those persons qualified for more responsible positions. If this objective were to be realized, there must be continuing study of the graduate's career, and according to Halsey personal contact was the best mechanism for so doing. He told fellow administrators during an all-normal school faculty institute held at Oshkosh in 1900, "You do not know with sufficient definiteness just what your graduates are doing,—how rapidly they have grown professionally . . . , unless by frequent correspondence or visits you come into close touch with their work."[1]

Halsey gave his ideas life by exacting a promise from graduates that they write him twice a year about their employment problems

[1] [Board of Regents of] Wisconsin Normal Schools, *Proceedings of an Institute of the Faculties of the Normal Schools, Held at Oshkosh, December 17–20, 1900* (Madison, 1901), pp. 305–306.

and professional objectives.[2] As a result, a body of letters unique in volume and scope among Oshkosh presidential files are present today in his papers. Extending from 1905 to 1907, the correspondence is mostly of Wisconsin origin, but whatever the source, it is a means for obtaining insights into teaching conditions in public schools at the beginning of the present century. It also reveals teacher attitudes toward those conditions.

Examination of the letters to Halsey discloses that adjustment to community patterns was a matter of first concern to the new teacher who often faced challenges to his or her capacity for adaptability. Carrie A. Parent wrote, "When I reached Racine, mud and rain welcomed me and immediately I found a dislike for the place." But a thoughtful superintendent had seen to it that three Oshkosh graduates be on hand to greet her at the train, and when each invited Carrie to dinner, things improved. Words could not express her delight when she saw the eager faces of her fellow alumni.[3] From Stiles, Eva Whipple confessed that there were several reasons for her not wishing to continue teaching at Oconto Falls. One was that en route to school she must walk over an immense hill and "Oconto Falls people never shovel snow in the winter."[4] From Theresa, Milton V. Jones informed Halsey that he had a busy classroom schedule, but no social life. "The people are pleasant," he stated, "but that is about as far as it goes. The saloon draws too much. With a population of about four hundred the town supports eight saloons and two breweries."[5] Ruby V. Fuller voiced a similar complaint at Elkhart Lake. Ruby remarked, "The town is entirely German and I can neither speak nor understand German. Besides this the place is so decidedly immoral that I do not care to stay. . . . They think of nothing but card-playing and beer drinking Sundays and every other day in the week. There is no English church. . . ."[6] Not everyone could report to Halsey as happily as did LaVergne Wood and John N. Stover. LaVergne taught in her home town of Brandon and consequently faced no arguments over which church she should attend and whether she should sing in the choir.[7] John taught at Cambridge where there were no saloons and the residents were "rich, retired farmers who on the whole believe[d] in good education, temperance, and churches."[8]

---

[2] State Historical Society of Wisconsin, Archives Division, Wisconsin State University, Oshkosh, President, Alumni Correspondence, Letters Received, series 90/1/1–1, Sara Bennett Jones to Halsey, September 11, 1905, mentions the requirement of writing twice a year. Hereinafter, all citations of letters to Halsey will be by date only.

[3] April 20, 1967. The letters cited in this article were written more than sixty years ago and hence have no bearing on present conditions in the communities mentioned.

[4] September 21, 1905.

[5] April 28, 1906.

[6] June 7, 1906.

[7] April 8, 1906.

[8] February 25, 1907.

Not all the teacher-graduates experienced difficulty in adjusting to community ways, even if they endured trying moments or were homesick for parents and friends or perhaps their *alma mater*. Resourceful individuals soon developed social outlets or became absorbed in their new surroundings. W. W. Werndlandt was admittedly "[un]acquainted with the rules of backwoods society" when he arrived at Elcho, but he came to know the tough lumberjacks and found the school board president courteous. And, although his pupils uttered threats against him and some residents showed "greed for the all-mighty dollar and . . . public recognition [sic]," Werndlandt thought Elcho a good place for "one interested in human nature in all its phases."[9] Moreover, teachers enjoyed occasional diversions from daily routine. At Embarrass, Louis U. St. Peter taught, it is true, in a building he described as "ramshackle," but he was intrigued by Indians who came from Keshena to pick cranberries in a marsh nearby and proceeded to stage a war dance after consuming intoxicants bought with their wages. Louis thought the dancing looked "very foolish," but even so he conceded it was "most amusing."[10]

A great tide of immigration was sweeping America at the turn of the century, and children of newcomers posed a worrisome problem for some Oshkosh alumni, mostly over lingering traits associated with cultural or social backgrounds. From Hilbert, Emily N. Cherosky outlined objections to the children's habit of using the German language at school. "I have told them they must not speak German within the school grounds. Am I right in doing so?" she queried.[11] From Sheboygan, Perly Thackray confided that her class were "all foreigners and [could not] speak a word of English, some . . . came from Russia only a few months ago. I haven't any American children. . . ." Moreover, Perly regarded her pupils as deficient in cleanliness and politeness. They did not know what to do with their hands.[12] Sophia Berge, who taught the first grade at Norway, Michigan, found herself in a quandary over a class entirely ignorant of English. "It is pretty hard to give these children regular first grade work," said Sophia.[13] Catharine E. Dolan wrote from Milwaukee that her pupils of foreign extraction were "not nearly as bright" as youngsters she had taught elsewhere.[14] And, Clara M. Calvert believed that if it were not for a strong principal in her school at Iron Mountain, Michigan, "extremely hard work" would result from disciplinary problems with immi-

[9] December 9, 1905.
[10] March 17, 1906.
[11] November 8, 1906.
[12] February 19, 1907.
[13] May 6, 1907.
[14] October 21, 1905.

grant pupils. To Clara, such children were "only about half civilized."[15]

But other Oshkosh graduates enjoyed the immigrant child. Ethel C. O'Leary wrote from Ironwood, Michigan, that although she had to "adapt" herself, she was "very proud of [her] fifty-two little Finns and Sweeds [sic]."[16] And, at Merrill, Wisconsin, Sara J. Morissey thought her forty-two children who represented "nearly every country in the Universe," were "all lovely." She wished that Miss Rose Swart, the Oshkosh normal school supervisor of student teaching, could visit her class. Sara said, "I know she would laugh. The children have such queer expressions, their vocabularies being so limited."[17] Josephine E. Gannon also enjoyed her immigrant pupils. "They seem like flowers in a bud," she remarked.[18]

Backward economic and social aspects of community life were another concern to the Oshkosh teacher-graduate. From Sheboygan, Ida C. Brown alleged that in a majority of homes in her school neighborhood, "every cent that can be spared from . . . getting the bare necessities of life is spent in the saloon. I have called at many . . . homes, and the standards of living in them, the conditions under which the children are being raised are appalling." Two years later, she stated, "In our ward we contend with the hardest of social conditions. Long before the pupils reach the fifth grade they are 'hard cases.' " Ida wished to instill ideals into her pupils each of whom she believed to possess good traits. But the goodness was often so deeply buried, months passed in uncovering it.[19] From the same city, Vesta Tibbits described poverty's effect upon school attendance. To assist with family income, many youngsters left school at the fifth grade, and classes dwindled accordingly. In 1904, there were [in her school?], fifty-six children in the fourth grade, twenty-six in the sixth, and only eight in the eighth.[20] Extra curricular activities also felt the impact of the working pupil. Oscar B. Thayer, teaching at Ashland, was unable to organize a football team because parents were poor and it was necessary for their sons to work after school to help earn the family livelihood.[21] And, from Mellen, Walter P. Hagman wrote that his pupils who were largely of foreign parentage would not stay in school as required by law. "Some children leave the very day they are fourteen," Hagman reported.[22]

---

[15] March 9, 1906.
[16] November 5, 1905.
[17] March 6, 1906.
[18] March 9, 1907.
[19] October 8, 1905, and January 11, 1907.
[20] October 14, 1905.
[21] October 28, 1905.
[22] October 28, 1905.

Historically, pupil disciplinary problems have troubled teachers, and many of Halsey's correspondents discussed lack of discipline, especially on the part of their predecessors. Some brought him their cares in this area. From Mondovi, Clara E. Tompkins reported excellent results from administering corporal punishment to three recalcitrants,[23] and J. W. Riley was no less successful in punishing an unruly youth at Racine. Riley was forced to take stern measures, however, and said, "I got along all right with him until today, when I *had* to give him an *old timer*, a *gentle reminder*, a *pusher*, and a *persuader*. He is much taller than I . . . and tried to handle me, . . . he came out a bad second best."[24] But from Nekoosa, Mabel M. Hall told a different tale. Mabel had attempted to correct a naughty boy striking him "smartly across the shoulder . . ." with a pointer, but the lad dodged and the blow fell upon his head. Bleeding followed, and when a resultant investigation ended, Mabel was jobless.[25]

The Halsey materials also contain abundant indications of teacher unrest over low wages. Indeed, the average wage for female teachers in the county schools of Wisconsin for the school year 1906, was only $39.75 and that of males $62.34.[26] It was little wonder that Daisy M. Rich, who was teaching at Marshfield, thought wages "in most towns were not much more than enough to live on,"[27] and at Rhinelander, Clara Christensen commented, "salaries are so low, and living expenses so high, that one can hardly afford to stay. . . ."[28]

There were exceptions to the rule. W. A. Werndlandt enjoyed a monthly salary of $70 at Elcho; he remarked, however, "It is worth it to live . . . here."[29] Edwin S. Billings was fortunate in receiving a like sum at Footville in 1907, but the figure included pay for essential janitorial duties. Thus, if a janitor were hired from his income, Billings would suffer a wage reduction. Besides, he believed that if the work were to be done properly he must do it himself. "This is a serious objection to the position," Billings observed.[30]

If board and room were high-priced and interest on teachers' loans expensive, the financial aggravation was deeper. Catherine E. Dolan's school board at Mondovi not only held back a month's

---

[23] October 30, 1905.
[24] January 23, 1906.
[25] December 11, 1905.
[26] *Thirteenth Biennial Report of the Department of Public Instruction of the State of Wisconsin July 1, 1906–June 30, 1908* (Madison, 1910), part II, p. 9, in volume II, State of Wisconsin, *Public Documents of the State of Wisconsin Being the Reports of the Various State Officers, Departments and Institutions, for the Fiscal Term Ending June 30, 1908.*
[27] January 27, 1907.
[28] April 22, 1907.
[29] October 21, 1906.
[30] April 23, 1907.

pay but also refused a contract until her second month of service. Meanwhile, Catharine could borrow money in order to live, but the interest she must pay was seven per cent.[31] J. J. Rettles, who taught at Westhope, North Dakota, earned fifty dollars a month, but his board cost twenty-five. The authorities paid Rettles by warrant, and if the treasury held sufficient funds, banks cashed the paper at full value. Otherwise, they discounted it at five per cent, thus reducing Rettle's salary through no fault of his own.[32]

There were those teachers who exerted pressure on the authorities for salary increments. After receiving half-hearted promises of an increase in pay, Idella D. Ray went so far as to warn her board that following Christmas she would not return to her post at Washburn. Idella's pluck resulted in a five-dollar-a-month increment which she thought was her due; nevertheless, she told Halsey that she felt guilty of misconduct.[33] It was a happy exception to most cases involving wages when George N. Murphy explained that he had unexpectedly received five dollars more per month than he had contracted for at Peshtigo—the board had decided to give him the same rate as that of his predecessor. "I felt greatly encouraged and have endeavored to give the people here full value for their money," he wrote.[34]

But for most teachers, finding a better paying position—perhaps in a big city—seemed the solution to inadequate income. This meant that to aid those seeking higher pay as well as individuals desiring professional advancement, Halsey became a one-man employment bureau answering dozens of calls. He helped more than one Oshkosh graduate to greater success, but he thought teachers should help maintain salary standards by not accepting too low wages.[35]

Compounding teacher unrest due to modest wages, were frustrations ranging through the course of professional life and experience. Jennie Goesling deplored lack of opportunity for self-improvement at Iron Mountain, Michigan,[36] and at Peshtigo, Wisconsin, principal Robert Wendt considered buildings so poor and crowded that good work was impossible. He decided to quit.[37] John M. Lorscheter, writing from Granton, told Halsey in an undated letter of January, 1907, that he was teaching fifteen classes a day and "The Board here has but little or no idea of what a teacher can and should do. They think all that is necessary is to

[31] July 17, 1905.
[32] December 26, 1905.
[33] December 22, 1905.
[34] May 23, 1907.
[35] Halsey to Agnes Haigh, August 8, 1908.
[36] February 26, 1906.
[37] February 27, 1906.

keep good order, while teaching should be . . . secondary. . . ." Lorscheter had reversed things, but had run into opposition in so doing. He would have written more, but he told Halsey "it only tires you to read our mournful tales." And E. M. Pauly, principal at Dunbar, was distressed over living conditions. "There is no possibility of getting any house to live in except such as is overrun with vermin," he stated. Pauly wished he were back at Oshkosh but nonetheless was attempting to inculcate his classes with the ideals of his *alma mater* whose wholesome influence came back to him "as sweetest remembrances and renewed inspiration."[38] From Bayfield, Sara Bennett Jones remarked that she almost hated the place because of parental interference with school work.[39] Nor was this all. At Footville, Edwin S. Billings thought it necessary to take residence in a hotel where gossips could not reach him so easily after a disturbance occurred over his re-grading the school.[40] And at Catawba, Bert Williams lost his position when the townspeople "voted to have all female teachers."[41]

But not all teaching situations were insurmountable. From Abbottsford, Henry E. Polley reported, "The only trouble of any consequence this year has been an attack by a village clergyman (Presbyterian). He is greatly alarmed about the idea of evolution that some h[igh] s[chool] pupils became interested in. He preached against a study of it in any way. . . . Yet we are not much alarmed for his influence in any matter is not very much."[42] And, although Markesan did not offer social diversions, Alta L. Pepper informed Halsey that her teaching assignment there was an improvement over her former post at the Northern Hospital [for the Insane]. Alta wrote, "there isn't the restraint and nervous strain experienced there."[43] From Mellen, Laura Walker wrote that she enjoyed her work, and liked the progressive spirit and invigorating climate of the North although "The thermometer registered fifty-two degrees below zero last week."[44] And if R. M. Radsch experienced difficulties in obtaining satisfactory pronunciation of English words from his German pupils at Oakwood, Wisconsin, he found the quiet life of the town delightful and "joy of joys, a fine compound microscope" with which he was attempting to duplicate biological work he had once accomplished on the fourth floor of the Oshkosh normal school building.[45]

[38] April 13, 1907.
[39] February 17, 1906.
[40] November 17, 1906.
[41] July 3, 1907.
[42] January 19, 1907.
[43] March 17, 1906.
[44] February 10, 1907.
[45] November 5, 1905.

Finally, the teacher-graduate letters to Halsey reveal a pride in the Oshkosh training program and a determination to fulfill the mission of their *alma mater*. Not a few disclose the influence of Halsey whose personal and professional standards were firm and unimpeachable. Oshkosh graduates often submitted their teaching to self-appraisal, and if needed, determined to correct shortcomings. Sometimes they viewed the work of others with a critical eye. At Ashland, Emma L. Saxton did not consider her principal—a Milwaukee normal school alumnus—to be as thorough and progressive as an Oshkosh man would have been. "But I can forgive him," she wrote.[46] Emma J. Schulze, whose schedule at Whitehall included English composition, Literary Readings I, II, and III, plus Ancient and American history, civics, and all the music taught in her school, was grateful that "One of best things I acquired there [at the Oshkosh normal school] was a habit of systematic hard work." Moreover, Emma considered Oshkosh methods as "good as gold" when put to the practical test.[47] And, something of Halsey's image as an educator is discernible in a letter of Arthur Sperling who taught at Random Lake. Sperling wrote, "One finds that to conduct a school successfully, one has to gain the good will and fellowship of the students, not by favoritism, but by square, open dealing and careful judgment."[48] The same could be said of H. C. Leister who wrote from New London, "The world, as a whole, has no need for the pessimist and much less does the teaching profession need the pessimist. The teacher must be an optimist."[49]

Rufus Halsey died in July, 1907, as the result of a shooting accident.[50] With his passing, the students lost a sincere counselor and warm friend devoted to serving their best interests. Halsey's tenure as president of the Oshkosh Normal School was the shortest of its kind, but no other presidential file discloses a similar relationship existent between the alumni and the school head. To accomplish his purpose of assisting the graduates, Halsey needed to follow the students' careers and to acquaint himself with their problems and hopes. The students responded, and their letters, written in frankness, provide a documentary portrayal of the school and the teacher of two generations ago.

---

[46] February 4, 1907.
[47] January 29, 1906.
[48] December 8, 1905.
[49] April 6, 1907.
[50] See *The Oshkosh Normal Advance*, Memorial Issue, September, 1907, for reviews of Halsey's work as an educator, and the *Oshkosh Daily Northwestern*, July 26, 1907, for details concerning his death.

# GINSENG: A PIONEER RESOURCE

*A. W. Schorger*

Father Jartoux (1810), while in China, was ordered by the Emperor to prepare a map of Tartary. He was at a village in the latter country, when the natives brought him four ginseng plants which they had collected in the mountains. A letter from him, dated Peking, April 12, 1711, and published in Paris in 1713, described the plant and its medicinal properties. He thought that the plant would be found in other countries, particularly Canada. The Jesuit missionary Lafitau (1718), stationed at the mission of Sault St. Louis, chanced to read the letter and began, with the aid of the Indians, a search for the plant which resulted in its discovery near Montreal in 1716. Two years later he published a monograph on ginseng in Canada. The new edition of the book contains considerable information on the commercial history of ginseng in Canada.

The Chinese have long considered ginseng to be a sovereign remedy, and placed special emphasis on its virtue as an aphrodisiac. Kalm (1772), stated that the French used it for asthma, stomach disorders, and promoting fertility in women. Medical science has been unable to confirm any of the claimed physiological results.

The discovery of ginseng *(Panax quinquefolium)* in Canada was likened to that of gold in California and Australia. The root was very profitable to the small traders since a pound costing 2 francs in Quebec, sold as high as 25 francs in Canton. In one year there was sent to China ginseng valued at 500,000 francs. In 1751, owing to the great profit to be realized, the *Compagnie des Indies* monopolized the ginseng trade. The price paid in Canada ultimately rose to 80 francs (Garneau, 1882). This was a sufficient incentive to send everybody into the woods, and ginseng was collected out of season and regardless of age. In addition it was dried in ovens, further lowering the quality. The product was unacceptable to the Chinese, so that the Canadian trade decreased sharply by 1754, in which year the exports dropped to 33,000 francs.

Kalm (1772), was in Quebec in August, 1749. He states that at Quebec, in the summer of 1748, ginseng sold at six francs a pound, though the usual price was five francs. The demand for ginseng was so great that all the Indians near Montreal were searching for the root so that the farmers could not hire, as usual, a single Indian to assist in harvesting their crops.

The furcated root (Fig. 1) is in the greatest demand owing to the fancied resemblance to the thighs of a man. The value of the root, in the eyes of the Chinese, is enhanced by being rendered semitransparent by steaming, sometimes in the presence of sugar. The root should be five to seven years of age, and should not be dug until the latter part of August and preferably in September and October. Indiscriminate collecting has eradicated the plant from much of its range which is largely east of the Mississippi. Several states have passed protective laws. Wisconsin (1905) passed a law prohibiting the digging of wild ginseng between January 1 and August 1, or dealing in green ginseng between these

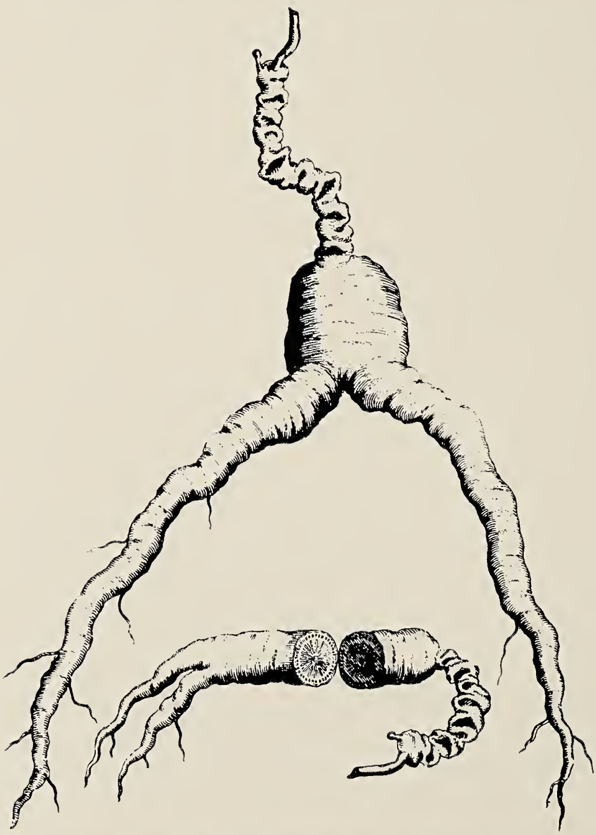


FIGURE 1. Root of ginseng (After Lafitau).

dates. In 1923 the owner of the land was excepted from the restrictions. The roots when dug should be washed thoroughly, and dried carefully at a moderate temperature to prevent molding. About two-thirds of the weight is lost in drying.

The fame of ginseng spread from Canada to New England, New York, and westward. The first settlers of Vermont found the plant in abundance. For a long time ginseng was purchased by most of the retail dealers in the state, the roots in the "crude state" bringing 34 cents a pound (Thompson, 1853). It was supposedly discovered in western New England in 1750 (Williams, 1809). Rev. Jonathan Edwards, in 1752, wrote to a friend in Scotland that ginseng had been discovered at Stockbridge, Massachusetts, the year previous (Speer, 1870). The Albany traders were eager buyers of the article for export to England. The discovery had a demoralizing effect on the Indians. Young and old ranged far and wide to collect it. This kept them from public worship, and when in Albany to sell the product, they were subjected to various vices. In 1773, the *Hingham,* sailed from Boston to China with 55 tons of ginseng (Williams, 1957).

The trade in ginseng, colloquially called "sang," from the beginning was largely in the hands of the fur traders. The American Fur Company handled the root. Astor is reputed to have made, in 1782, the first shipment of ginseng to China following the revolution.* Astor (1910), in 1815, wrote to Ramsay Crooks that the ginseng should reach New York by the first of May. Even today most of the wild ginseng is purchased by fur buyers.

One of the early dealers in ginseng in New York was Sir William Johnson (1721–65). His papers contain numerous references to the trade. On November 29, 1750, he delivered 41 pounds of ginseng. A letter of September 12, 1751, to Samuel and William Baker, London, inquired for the price of ginseng to be expected in England. He had most of the members of the Five Nations gathering ginseng, and, owing to its scarcity he had obtained only four hogsheads over a period of three months. If ginseng sold under 12s. a pound he would be a loser. In 1752 he heard of ginseng selling from 32s. to 40s. a pound. The plant could not have been scarce for in 1766 the chief of the Tuscaroras asked for a trader as it was plentiful in their country. A shipment of ginseng which Johnson sent to London in 1759 was valued at £ 144.4.7. Ginseng was highly profitable to the buyers in 1752, but the following year they were nearly ruined. The Indians in Broome County, who had

* L. T. Williams, l.c. p. 344. The date at least is incorrect since Astor did not arrive in America until 1783 and did not engage in the fur trade until the following year.

collected it in large quantities, however, benefitted considerably (Hawley, 1850).

The Moravian missionaries (Beauchamp, 1916) among the New York Indians in 1752, depended heavily on the ginseng which they dug to furnish their necessities, such as blankets and shoes. When they arrived at some of the Indian villages, they were nearly depopulated as the inhabitants were away gathering ginseng. The demand for ginseng seems to have been low in 1755 for the missionaries received for their roots only a traveler's kettle from a reluctant trader.

The noble, Daniel de Joncaire, Sieur de Chabert et de Clausonne, was sent to the Bastile in Paris in 1761 to await trial for undoubtful corruption in handling supplies for Fort Niagara. He used ginseng in his defense: "I enjoyed a prosperity acquired by the most legitimate means. . . . This is the chief source of my fortune. The craze for ginseng spread from Europe to Canada. My connection with the Indians made it possible for me to profit by this. They gathered this plant as much as I wished, at 15 livres the pound; it sold at Montreal for 24 livres. If this trade had lasted a longer time, I could have made great loans to the State and the King" (Severance, 1917).

Attempts were made frequently to propagate ginseng in Europe though the seed will not germinate or the root grow if allowed to dry. Barbé-Marbois (1929) was in the Oneida Reservation in September, 1784, where he had engaged an Indian to collect five or six barrels of ginseng to be shipped to France for transplanting. His statement that, prior to the discovery of ginseng in America, the supply from Tartary was so limited that in China it was worth its weight in gold, shows the incentive.

The early settlers of New York also collected ginseng. The inhabitants of the town of Kirkland, Oneida County, were greatly in need of food in 1789 on account of a crop failure the previous year. A local merchant accepted ginseng in payment for supplies in place of gold and silver (Durant, 1878). It is surprising that the plant persisted in quantity for so long a period. Dwight (1822) wrote in September, 1799, that the Brothertown and Oneida Indians, near Clinton, New York, at that season, collect annually a thousand bushels of ginseng for which they receive two dollars a bushel. Most of it was sent to Philadelphia, thence to China.

Philadelphia remained for many years the principal port for export. In 1752 it was hoped by the merchants of this city that a market for ginseng could be created in England. This hope did not materialize and by 1772 ginseng was no longer exported to England (Jansen, 1963). While Schoepf (1911) was at Laurel Hill, Pennsylvania, he met a man with two horses carrying 500 pounds of ginseng bound for Philadelphia. Much was brought to Fort Pitt. An energetic man could collect 60 pounds in a day. The price paid was about a shilling sterling per pound. In going over the Alleghany Mountains in September, 1794, Washington (Fitzpatrick, 1925) met "numbers of persons and Pack horses going in with Ginseng."

The members of the Moravian Mission (New Salem) on the Huron River, northern Ohio, relied largely on ginseng for support. Zeisberger (1885) recorded on August 29, 1787, that nearly all the brethren were gathering ginseng. There was a great demand for it, while skins were worthless. The price was $3.00 a bushel. The plant was abundant in some places and scarce in others. Where plentiful a man could collect a full half-bushel in a day. There was a big demand for ginseng in Ohio in the period 1798–1808 (Hildreth, 1852).

Large amounts of ginseng were purchased by Daniel Boone in Kentucky (Bakeless, 1939). Owing to the absence of an Indian population, the collection of the roots must have been made largely by the white settlers. He personally collected some ginseng. The winter of 1787–88, he started up the Ohio in a boat containing nearly 15 tons of ginseng. The boat overturned, and before the cargo could be salvaged and transported to Philadelphia the price had declined. Undismayed he had on hand 15 "caggs" of ginseng in the fall of 1788.

According to the botanist Michaux (1805), ginseng in 1802 was the only product from Kentucky that would bear the cost of transportation overland to Philadelphia. It was collected by people having some leisure, and by hunters who carried a digging tool in addition to a rifle. A collector seldom dug more than 8 or 9 pounds of the roots in a day. These roots were less than an inch in diameter even after an age of fifteen years. He received a shilling for the dry roots which brought twice that amount in Philadelphia. The process whereby the Chinese rendered the roots transparent, i.e. by steaming, was considered a secret, although knowledge of it was long known, and worth 400 piasters (dollars). Some of the Philadelphia merchants paid six or seven piasters per pound for the beneficiated roots.

Large quantities of ginseng were being sent to China from Wisconsin and Minnesota in the 1860's (Speer, 1870). About 1845, Green County, Wisconsin, was known as the "sang" country. The supply was soon exhausted as men, women, and children devoted their leisure time to collecting the roots. A. Ludlow of Monroe purchased all that was available for shipment to New York. A boy in 1846 within three months, collected 500 pounds for which he received $0.22 a pound (Bingham, 1877). Much was collected in the Bark River woods, Jefferson County, where it was abundant (Warner, 1930). As late as 1900 ginseng could still be found in the county in considerable amount. John Hooper obtained about 5000 plants annually during the three years 1904–1906, by personal collection and purchase of a small number (Moore, 1940). There does not appear to have been any early interest in the plant in Dane County. In 1893, it was said of ginseng in the vicinity of Madison: "Occasional in rich woods. Becoming rather rare" (Cheney, 1893).

The collection of ginseng received much attention in Sauk County. Charles Hirschinger, when ten years of age came with his family to a farm near Baraboo in 1847. As an aid to the family, he dug ginseng for which he received a few cents a pound (Cole, 1918). Mrs. L. H. Palmer, a widow, with the aid of her children collected and sold at a dollar a pound, sufficient ginseng to pay the mortgage on her place. Thousands of pounds were dug in the town of Ironton. Though initially bringing a dollar a pound, the price fell to fifty cents; nevertheless, ginseng brought comfort to many families. This was particularly true about 1859, when times were difficult (Western Hist. Co., 1880). During June of this year the merchants at Tomah were doing a thriving business in ginseng which was to be found in quantity to the southward (Tomah, 1859). However, a New York firm, Schiffelin Brothers and Company, contributed a letter stating that ginseng was not in the best of condition until fall, and should not be collected before that time (Ripon, 1859).

Within a few weeks, in the spring of 1859, over $1200 had been paid for ginseng collected in the valley of the Baraboo River. The price of 12½ cents probably represented that of the green root (Baraboo, 1859). At this time the number of diggers of ginseng in the Trimbelle woods, Pierce County, was estimated at 300. One load of about 1200 pounds was noticed. The price of the green root was 9 to 10 cents a pound. Fraudulent practices consisted in soaking the roots in water and inserting sand into the large ones (Prescott, 1859).

Men and boys about 1860 were occupied in digging ginseng in Dunn County. Haugen (1927) relates that in the summer of 1861 he went with a party to Maple Springs, town of Eau Galle, and spent a month digging the roots. The men received six cents a pound, and individuals sometimes dug as high as thirty pounds a day. The boys received six dollars a month and board. In the spring of 1864 speculators were paying fifteen cents a pound for the green root at Menomonie. Ginseng to the amount of $8,000 had been purchased (Menomonie, 1864). At the same time ginseng was in great demand at Mauston (Mauston, 1864). The occupation of George W. Shaffer, of Downsville, was farming and digging ginseng (Forrester, 1891–92).

Ginseng was plentiful in 1866 in the town of Rock Elm, Pierce County, and was worth ten cents a pound in the green state. The ginseng trade revived at Ellsworth in the fall of 1875, and twenty cents a pound was paid for it (Ellsworth, 1875). This price prevailed in 1878 (Ellsworth, 1878). Trade was active in 1879. E. L. Davis advertised for 100,000 pounds of ginseng. Sanderson and Campbell were shipping several hundred pounds weekly. The initial price of thirty cents a pound soon fell to twenty cents (Ellsworth, 1879). E. R. Condit of the village of Rock Elm, in the fall of 1880, had on hand two tons of ginseng which he had purchased. It was "the only legal tender in exchange for goods at our store, bringing 15 cents a pound" (Weld, 1906). J. P. Fetherspil came to the town of Springfield in 1896, and acquired a wide reputation as a collector and grower of ginseng (Easton, 1909).

Ginseng was a boon to the settlers of Vernon County in the years 1854–1856 (Rogers, 1907), as in the dry condition it brought from $0.50 to $1.00 a pound (Union Publ. Co., 1884). Owing to the scarcity of money, ginseng circulated as currency. In the town of Liberty, a young couple about to be married, brought with them an artistically arranged basket of ginseng with which to pay the minister (Stout, 1899).

Most of the ginseng marketed in the northern counties was collected by the Indians. In the 1870's, Fred E. Bailey had a trading post at Rice Lake, Barron County. He hired Indians to dig ginseng and trap furbearers (Gordon, 1922). Indians, in the 1880's and 1890's, came to Perkinstown, Taylor County, to collect ginseng, which was also purchased from them in the town of Hammel (Latton, 1947). John Brinkman, in Wood County, began trading with the Indians about 1880. One season he bought nearly $3000 worth of ginseng, paying $2.00 a pound for it (Jones, 1923). Only a few years prior to 1922, Indians came to Antigo, Langlade County, to sell ginseng and other products which they had gathered in the woods (Dessureau, 1922). In Lincoln County the Indians obtained from $2.00 to $5.00 a pound (Drew, 1898).

The most extensive recorded experience in collecting ginseng is that of Jabez Brown (1855) in Sauk County. His first entry is for September, 1855. On the 25th of this month he dug a bucketful. On July 16, 1858 he dug 15 pounds of green roots. He and his father on September 10 dug about 20 pounds each, and each made about $1.50. His entry for September 18 reads in part: "I hunted sang all day but got but about half a bushel. I came home late very tired. It is curious to see what excitement the Sang business has got up in this country. All classes of men are digging. Some make as high as three dollars per day. I have dug from ten to about twenty pounds per day of green roots. In the extreme money pressure it is all the article that will fetch cash or goods. Some individuals have dug hundreds of lbs. and in Bad Ax, Sauk and Richland Cos. thousands and thousands of lbs. have been dug. Men go out with wagons and teams and provisions and bedding and camp in the woods to dig Gin Sang."

The fall of 1858 Brown began buying ginseng to take to market at Richland Center where he arranged with a merchant to deliver from two to four hundred pounds at 37½ cents per pound. The ginseng was purchased in small lots for which he paid from 30 to 32 cents a pound. On October 11, he and an associate sold 382½ pounds in Richland Center at 38 cents a pound. Within a few years the price increased greatly. In July, 1870, a merchant at Richland Center paid $3.00 per pound for the dry product, and the following year $3.75 (Pease, 1870).

Statistics on the early trade in ginseng in Wisconsin are almost entirely wanting; however, the state is reported to have shipped ginseng to the value of $40,000 in 1858 and $80,000 in 1859 (Nash, 1895). As soon as the wild plant became scarce, attempts were made to cultivate it. In 1877 it was stated that all attempts to grow it in Wisconsin ended in failure. One man after spending several hundred dollars was unsuccessful in growing it from seed (Ann. Rept. 1877). Eventually the difficulties were overcome so that most of the ginseng exported today is from cultivation. It is one of the wild plants which does not conform readily to man's ministrations. The tribulations of the Fromm Brothers in growing it in Marathon County have been well described (Pinkerton, 1953).

## References

Ann. Rept. Com. Agr. for 1877. p. 545.

Astor, J. J. 1910. Letter, N. Y., Feb. 14, 1815. Wis. Hist. Colls. 19:369.

Bakeless, John. 1939. Daniel Boone. New York. p. 331.

*Baraboo Republic*, June 30, 1859.

Barbé-Marbois, F. 1929. Letters . . . 1779–1785. New York. p. 204.

Beauchamp, W. M. 1916. Moravian journals relating to central New York. Syracuse. p. 113, 120, 122, 124–27, 132, 134, 138, 153–54, 203, 243.

Bingham, H. M. 1877. History of Green County, Wisconsin. Milwaukee. p. 118, 119.

Brown, Jabez. 1855. Diary. Wis. Hist. Soc. Library.

Chaney, L. S. and R. H. True. 1893. On the flora of Madison and vicinity. Trans. Wis. Acad. Sci. 9:72.

Cole, H. E. 1918. A standard history of Sauk County, Wisconsin. Chicago. I:69, 84.
Dessureau, R. M. 1922. History of Langlade County, Wisconsin. Antigo. p. 2.
Drew, Lola E. [1898?] History of the Indians [of Lincoln County]. MS. Wis. Hist. Soc.
Durant, S. W. 1878. History of Oneida County. New York. p. 457.
Dwight, T. 1822. Travels: in New England and New York. New Haven. 3:182.
Easton, A. B. 1909. History of the St. Croix Valley. Chicago. p. 920.
*Ellsworth Herald*, Aug. 4, 1875.
———. June 19, 1878.
———. June 11, 18, 25; July 2, 9, 1879.
Fitzpatrick, J. C. 1925. The diaries of George Washington. Boston. II:289.
Forrester, G. 1891–92. Historical and biographical album of the Chippewa Valley, Wisconsin. Chicago. p. 600.
Garneau, F. X. 1882. Histoire du Canada. Montreal. II:154.
Gordon, S. and F. Curtiss-Wedge. 1922. History of Barron County, Wisconsin. Minneapolis. p. 198.
Haugen, Nils. 1927. Pioneer and political reminiscences. Wis. Mag. Hist. 11: 139.
Hawley, J. 1850. Journey to Onohoghgwage in 1753. Doc. Hist. N.Y. 2:1035.
Hildreth, S. P. 1852. Biographical and historical memoirs . . . settlers of Ohio. Cincinnati. p. 308.
Jansen, A. L. 1963. The maritime commerce of colonial Philadelphia. Madison. p. 93.
Jartoux, Pére. 1810. Lettre. Lettres édifantes et curieuses. Toulouse. 18:97–110; 1714. The description of a Tartarian plant called gin-seng. Phil. Trans. Roy. Soc. London. 28:237–247.
Johnson, Sir William. 1921–1965. Papers. Albany. I:311, 346, 373; 12:168; 13:126.
Jones, George O. 1923. History of Wood County, Wisconsin. Minneapolis. p. 11.
Kalm, P. 1772. Travels in North America. London. II:272–273.
Lafitau, Joseph Francois. 1718. Concernant la précieuse plante du gin seng la Tartarie decouverte en Canada. Paris. 88 pp.; 1858. New ed. Montreal. 46 pp.
Latton, A. T. [1947]. Reminiscences and anecdotes of early Taylor County. n.p. p. 33, 43.
*Mauston Star*. June 8, 1864.
*Menomonie Lumberman*. June 18, 1864.
Michaux, F. A. 1805. Travels to the westward of the Allegany Mountains. London. p. 158, 207–212.
Moore, E. B. and R. Sanford. 1940. Spring flora on Farmer's Island, Lake Mills, Wisconsin. Trans. Wis. Acad. Sci. 32:71–74.
Nash, G. V. 1895. American ginseng: its commercial history, protection, and cultivation. U.S.D.A., Div. of Botany, Bull. 16:22 pp.
Pease, D. E. 1870. Account book. Wis. Hist. Soc. Library.
Pinkerton, Kathrene. 1953. Bright with silver. New York. 364 pp.
*Prescott Democrat*. June 28, 1859.
*Ripon Times*. July 15, 1859.
Rogers, E. M. 1907. Memoirs of Vernon County. Madison. p. 52.
Schoepf, J. D. 1911. Travels in the Confederation (1783–1784). Philadelphia. p. 236.
Severance, F. H. 1917. An old frontier of France. New York. II:405.

SPEER, W. 1870. The oldest and newest empire. Cincinnati. p. 61.
STOUT, STANLEY. 1899. History of the town of Liberty, Vernon County, Wis. MS. Wis. Hist. Soc.
THOMPSON, Z. 1853. History of Vermont. Burlington. I:221.
*Tomah Chief*. June 25, 1859.
Union Publ. Co. 1884. History of Vernon County, Wisconsin. Springfield. p. 664.
WARNER, MRS. AMBROSE. 1930. Recollections of farm life. Wis. Mag. Hist. 14:196.
WELD, A. P. The story of Pierce County. *Spring Valley Sun*, Feb. 22, 1906.
Western Hist. Co. 1880. The history of Sauk County, Wisconsin. Chicago. p. 626.
WILLIAMS, L. O. 1957. Ginseng. Economic Botany 11:344.
WILLIAMS, S. 1809. The natural and civil history of Vermont. Burlington. I:85–86.
Wisconsin. Chapter 194, Laws of 1905, Secs. 1481 a–e.
ZEISBERGER, D. 1885. Diary. Cincinnati. I:366, 369; II:48, 54.

# LAKE SIZE AND TYPE ASSOCIATED WITH RESORT LOCATIONS AND DENSITY IN NORTHEASTERN WISCONSIN: I. ONEIDA–VILAS AREA

*L. G. Monthey**
*The University of Wisconsin*
*Madison, Wisconsin*

SYNOPSIS

Of the 2,450 lakes in the Oneida–Vilas region of Northeastern Wisconsin, 951 are named lakes and 301 of these were used by resort establishments in 1964. They contained 1,206 resorts, or slightly over 25% of the State's total. In general, about three-fourths of the resorts were situated on drainage-type lakes over 100 acres in size with a medium to high fertility rating. However, over 10% were on lakes of 100 acres or less, and over 20% were on lakes classed as low or very low in biological productivity. Further, about one-fourth of all resorts had less than 40 acres of available water surface (per resort), and one-fifth had a shoreline factor of less than 0.5 mile. Almost 4% of the resorts were on 21 shallow lakes which were subject to periodic winterkill. Dwelling density on the resort lakes averaged 6 buildings per mile of shore, with a range of 0 to 20 dwellings per mile. The larger resorts in this region were, with few exceptions, on the larger drainage-type lakes with medium to high productivity ratings. Certain guidelines for selecting or evaluating resort sites are included in this report, which was presented at the 98th Annual Meeting of the Wisconsin Academy of Sciences, Arts, and Letters at Eau Claire, Wisconsin, in April 1968.

Many tourist-lodging businesses in Northern Wisconsin, and particularly the so-called "resorts", are situated on lakeshore lands. This site provides atmosphere, esthetic qualities, and convenient access to water-based recreation—swimming, boating, angling, water skiing, nature study, and so on.†

---

* Extension specialist, travel-recreation industry, University Extension, The University of Wisconsin.

† Water-oriented activities, which dominate the recreation picture in Northeastern Wisconsin, have great appeal to a majority of our vacationing tourists. A survey of prospective vacationers in 1964, conducted by the Department of Resource Development and directed by Prof. I. V. Fine, showed that 52% of the people who were interviewed had indicated water activities as their *main* pursuit while on their most recent long recreation trip. Sightseeing and "touring" were close behind—and probably related to water as well. A study of tourist-accommodations people in 1962, also by Fine, indicated that 76.8% of the operators in Northeastern Wisconsin considered *fishing* as their main attraction with *boating* and *swimming* (also water-based) a fairly close second at 59.7%. Only 10 percent of these operators said they had no recreational waters on or adjacent to their premises.

In a 1959 study of tourist preferences. Fine found that the following activities (and facilities) were rated "good to excellent" by high percentages of the vacationers surveyed:

| | |
|---|---|
| fishing—46.3% | boating—88.1 |
| swimming—75.4 | sightseeing—92.3 |

The last-mentioned study also revealed that 62.9% of all recreational travelers who vacation in Wisconsin during the mid-summer period (July and August) visited the Northeast region.

The quality of recreation provided, as well as the probable success of a resort enterprise, is closely related to the quality of the lake being utilized. Lakes vary greatly with respect to size, type, fertility, depth, water clarity, shoreline, etc. Many lakes are too small, too shallow, too infertile—or otherwise inadequate—to provide good recreation, a quality environment, or high scenic values. As this study shows, some of our resort establishments are located on these low-quality lakes.

Wisconsin has over 8,700 lakes, of which nearly 60% (or 5,100) are named. Only 13% of the total, or 1,134 lakes, are over 100 acres in size. At least 90% of our 4,500 resort enterprises are associated with this relatively small group of lakes—which range in size from 100 acres upward to 137,700 acres (Lake Winnebago).

What lake characteristics and factors can be identified most closely with resort locations and distribution? The purpose of this report it to provide some general answers to this question.

A resort is defined as a visitor-housing business with accommodations for at least two families (six people or more) in a scenic recreational environment.

This study included *all* of the resorts and resort lakes in Oneida and Vilas counties in 1964. This area has over 25% of the state's totals for both resorts and lakes. The figures showed 1,206 resorts on 301 lakes. Basic data on the lakes studied were obtained from recent county inventories of surface water resources, as published by the Wisconsin Department of Natural Resources. Data on resort numbers were obtained from the State Board of Health and by field surveys.

The 301 resort lakes comprised 12.3% of all lakes (2,450 total) in the Oneida–Vilas area, and 31.7% of all the *named* lakes. This area has a total of 951 named lakes, mostly over 10 acres in size, including all of the larger ones. In addition there are 1,499 unnamed lakes, all under 100 acres and 92% under 10 acres in size. Less than ten of these were used by resort establishments. Generally speaking, the 2,150 lakes not being used are probably too small, too infertile, too marshy, or otherwise not suitable for resort development.

With respect to over-all quality, and especially biological productivity, lakes are somewhat comparable to soils and soil fertility. They vary greatly, just like farms or farm fields. There is fully as much variation in productivity between landlocked lakes rated as "very poor" and drainage lakes rated as "excellent" as there is between a sandy, abandoned farm in northern Wisconsin and a fertile, prairie-soil farm in southern Wisconsin.

What are the main factors involved in lake quality? From the standpoint of resort utilization, or human recreation, the following lake characteristics assume major importance:

1. *TYPE*—drainage, landlocked, spring, bog, etc.
2. *SIZE*—area, shape, configuration.
3. *FERTILITY*—water acidity, hardness, nutrient content.
4. *DEPTH*—maximum depth, area under 5′ depth, area over 10′ depth.
5. *CLARITY*—water color, turbidity, algae, etc.
6. *SHORELINE*—type, length, soils, vegetation.

There are other lake characteristics, of course, but the primary lake-quality factors of (1) size, (2) depth, and (3) productivity (fertility) would rate a high priority in the evaluation of any lake for recreational purposes. The matter of *lake type*, or classification, would also deserve careful consideration along with these basic factors in the appraisal of a given lake for its potential or optimum usage. Such things as water quality, lakeshore types, and shoreline developments might be considered in addition.

This paper is concerned chiefly with the type of lakes used, the size of lakes used, fertility ratings, and certain water-space factors related to resort density. The resort counts and lake-inventory data were compiled in 1964 and 1965. Subsequent studies will relate resort distribution to other lake-quality factors, including depth, water clarity, shoreline characteristics, and present usage of the lakes concerned.

## Classifying Resort Lakes

A lake is defined as an inland body of standing water, with meandered shoreline, that is navigable at least 9 out of 10 years. Some authorities say that a lake must have at least 10 acres of surface water and that anything less than 10 acres is a "pond." However, our official inventory of surface waters in Wisconsin includes named and unnamed lakes down to 1.0 acre (even smaller) in total area. And, our studies of resort locations reveal that a number of these establishments are presently located on lakes under 10.0 acres in size!

As to classification of lakes by type, the following *lake types* are recognized and have been identified in some or all of the Wisconsin county inventories:

1. *Drainage* lakes—natural lakes and impoundments having both inlets and outlets (affluent and effluent streams).

2. *Landlocked* lakes—lakes that are fed by seepage water; no inlets and no outlets (water level is dependent on groundwater table).
3. *Drained* lakes—very similar to landlocked lakes; no inlet, but have very small or intermittent outlets.
4. *Spring* lakes—somewhat similar to landlocked lake; seldom have inlets, but have outlets of substantial flow.
5. *Bog* lakes—small, kettle-hole lakes with encroaching bog vegetation, usually brown-colored water. (Normally acid if landlocked, but may be alkaline if connected with a stream.)
6. *Impoundments*—lakes with over 50% of the depth attributable to a manmade structure.

The two major categories, drainage lakes and landlocked lakes, are often further divided into two subclasses: acid and alkaline. For example, *acid* drainage lakes and *alkaline* drainage lakes are differentiated in some of the Wisconsin county inventories.

In this study of resort lakes in Oneida and Vilas counties, all named lakes were included under three categories: (1) *Drainage* lakes; (2) *Landlocked* lakes; (3) *Spring* lakes. All "drained" lakes are classed as landlocked lakes, as are the bog lakes that have no inlet or outlet. (All impoundments are included with the drainage lakes.)

Each of these lake types has significant natural properties and limnological characteristics peculiar to it, based on the general chemical and physical properties. Production of plant and animal life, for example, varies considerably with the type of lake.

In general, drainage lakes and spring lakes have the highest fertility levels. Water sources for these two types have higher mineral contents, because of their greater exposure to the soil and subsoil minerals. The groundwater of spring lakes, as a general rule, will have a greater mineral concentration than that of drainage lakes. This fact is especially evident in the small spring lakes with limited watersheds. Landlocked lakes generally have the lowest fertility levels, although some exceptions do occur. Within the landlocked category, drained lakes are slightly more fertile than the average (for seepage lakes), while bog lakes are almost always acid and relatively infertile.

Lake size is an important consideration. The smaller lakes often have inadequate or limited space (water surface) for many activities and, generally, are more readily injured by heavy pressures and overuse. Some limnologists feel quite strongly that no motors of any kind should be permitted on lakes under 50 acres in size. There is considerable justification for this belief, although we feel that a 40-acre minimum might be more appropriate. Large lakes can sometimes be a problem too, because of large waves during high winds, the increased difficulty in locating fishing grounds, or the improved prospects for getting lost.

In this study of resort lakes, nine size categories were used initially, but these are reduced to only four in this report. They are as follows:

| *Lake Size Class* | *Area of Surface Water* |
|---|---|
| Class I —large | 1001 Acres and up |
| Class II —medium large | 501 to 1000 Acres |
| Class III—medium | 101 to 500 Acres |
| Class IV—small | 1 to 100 Acres |

Threinen and others suggest three (3) lake-size categories as follows: Small (under 100 A.); Medium (101 to 1000 A.); Large (more than 1000 A.). However, in considering resort distribution and lake usage in the Oneida–Vilas area, it seemed appropriate to separate the medium-sized lakes of 101 to 500 acres from those of 501 to 1000 acres. Thus, the accompanying tables include these two classes of medium-sized lakes. From the standpoint of resort distribution, density and lake utilization, important differences were found between them.

## Resorts and Lake Type

Table 1 shows the distribution of resort establishments by type and size of lake used. These data include all resorts identified by the Board of Health in 1964 and all resort lakes in the Oneida–Vilas region.

This area has a total of 951 named lakes and approximately one-third of these, or 301 named lakes, contained all of the 1,206 resorts. Thus, over two-thirds (68.3%) of the named lakes had no resorts on them. Many of the lakes in the latter group were sizeable, good-quality ones, and this suggests a potential for future resort development. The average size of the 301 lakes used by resorts was 390.6 acres, and the over-all density was 4.0 establishments per resort lake.

A large majority of the resorts (915) were located on drainage lakes, although only 28 percent of the 951 named lakes were of this type. Of the 267 drainage-type lakes, 60.7% or 162 had resorts on them. The average lake size for this group was 482 acres, and the average resort density was 5.6 resorts per lake.

Landlocked (or seepage-type) lakes were predominant among the named lakes, comprising 62.0% of the total. However, only 101 of these 590 lakes (or 17.1%) had resorts, with a total of 189

TABLE 1. RESORT DISTRIBUTION BY TYPE AND SIZE OF LAKE IN THE ONEIDA–VILAS AREA OF WISCONSIN

| TYPE AND SIZE CLASS OF LAKES | TOTAL NO. OF *Named* LAKES (BY LAKE CLASS) | NO. OF *Named* LAKES WITH RESORTS | % OF *Named* LAKES WITH RESORTS | TOTAL NO. OF RESORTS (BY LAKE CLASS) | % OF ALL RESORTS | AVERAGE NO. RESORTS PER LAKE WITH RESORTS |
|---|---|---|---|---|---|---|
| DRAINAGE LAKES | | | % | | % | |
| I. Large—over 1000A | 33 | 22 | 66.7 | 276 | 22.89 | 12.5 |
| II. Med. Large—501–1000A | 36 | 33 | 91.7 | 258 | 21.39 | 7.8 |
| III. Medium— 101–500A | 127 | 87 | 68.5 | 341 | 28.27 | 3.9 |
| IV. Small—under 100A | 81 | 20 | 24.7 | 40 | 3.32 | 2.0 |
| Subtotals | 267 | 162 | 60.7% | 915 | 75.87% | 5.6 |
| LANDLOCKED LAKES | | | % | | % | |
| I. Large—over 1000A | 3 | 3 | 100.0 | 5 | 0.41 | 1.7 |
| II. Med. Large—501–1000A | 8 | 5 | 62.5 | 18 | 1.49 | 3.6 |
| III. Medium— 101–500A | 74 | 38 | 51.3 | 98 | 8.13 | 2.6 |
| IV. Small—under 100A | 505 | 55 | 10.9 | 68 | 5.64 | 1.2 |
| Subtotals | 590 | 101 | 17.1% | 189 | 15.67% | 1.9 |
| SPRING LAKES | | | % | | % | |
| I. Large—over 1000A | 0 | 0 | 0.0 | 0 | 0.0 | 0.0 |
| II. Med. Large—501–1000A | 5 | 5 | 100.0 | 21 | 1.74 | 4.2 |
| III. Medium— 101–500A | 34 | 24 | 70.6 | 64 | 5.31 | 2.7 |
| IV. Small—under 100A | 55 | 9 | 16.4 | 17 | 1.41 | 1.9 |
| Subtotals | 94 | 38 | 40.4% | 102 | 8.46% | 2.7 |
| Totals | 951* | 301 | — | 1,206 | 100.0% | 4.0 (Ave.) |

*In addition, the Oneida–Vilas area has 1,499 unnamed lakes under 100A each.

establishments. The average size of the landlocked resort lakes was 170 acres, and the average density was 1.9 resorts per lake used.

The remaining 94 named lakes—9.9% of the grand total—were spring-type lakes. Two-fifths of these lakes (40.4%) had resorts. The average size of spring lake used by resorts was 260 acres, and the average resort density was 2.7 resorts per lake.

All in all, we find that slightly over three-fourths of all resort enterprises in the region were located on drainage-type lakes, 15.7% were on landlocked lakes, and only 8.4% were on spring-type lakes. In fact, 72.5% of the 1,206 resorts were on 142 drainage lakes of medium-to-large size (over 100 acres), and the resort density on these lakes was 6.2 resorts per lake. It is noteworthy that these 142 lakes comprise only one-seventh (14.9%) of the total named lakes in the area, and only one-seventeenth (5.8%) of the 2,450 lakes found in the two counties.

## Resorts and Lake Size

There are 36 Class I lakes (over 1,000 acres each) in the Oneida–Vilas area, of which 33 are drainage lakes and 3 are landlocked lakes. Over two-thirds of them—25 lakes—were used by resorts. These lakes, which averaged 1,504 acres each, had a total of 281 resorts—or 23.3% of the 1,206 establishments. There was an average density of 11.2 resorts per lake used.

Class II lakes (501 to 1,000 acres) in the Oneida–Vilas area total 49, and 43 of them or 87.8% were used by resorts. Most of these (33) were drainage-type lakes, with the remainder divided equally between the other two types (5 landlocked and 5 spring lakes). The number of resorts on them was 297 or 24.6% of all resorts in the 2-county area. Resort density was 6.9 per lake used.

There are 235 named Class III lakes (101 to 500 acres), of which 149 or 63.4% had resorts. This group of lakes (about 71% drainage-type) had a total of 503 resorts, or 41.7% of the grand total, and a density of 3.4 resorts per lake.

Finally, there were 641 named Class IV lakes (100 acres or less) in this area, of which 84 or about 13.0% were used by resorts. Of the 84 total, 55 were landlocked lakes, 20 were drainage-type, and 9 were spring type. These lakes contained 125 resorts, which is 10.4% of the total establishments in the area, and the density was 1.5 resorts per lake used.

It is interesting to note that almost 5% of all resorts in the region were on 46 lakes under 50 acres in size, and 31 of these lakes were either low or *very low* in fertility! As suggested previously, practically all of the unnamed lakes were too small, too shallow, too marshy or too unproductive to be of interest to resort operators. Oneida County has a total of 726 unnamed lakes (all under 100 acres) of which 673 have less than 10 acres of water surface. In Vilas County there are 773 such lakes, of which 710 are under 10 acres in size.

## Water Area Per Resort

One index for measuring the resort density (or crowding) on a given lake is the acreage of "available" surface water per resort—or WA/R ratio. This factor is obtained by dividing the total acreage of the lake by the number of resorts thereon. Thus, a lake of 1,000 acres with 10 average resorts* on its shoreline would have a WA/R value of 100. This is slightly higher than the average figure for resort lakes of the Oneida–Vilas area. The average values for our 12 categories of lakes used by the 1,206 resorts in the region are shown in Table 2.

We note that 25.1% (303) of the 1,206 resorts were on lakes with a WA/R ratio less than 40. These 303 resorts are on 78 lakes, of which 53 are Class IV lakes (under 100 A), 23 are Class III lakes (101 to 500 acres), and 2 are Class II lakes. The distribution of these 303 resorts is as follows:

| | Number of Resorts | Number of Lakes |
|---|---|---|
| Drainage Lakes: | | |
| Class II | 52 | 2 |
| Class III | 122 | 17 |
| Class IV | 33 | 13 |
| Subtotals | 207 | 32 |
| Landlocked Lakes: | | |
| Class II | 0 | 0 |
| Class III | 24 | 5 |
| Class IV | 47 | 34 |
| Subtotals | 71 | 39 |
| Spring Lakes: | | |
| Class II | 0 | 0 |
| Class III | 11 | 1 |
| Class IV | 14 | 6 |
| Subtotals | 25 | 7 |
| Over-all Totals | 303 | 78 |

* The average cottage resort in northern Wisconsin has seven (7) cabins or cottages, eight (8) boats and motors, and a capacity for about thirty (30) guests when filled.

TABLE 2. SURFACE WATER ACREAGE PER RESORT (WA/R RATIO) IN THE ONEIDA–VILAS LAKE REGION OF WISCONSIN

| Type and Size Class of Resort Lakes | No. of Resort Lakes | No. of Resorts | Water Acreage Per Resort (WA/R Ratio) Under 40 A. | 41–80 A. | 81–200 A. | 201 A.+ | % Resorts Each Class with 40 A. or Less |
|---|---|---|---|---|---|---|---|
| | | | No. Resorts | No. Resorts | No. Resorts | No. Resorts | |
| DRAINAGE LAKES: | | | | | | | |
| I. Large | 22 | 276 | 0 | 74 | 133 | 69 | 0.00% |
| II. Medium Large | 33 | 258 | 52 | 112 | 82 | 12 | 20.16 |
| III. Medium | 87 | 341 | 122 | 161 | 50 | 8 | 35.78 |
| IV. Small | 20 | 40 | 33 | 5 | 2 | 0 | 82.50 |
| Subtotals | 162 | 915 | 207 | 352 | 267 | 89 | 22.62 |
| LANDLOCKED LAKES: | | | | | | | |
| I. Large | 3 | 5 | 0 | 0 | 0 | 5 | 0.00 |
| II. Medium Large | 5 | 18 | 0 | 0 | 15 | 3 | 0.00 |
| III. Medium | 38 | 98 | 24 | 49 | 18 | 7 | 24.49 |
| IV. Small | 55 | 68 | 47 | 17 | 4 | 0 | 69.12 |
| Subtotals | 101 | 189 | 71 | 66 | 37 | 15 | 37.57 |
| SPRING LAKES: | | | | | | | |
| I. Large | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| II. Medium Large | 5 | 21 | 0 | 10 | 4 | 7 | 0.00 |
| III. Medium | 24 | 64 | 11 | 18 | 31 | 4 | 17.19 |
| IV. Small | 9 | 17 | 14 | 1 | 2 | 0 | 82.35 |
| Subtotals | 38 | 102 | 25 | 29 | 37 | 11 | 24.51 |
| Totals | 301 | 1,206 | 303 | 447 | 341 | 115 | 25.12% |
| % of All Resorts | — | 100.0 | 25.1 | 37.1 | 28.3 | 9.5 | — |

Thus, we see that 207 of these 303 resorts (which have WA/R values under 40) are on 32 drainage-type lakes, of which 30 are either small or medium in size. Another 71 resorts are located on 39 landlocked lakes, and 34 of these lakes are under 100 acres in size. The remaining 25 resorts are on 7 spring-type lakes, of which 6 are less than 100 acres. It would appear that those resorts with limited water surface are predominately on lakes under 500 acres in size, with almost one-third of them on 53 lakes of less than 100 acres each.

About three-eighths (37.6%) of the 189 resorts located on landlocked lakes had a WA/R value of 40 or less; whereas only 22.6% of the 915 resorts on drainage-type lakes were in this category. For spring-type lakes, the 40-or-under group included 24.5% of the 102 resorts located on them.

Well over half (62.2%) of the 1,206 resorts had a WA/R value of 80 or less. Of these 750 resorts—each with 80 acres or less water surface—74 were on Class I lakes, 174 on Class II lakes, 385 on Class III lakes, and 117 on Class IV (small) lakes.

The WA/R factor varied from about 5.0 acres (Dog Lake and Minnow Lake) to well over 1,400 acres (Ike Walton Lake) in Vilas County. These were the extremes, and the values for lakes in Oneida County fell within this range. No attempt was made to separate lakes with high concentrations of private dwellings from those with relatively low concentrations, but the dwelling density (cottage and home numbers) per mile of shoreline was calculated for 135 of the 301 resort lakes. (See Table 5 for summary.) It is noteworthy that some of the lakes with the lowest WA/R values also had rather high concentrations of private dwellings and cottages on their shores. This denotes a crowded condition which could very well have deleterious effects. This may result in rapid deterioration and a shorter life for the lakes concerned.

On a particular lake, the surface water acreage per resort (WA/R value) is becoming more important each year, especially with the rapid increase in private dwellings on the preferred lakes. A WA/R value of 40 is considered minimal for a good-quality lake with a low dwelling density (less than 10 cottages per mile of shoreline). The average for all 301 resort lakes was 97.5 A.

The spatial requirements of certain aqua sports—notably speedboating and water skiing—are rather great. These sports are pursued not only by resort guests, but also by residents and transient visitors on most larger resort lakes. One lake authority has stated that about 20 acres of water surface are needed for one powerboat and skier making a complete (360°) turn! Thus, a lake with 80 acres of surface area may serve very well for one cottage resort (averaging seven rental cottages and 30 guests), but it might be somewhat too small for two such establishments when both are operating at or near capacity. If this same 80-acre lake had three or four resorts on it, as some already have, along with 10 or 12 dwellings per mile of shore, the utilization conflicts on a hot July day can be visualized quite readily. On most resort lakes, the surface-water area must be shared with residents, cottage owners, area fishermen, transient boaters, and other non-resort people.

Three small lakes in Vilas county had less than 10 acres of water surface per resort (WA/R values of 5, 6, 9), and all three had private cottages as well, with an average density of 9 dwellings per lake! In the Oneida–Vilas area, there were 87 resorts on 29 lakes which had WA/R values under 21 acres. Over half, 50 resorts, were on Class IV lakes (under 100 acres); the remainder of 37 were on Class III lakes. Landlocked lakes predominated in this group; there were 17 of them with a total of 25 resorts, and all were Class IV lakes. There were nine (9) drainage-type lakes with 47 resorts, and three (3) spring-type lakes with 15 resorts. The lakes in this group had an average of 8.38 private dwellings on their shores, or about 6 per mile of shoreline. This figure approximates the average dwelling density for all resort lakes in this region.

## SL/R Ratio Studied

Another index of resort distribution on a given lake is the amount of "available" shoreline per resort, or the SL/R ratio. Since it is another measure of resort density, or crowding, it further highlights the spatial requirements in resort-lake usage. This value is obtained by dividing the total miles of shoreline on a given lake by the total number of resorts thereon. The SL/R values obtained reflect the average length of shoreline per resort on specific lakes, disregarding the amount of lakeshore actually owned by the resorts or other landowners on those lakes. The average values (and resort distribution) for our 12 categories of resort lakes are shown in Table 3.

For example, a lake with 12.0 miles of shoreline and 12 resorts thereon would have an SL/R value of 1.00—or somewhat less than the average figures for the 2-county area. (Oneida county is 1.36, while Vilas lakes have an average value of 1.11 miles per resort.)

It is true that those lakes having large numbers of resort establishments are also attractive to second-home owners, and thus they often have above-average concentrations of homes and cottages. This tends to complicate the interpretation of SL/R values. How-

TABLE 3. SHORELINE PER RESORT (SL/R RATIO) IN THE ONEIDA–VILAS AREA OF WISCONSIN

| Type and Size Class of Resort Lakes | No. of Resort Lakes | No. of Resorts | Shoreline Per Resort (SL/R Ratio) | | | | % of Resorts Each Class with .5 mi. or Less |
|---|---|---|---|---|---|---|---|
| | | | Under 0.5 mi. | .51–1.0 mi. | 1.01–2.0 mi. | 2.01 mi.+ | |
| | | | No. Resorts | No. Resorts | No. Resorts | No. Resorts | |
| DRAINAGE LAKES: | | | | | | | |
| I. Large—1001A+ | 22 | 276 | 38 | 102 | 103 | 33 | 13.77% |
| II. Med. Large—501–1000A | 33 | 258 | 60 | 115 | 68 | 15 | 23.26 |
| III. Medium—101–500A | 87 | 341 | 90 | 133 | 89 | 33 | 26.39 |
| IV. Small—100A | 20 | 40 | 10 | 10 | 14 | 2 | 25.00 |
| Subtotals | 162 | 915 | 198 | 360 | 274 | 83 | 21.64 |
| LANDLOCKED LAKES: | | | | | | | |
| I. Large—1001A+ | 3 | 5 | 0 | 0 | 0 | 5 | 0.00 |
| II. Med. Large—501–1000A | 5 | 18 | 0 | 11 | 0 | 7 | 0.00 |
| III. Medium—101–500A | 38 | 98 | 8 | 34 | 38 | 18 | 8.16 |
| IV. Small—100A | 55 | 68 | 9 | 33 | 23 | 3 | 13.24 |
| Subtotals | 101 | 189 | 17 | 78 | 61 | 33 | 9.00 |
| SPRING LAKES: | | | | | | | |
| I. Large—1001A+ | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| II. Med. Large—501–1000A | 5 | 21 | 0 | 10 | 0 | 11 | 0.00 |
| III. Medium—101–500A | 24 | 64 | 11 | 14 | 28 | 11 | 17.19 |
| IV. Small—100A | 9 | 17 | 4 | 9 | 4 | 0 | 23.53 |
| Subtotals | 38 | 102 | 15 | 33 | 32 | 22 | 14.71 |
| Totals | 301 | 1,206 | 230 | 471 | 367 | 138 | 19.07 |
| % of All Resorts | — | 100% | 19.07 | 39.06 | 30.43 | 11.44 | — |

ever, dwelling density is evaluated in a subsequent section of this paper, and it can be related quite easily to the resort distribution on each lake.

The SL/R value, in our opinion, should be at least 0.5 mile per resort under average circumstances—especially on landlocked lakes where there is no easy access or channels to other waters—and particularly where the dwelling density exceeds 10 units per mile of shore.

Why is "available" shoreline important? First, much of the recreational activity on most lakes takes place within ¼ mile of the shore. The central area of a large lake—particularly one without islands—is used very little. Secondly, certain major activities such as fishing and canoeing are high users of shoreline, and the "acres per boat" or "people per acre" figures are less significant. Thirdly, lakes vary greatly in shore length per 100 acres of surface. For example, Dollar Lake and Watersmeet Lake in Vilas County are about 100 acres each. Dollar (nearly round) has 1.4 miles of shore, whereas Watersmeet (spider shaped) has 10.5 miles. Dollar (3 resorts) has an SL/R value of 0.47 miles; Watersmeet (8 resorts) has 1.3 miles. These are extremes, of course, but they illustrate the point.

Of the 1,206 resorts in the Oneida–Vilas region, about 19.0% (230 resorts) had SL/R values of less than 0.5 mile. Of this group, 38 were on Class I lakes; 60 on Class II lakes, 109 on Class III lakes, and 23 on Class IV (under 100 acres). The big majority of them (86.1%) were on drainage-type lakes. The remainder was almost evenly divided (7.4% and 6.5%) between landlocked lakes and spring lakes, respectively.

## Resorts and Lake Fertility

A reasonably reliable index of lake quality, or biological productivity, is the fertility rating or total alkalinity of the water in a given lake. This is a key factor in the quality of resort lakes, since it is not only associated with fishery yield and composition but also the prevalence or abundance of algae, aquatic plants, plankton, etc.

Generally speaking, soft-water (acid) lakes are relatively infertile. Most landlocked lakes are of this type. On the other hand, most hard-water lakes show a medium or high fertility rating. This index, expressed as total alkalinity in Wisconsin lake inventories and determined by chemical tests, is a measure of the dissolved solids (carbonates, bicarbonates, hydroxides, etc.) in a sample of water. It is commonly reported as parts per million of calcium carbonate (ppm $CaCO_3$) and is an indicator of lake productivity. The following classification is used to indicate fertility ratings of the 301 resort lakes in this study:

| Productivity | Total Alkalinity | Water Hardness | Fertility Rating |
|---|---|---|---|
| VL = Very low | 1– 4 p.p.m. | Ultra soft | Very infertile |
| L = Low | 5–20 p.p.m. | Very soft | Infertile |
| M = Medium | 21–40 p.p.m. | Soft | Fairly fertile |
| H = Medium high | 41–90 p.p.m. | Med. hard | Fertile |
| & High | 91+ p.p.m. | Hard | Very fertile |

In this report the last two categories are combined into one, i.e., "high" fertility. Lakes in this class are generally the most productive and support a large population of fast-growing fish, other organisms, and aquatic plants. Conversely, lakes rated as "very low" or "low" are relatively unproductive—like a poor soil—with a limited population of slow-growing fish and relatively clear, weed-free water. Fish are sometimes stunted, especially if predators and large fish are inadequate to control the population.

Table 4 shows the distribution of our 1,206 resorts by lake fertility, type and size class. Four levels of fertility, or productivity, are indicated for each of the 12 lake type-and-size categories. The table reports both the number of resorts and the number of resort lakes under each fertility class. It is noteworthy that 78.8% of all resorts were on lakes of medium or high fertility; further that 825 (86.8%) of these 950 resorts were on drainage-type lakes. Thus, it appears that the great majority of resort establishments have selected, wisely or by chance, resort lakes of good or above-average productivity.

However, there were 256 resorts on 115 lakes of low or very low fertility. They comprised over one-fifth (21.2%) of all resorts in the region. Almost two-thirds of these resorts (161 establishments) were on infertile landlocked lakes; 90 were on drainage-type lakes; only 5 were on spring lakes.

At the "very low" level of water fertility—or productivity—there were 54 resorts on 42 lakes. Thirty of these lakes were small, 100 acres or less, and only two were over 500 acres in size. All 42 were landlocked lakes, and most of them were questionable or undesirable sites for resorts, because of their small size and limited fishery.

TABLE 4. RESORT DISTRIBUTION BY LAKE TYPE AND LAKE FERTILITY IN THE ONEIDA–VILAS AREA

| Type and Size Class of Resort Lakes | No. of Resort Lakes | No. of Resorts | Resort Distribution by Lake Fertility Class*: Very Low | | Low | | Medium | | High | | % of All Resorts on Low-Fertility Lakes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. of Lakes | No. of Resorts | No. of Lakes | No. of Resorts | No. of Lakes | No. of Resorts | No. of Lakes | No. of Resorts | |
| DRAINAGE LAKES: | | | | | | | | | | | |
| I. Large | 22 | 276 | | 0 | | 0 | (15) | 199 | ( 7) | 77 | 0 |
| II. Medium Large | 33 | 258 | | 0 | ( 4) | 36 | (23) | 169 | ( 6) | 53 | 3.00 |
| III. Medium | 87 | 341 | | 0 | (16) | 50 | (55) | 227 | (16) | 64 | 4.17 |
| IV. Small | 20 | 40 | | 0 | ( 3) | 4 | (13) | 29 | ( 4) | 7 | 0.33 |
| Subtotals | 162 | 915 | | 0 | (23) | 90 | (106) | 624 | (33) | 201 | 7.50 |
| LANDLOCKED LAKES: | | | | | | | | | | | |
| I. Large | 3 | 5 | ( 1) | 1 | ( 1) | 1 | ( 1) | 3 | | 0 | 0.17 |
| II. Medium Large | 5 | 18 | ( 1) | 6 | ( 3) | 11 | ( 1) | 1 | | 0 | 1.41 |
| III. Medium | 38 | 98 | (10) | 14 | (23) | 65 | ( 5) | 19 | | 0 | 6.58 |
| IV. Small | 55 | 68 | (30) | 33 | (20) | 30 | ( 4) | 4 | ( 1) | 1 | 5.25 |
| Subtotals | 101 | 189 | (42) | 54 | (47) | 107 | (11) | 27 | ( 1) | 1 | 13.41 |
| SPRING LAKES: | | | | | | | | | | | |
| I. Large | 0 | 0 | | 0 | | 0 | | 0 | | 0 | 0 |
| II. Medium Large | 5 | 21 | | 0 | | 0 | ( 5) | 21 | | 0 | 0 |
| III. Medium | 24 | 64 | | 0 | | 0 | (14) | 36 | (10) | 28 | 0 |
| IV. Small | 9 | 17 | | 0 | ( 3) | 5 | ( 6) | 12 | | 0 | 0.41 |
| Subtotals | 38 | 102 | | 0 | ( 3) | 5 | (25) | 69 | (10) | 28 | 0.41 |
| Grand Totals | 301 | 1,206 | (42) | 54 | (73) | 202 | (142) | 720 | (44) | 230 | 21.22% |

*NOTE—The figures in parentheses indicate number of lakes in each category.

## Dwelling Density on Resort Lakes

As mentioned previously, non-resort shoreline developments, including cottages, seasonal homes, year-round residences, camps and marinas, affect lake usage by and water availability for resort enterprises. Heavy usage by resorts plus a high concentration of private dwellings can mean an overcrowded condition on the lake concerned. However, both factors can be measured and evaluated, separately and together, to determine the pressure on a given lake in quantitative terms.

Table 5 indicates the cottage-dwelling density on 135 resort lakes in Vilas County, where dwelling counts were taken. The average number was 26.4 dwellings per lake, and the average density was just under 6 dwellings per mile. This rates as a "moderately-low" concentration when measured by the following scale:

| *Dwellings per Mile of Shoreline* | *Concentration or Density Rating* |
|---|---|
| 1 to 4 | Low |
| 5 to 10 | Moderately Low |
| 11 to 20 | Medium |
| 21 to 30 | Moderately High |
| 31 to 50 | High |
| 51 and Over | Very High |

On a given lake, the total number of dwellings (seasonal and year around) is divided by the total miles of shoreline to determine the dwelling density. On the resort lakes studied, this factor varied from 0 to over 20/mile. For the 12 type-size categories of resort lakes, the average dwelling density ranged from 1.18/mile to 9.55/mile, with the greatest variation among landlocked and spring-type lakes. However, this value averaged approximately 6.0 per mile for each of the three major lake types, with spring lakes (6.53) being slightly higher than the two other categories.

Class II landlocked lakes had the greatest dwelling density, 9.55 per mile. Class III spring lakes (with 8.14) and Class IV drainage lakes (with 7.75) had the next highest densities in terms of dwellings per mile of shoreline.

As would be expected, the larger lakes have more dwellings *per lake,* but somewhat fewer per mile of shoreline. However, the differences in dwelling density were rather small, as the following data indicate:

| Size Group | No. of Resort Lakes | Dwellings Per Lake | Dwellings Per Mile |
|---|---|---|---|
| I. 1000 Acres + | 13 | 66.2 | 5.86 |
| II. 501–1000 Acres | 23 | 45.7 | 5.97 |
| III. 101–500 Acres | 58 | 23.2 | 5.95 |
| IV. 100 Acres or Less | 41 | 7.5 | 6.37 |

In general, lakes of the Oneida–Vilas region are relatively uncrowded in terms of dwelling density, especially when compared to the majority of lakes in southern Wisconsin. Densities of 20 or more dwellings per mile of lakeshore were evident in only a few cases, mostly on smaller lakes. However, when a 100-acre lake has a medium concentration of 11 or more cottages per mile of shore, plus two or more cottage resorts of average size, we are beginning to approach conditions that could easily lead to overcrowding in a few years.

This study of dwelling density involved 3,564 private cottages and homes on 135 resort lakes. This is almost one-third of all such dwellings, which numbered approximately 12,000 in this two-county area in 1964.

## Lakes With Large Resorts

There were 25 resort establishments in the Oneida–Vilas area which had 30 bedroom units or more. These enterprises were located on 22 resort lakes, which range in size from 110 acres (smallest) to 3,870 acres. The lake type, size, and general characteristics of these 22 lakes are reported in Table 6.

In general, the larger resorts were located on the larger, better-quality lakes. Although eight of the 22 lakes used were Class III lakes (101 to 500 acres), almost two-thirds of them were Class I or Class II lakes, and the average size of all 22 was over 1,000 acres. All but one of these lakes were of the drainage type, and all but three were medium to high in fertility rating.

These lakes were also popular with cottagers and owners of private dwellings. Only one of the 22 lakes had no dwellings other than resorts, and the other 21 averaged slightly over 7.0 dwellings per mile of shoreline—or about 20% higher than the average dwelling density for all resort lakes. However, this density was more than doubled on four of the 22 resort lakes; these were located fairly close to a major city or village, which may account for the higher densities of 14.5 to 17.4 per mile.

TABLE 5. COTTAGE AND HOME CONCENTRATIONS ON RESORT LAKES (VILAS COUNTY ONLY)

| Type and Size Class of Resort Lakes | No. Resort Lakes w/Cottages and Homes | Total No. Cottages and Homes | Dwellings Per Resort Lake (Ave. No.) | Dwellings Per Mile of Shoreline (Ave. No.) |
|---|---|---|---|---|
| A. DRAINAGE LAKES: | | | | |
| I. Large | 12 | 849 | 70.8 | 6.25 |
| II. Medium Large | 18 | 892 | 49.5 | 5.67 |
| III. Medium | 36 | 834 | 23.2 | 5.47 |
| IV. Small | 15 | 152 | 10.1 | 7.75 |
| Subtotals | 81 | 2,727 | 33.7 (Ave.) | 5.86 (Ave.) |
| B. LANDLOCKED LAKES: | | | | |
| I. Large | 1 | 11 | 11.0 | 1.18 |
| II. Medium Large | 3 | 127 | 42.3 | 9.55 |
| III. Medium | 13 | 239 | 18.4 | 5.77 |
| IV. Small | 22 | 136 | 6.2 | 6.01 |
| Subtotals | 39 | 513 | 13.2 (Ave.) | 5.92 (Ave.) |
| C. SPRING LAKES: | | | | |
| I. Large | 0 | 0 | 0 | 0 |
| II. Medium Large | 2 | 33 | 16.5 | 3.30 |
| III. Medium | 9 | 271 | 30.1 | 8.14 |
| IV. Small | 4 | 20 | 5.0 | 3.17 |
| Subtotals | 15 | 324 | 21.6 (Ave.) | 6.53 (Ave.) |
| Grand Totals | 135 | 3,564 | 26.4 (Ave.) | 5.92 (Ave.) |

Five of these 22 lakes appeared to be somewhat "crowded" already—three of them almost certainly because of high dwelling densities. (This will be verified by a field survey and study.) On these five, the WA/R factor was less than 40 acres; and the SL/R factor ranged from 0.25 to 0.59 mile. These figures indicate a limited water area and a rather low shoreline factor per resort, even with a low dwelling density. But three of the five lakes are well above average in this respect, having densities of 7.98, 11.13, and 14.52 per mile. These three lakes are definitely not the most crowded lakes in the Oneida–Vilas area, but their example is noteworthy since each of them contains one of the area's larger resorts on its shores. Another lake in this group of five had two large resorts, but its dwelling density was only 3.48 per mile. Even so, one of the two resorts was being subdivided into lakeshore lots, which may be an indication of its operational problems and the low fertility of the lake. It is believed, however, that problems of this nature which result from over-use of lake resources can be foreseen or better identified by using the space and shoreline factors previously described, along with published information on lake type, depth, fertility, etc.

## Lake Depth Important Too

We have said very little about water depth, an important factor in lake quality, because shallow lakes (under 10 feet of depth) are often small and have been largely ignored by resort developers and second-home builders. Such lakes have esthetic and wildlife values, but are often limited as to fishery and boating or swimming opportunities. Many of these shallow lakes, especially the landlocked variety, have a regular or periodic winterkill of fish; thus they are often referred to as "winterkill lakes." Wisconsin has more than one thousand of this type.

Depth is usually a major factor in winterkill, since these lakes generally have a maximum depth under 10 feet and are likely to have a high percentage of their surface area under five feet deep. However, shallow lakes of the drainage or spring type are frequently not subject to winterkill, whereas certain other lakes up to 20 feet in maximum depth may have die-offs regularly.

Threinen's reports indicate that there are approximately 546 lakes with a maximum depth of nine (9) feet or less in this two-county area. The majority of these are small and unnamed, but at least 16 of them are resort lakes. In fact, almost one-third of the 301 resort lakes have a maximum depth under 20 feet.

There are at least 118 known winterkill lakes in Vilas County (with an average maximum depth of 6.1 feet), and probably as

TABLE 6. LAKE CHARACTERISTICS ASSOCIATED WITH THE 25 LARGEST RESORT ESTABLISHMENTS IN THE ONEIDA–VILAS AREA OF WISCONSIN

| Name and Type of Lake | | No. of Resorts on Lake | Resort Lake Characteristics | | | | |
|---|---|---|---|---|---|---|---|
| Name | Type | | Size (In Acres) | Fertility Rating | WA/R (Acres) | SL/R (Miles) | Dwellings per Mile |
| Trout | D-I | 12 | 3,870.0 | M | 322.5 | 1.58 | 3.26 |
| Tomahawk | D-I | 14 | 3,626.6 | H | 259.0 | 2.05 | 5.26 |
| Lac Vieux Desert | D-I | 14 | 2,853.0 | M | 203.8 | 1.18 | 4.18 |
| Squirrel | D-I | 13 | 1,352.0 | H | 104.0 | 0.88 | 7.28 |
| Minocqua | D-I | 15 | 1,285.0 | H | 85.7 | 1.23 | 14.65 |
| White Sand | D-I | 9 | 1,195.0 | M | 132.8 | 0.61 | 15.45 |
| Star | D-I | 3 | 1,150.0 | M | 383.3 | 3.93 | 1.61 |
| Little St. Germain | D-II | 38 | 956.0 | M | 25.2 | 0.34 | 7.98 |
| Plum | D-II | 15 | 938.0 | H | 62.5 | 0.92 | 4.42 |
| Long | D-II | 7 | 872.0 | M | 124.6 | 1.13 | 7.97 |
| Eagle | D-II | 4 | 591.0 | M | 147.7 | 1.15 | 9.57 |
| Lost | D-II | 14 | 541.0 | L | 38.6 | 0.33 | 3.48 |
| Boulder | D-II | 6 | 525.0 | H | 87.5 | 1.07 | 2.19 |
| Big Manitowish | D-II | 12 | 506.0 | M | 42.2 | 0.65 | 6.92 |
| Moen | D-III | 8 | 460.0 | L | 57.5 | 0.49 | 17.44 |
| George | D-III | 15 | 434.5 | M | 29.0 | 0.41 | 14.52 |
| Thompson | D-III | 9 | 382.4 | M | 42.5 | 0.87 | 9.74 |
| Spirit | D-III | 4 | 342.4 | M | 85.6 | 1.00 | 4.00 |
| Spider | D-III | 9 | 256.0 | M | 28.4 | 0.59 | 11.13 |
| Deer | D-III | 3 | 174.7 | L | 58.2 | 1.34 | 6.50 |
| Garth | L-III | 1 | 114.1 | M | 114.1 | 1.80 | 3.33 |
| Brandy | D-III | 8 | 110.0 | M | 13.8 | 0.25 | 0 |
| Averages | | 10.6 | 1,024.3 | M+ | 111.3 | 1.08 | 7.31 |

many more in Oneida County. A number of resort lakes are in this group. This study revealed 46 resorts on 21 winterkill lakes, 30 in Oneida County and 16 in Vilas County (almost 4% of all resorts). All in all, there were 27 resorts on 16 lakes with a maximum depth of nine feet or less, and a total of 333 resorts on lakes that were under 20 feet in depth. Most of these shallow resort lakes, however, were not subject to severe winterkill.

There are also some resort locations in this region that experience a periodic "summerkill" of fish, particularly in algae-laden bays of fertile lakes. Both winterkill and summerkill conditions tend to reduce recreational opportunities or esthetic values for resort guests, and lakes subject to them cannot be considered as good sites for resort operation or development.

## Summary and Discussion

There are 951 named lakes in the Oneida-Vilas area of Northeastern Wisconsin, of which 301 were used by resorts in 1964. Of the 301 resort lakes, 162 were drainage type, 101 were landlocked, and 38 were spring-type lakes. The distribution of resort enterprises was 915 on "D" lakes, 189 on "L" type, and 102 on "S" lakes. Almost three-fourths of all establishments were on "D" lakes over 100 acres in size. About one-fourth of the resorts were on Class I lakes (over 1,000 acres). Another fourth were on Class II lakes (501 to 1,000 acres), and about two-fifths were on Class III lakes (101 to 500 acres). The remainder (10.37%) were on Class IV lakes (100 acres or less).

Well over half of all resorts (62.2%) had a WA/R ratio (water acreage per resort) of 80 acres or less. One-fourth of them had under 40 acres of water. About one-fifth had a SL/R factor of 0.5 mile or less, under ½ mile of shoreline per resort. Over one-fifth of all resorts were on 115 lakes of low or very low fertility; 78.7% were on 186 lakes of medium or high fertility. Almost 5% of the resorts were on 42 landlocked lakes of very low fertility, and well over 3% were on winterkill lakes.

On these resort lakes, dwelling densities averaged almost six buildings per mile of shore. Over 75% of all resorts and almost 75% of all dwellings were on drainage-type lakes.

A study of the lake characteristics associated with the 25 largest resort establishments in the region was included. This group of 22 resort lakes averaged 1,024 acres each, and all but one were drainage-type lakes. Only three of these lakes had a low fertility rating, 14 were medium and 5 were highly fertile. Five of these lakes showed signs of being overdeveloped, with low WA/R and

SL/R values coupled with above-average concentrations of dwellings. Dwelling densities for these lakes averaged slightly over seven buildings per mile, with a range of 1.61 to 17.44 per mile, compared to an average of 5.92 for all resort lakes. In general, the larger resorts, all of which had 30 bedroom units or more, were associated with the larger, more fertile, and better-quality lakes.

As a result of this study and related field observations, the following comments and suggestions are offered:

1. Resorts should not be located on any lake under 50 acres in size. In fact, it is felt that no motors or powerboats should be operated on these small bodies of water, particularly landlocked lakes. Yet 4.6% of all resorts in the Oneida–Vilas area were situated on lakes in this group.
2. It is questionable whether any resorts should be situated on *landlocked* lakes smaller than 100 acres, as they are usually infertile and easily damaged. Motors rated over 10 h.p. should not be used on them. This region had a total of 68 resorts on such lakes.
3. A minimum of 40 acres of surface water per resort is recommended on lakes where dwelling densities are low or moderately low (10 or fewer dwellings per mile). With medium dwelling densities (11 to 20 per mile), the WA/R factor should be at least 50 acres. When the density is greater, 21 or more dwellings per mile, this "space" value could be 60 or higher. One-fourth of all lakes in the Oneida–Vilas area had WA/R values under 40, and 87 resorts on 29 lakes showed WA/R values of 20 or less.
4. The SL/R factor, miles of shoreline per resort, ought to be 0.50 or more, since most of the water-based recreation is related to the use of shoreline. Yet 19% of all resorts in this area had SL/R values of 0.50 or less, and 33 resorts on five lakes had SL/R values under 0.25 mile.
5. Resort lakes should preferably have a fertility rating of "medium" or higher. Those with a low—and especially a very low—fertility rating just cannot withstand the present day fishing pressures and produce game fish of satisfactory quantity or quality. Yet, 54 resorts (4.5% of all resorts in this region) were located on lakes of very-low fertility.
6. The dwelling density on a given lake should be under 20 per mile, if that lake is to provide the kind of seclusion and recreational opportunity that most resort guests are seeking when they come to Northern Wisconsin. Only a few resort lakes in the Oneida–Vilas area are now approaching this figure. However, with the rapid increase in "second homes" and private

lake cottages, many lakes will probably become rather heavily developed and thus lose their northwoods atmosphere, even with land-use zoning and other building regulations.

7. Certain kinds of lakes should probably be avoided, by new resort enterprises at least, aside from the basic size, type, and fertility characteristics they possess. These lakes might include:

   a. Very shallow lakes where the maximum depth is under 10 feet, regardless of lake type.
   b. Winterkill lakes with a known history of regular or periodic fish die-offs during winter months because of oxygen deficiencies.
   c. Summerkill lakes with low-oxygen areas at certain periods in the summer season.
   d. Highly-acid, bog-type lakes with brownish water and low fertility. Such lakes usually have a high percentage of soft, marshy shoreline—and thus may never be crowded—but their fishery is usually too limited and the water color and quality is not desirable for recreationists.
   e. High-algae lakes that produce greenish or brownish "blooms" and scum quite regularly each summer. Such lakes are usually highly fertile, and hence may be good for fishing, but the odors and esthetic characteristics are objectionable to swimmers, boaters and vacationers in general.
   f. Lakes seriously affected by pollutants of any type.

8. It is urged that a comprehensive lake use and conservation plan be prepared as soon as practicable for each and every inland lake of 500 acres or more in Wisconsin. Ultimately, perhaps by 1975, a detailed plan could be developed for each of our 1,200 lakes and flowages that are over 100 acres in size. These inventory studies, which include the findings and recommendations of qualified lake specialists, would provide the following information:

   1. Geographic description
   2. Physical features (of lake and basin)
   3. Water quality and chemical data
   4. Aquatic resources
   5. Shoreline and related resources
   6. Present land use and development
   7. Current and future problems
   8. Protection measures needed
   9. Lake use possibilities and future development

This report, which involved over 25% of Wisconsin's resorts and inland lakes, suggests that we need to take a more careful look at our lake resources and how they are used. These resources are more valuable with each passing year, but they also are quite vulnerable to misuse and are highly perishable. In some cases, it appears that lakes too small, too infertile, and too shallow are being used. A few of the better lakes seem to be overcrowded already, and water pollution is in evidence. Perhaps the time has arrived for a re-evaluation and careful study of resort patterns and the resort lakes being used or developed. Such an effort would help to insure the protection of these most valuable resources and will benefit Wisconsin's recreation industry as well.

## References


ANDREWS, L. M. and C. W. THREINEN. (1966) *Surface Water Resources of Oneida County.* Conservation Division, Wis. Dept. Natural Resources, Madison. 284 pp.

BIRGE, E. A. and CHAUNCEY JUDAY. (1914) *The Inland Lakes of Wisconsin.* Bulletin No. 27, Series 9, Wis. Geol. and Nat. History Survey, Madison. 137 pp.

BLACK, J. J., L. M. ANDREWS, and C. W. THREINEN. (1963) *Surface Water Resources of Vilas County.* Conservation Division, Wis. Dept. Natural Resources, Madison. 318 pp.

FINE, I. V. (1966) *Wisconsin and The Vacationer.* Wisconsin Department Resource Development, Madison, 25 pp.

FINE, I. V. and R. E. TUTTLE. (1962) *Wisconsin Vacation-Recreation Papers,* Vol. II, No. 3. University of Wisconsin, Madison, 24 pp.

FINE, I. V. and E. E. WERNER. (1960) The Wisconsin Vacationer, *Wisconsin Vacation-Recreation Papers,* Vol. I, No. 11. University of Wisconsin, Madison, 15 pp.

HUMPHRYS, C. R. and J. O. VEATCH. *Classifications for Michigan's Inland Lakes.* Water Bulletin No. 8, Dept. Resource Development, Michigan State University, East Lansing. 18 pp.

MONTHEY, L. G. (1963) *Classification and Inventory of Tourist-Lodging Businesses in Wisconsin.* Recreation & Touristry Notes RT-01, University of Wisconsin. 10 pp.

MONTHEY, L. G. (1964) *The Resort Industry of Wisconsin.* Wis. Academy Science, Arts & Letters Transactions, Vol. 53—Part A, pp. 79–94.

THREINEN, C. W. (1962) *Some Spatial Aspects of Aquatic Recreation.* Fish Management Misc. Report No. 6, Conservation Division, Wis. Dept. Natural Resources, Madison, 11 pp.

*Wisconsin Lakes.* (1968) WCD Publication 218–68, Conservation Division, Wis. Dept. Natural Resources, Madison. 36 pp.

WCD Lake Use Report No. FX-31. *Booth Lake, Walworth County, Wisconsin.* (1968) Conservation Division, Wis. Dept. Natural Resources, Madison. 16 pp.

# GLACIAL GEOLOGY OF NORTHERN KETTLE MORAINE STATE FOREST, WISCONSIN

*Robert F. Black*

## Abstract

More than a century ago typical stagnant-ice features were recognized and correctly interpreted in the world-famous Kettle Interlobate Moraine in eastern Wisconsin. The common border of the Green Bay and Lake Michigan lobes of late-Woodfordian age. (Cary) is a drainageway established on and partly let down from the surface junction of the two lobes. In the Northern Kettle Moraine State Forest that drainageway, now 0.5 to 3.0 miles wide, is a marked depression that is floored largely with stratified clastics. Rising abruptly from the center of the depression are numerous striking moulin kames and from the flanks numerous crevasse fills, eskers, kames, and other stagnant-ice features that constitute "end" moraines of the two lobes. The "end" moraines are 0.5 to 3.0 miles wide and merge abruptly up ice into ground moraine with drumlins and scattered stagnant-ice features. Abrupt bends in the interlobate moraine seem related to bedrock topography and local direction of ice movement of the opposing lobes.

Many representative stagnant-ice features are preserved in the Northern Kettle Moraine State Forest, but most of the moulin kames are outside it. These kames are the best examples to be found for hundreds of miles around and are among the best to be found in the world. However, they are being destroyed rapidly because of the demand for construction aggregates.

## Introduction

Since its inception in 1937, the Northern Kettle Moraine State Forest and environs has been one of the more popular public recreational areas in Wisconsin. The center of the Forest is only 45 miles north of Milwaukee (Fig. 1) and serves especially the heavily populated area from Chicago north to Green Bay. The Forest contains many excellently developed and representative glacial features which are internationally famous, but others even more important or striking lie just outside it. The kettles—depres-


FIGURE 1. Portion of the official Wisconsin State Highway Map, centering on the Northern Kettle Moraine State Forest.

sions from the melting out of buried ice blocks—are the first in the world to have been described adequately and interpreted correctly (Whittlesey, 1860 and 1866; Chamberlin, 1877 and 1878; White, 1964). Alden (1918, p. 308) cited the area east and northeast of Kewaskum (Fig. 2) as ". . . one of the finest examples of terminal-moraine topography in the United States." Many thousands of tourists and students each year who visit the Forest do so in part because of their interest in the various glacial features, of which many may be seen along the Kettle Moraine Drive (Fig. 2). It seems timely to outline for them the glacial history of the area as we now know it, because the earlier literature is largely out of print and not focused specifically on the Forest area.

The Northern Kettle Moraine State Forest includes some 24,000 acres in a very irregular area about 22 miles long and 1 to 4 miles wide (Fig. 1). It extends from the vicinity of Glenbeulah in Sheboygan County southwesterly and then southerly to the vicinity of County Highway H, about three miles southeast of Kewaskum, in Washington County. The Forest encompasses much of the area along the common boundary between Fond du Lac and Sheboygan Counties. In and adjacent to the Forest a variety of topographic features rise abruptly some tens of feet to 200 or 300 ft. above prominent lowlands. The precipitous wooded slopes interspersed between typical well-kept Wisconsin farmlands (Fig. 3) and abundant lakes (Fig. 4) makes the area especially photogenic. The numerous lakes and the wooded hills and trails make for an ideal vacation land close to major centers of population.

The Northern Kettle Moraine State Forest lies athwart the internationally famous Kettle Interlobate Moraine. The moraine, as the name implies, was built between two ice lobes—the Green Bay lobe on the west and the Lake Michigan lobe on the east (Alden, 1918, p. 308–309)—during Woodfordian time, between 13,000 and 22,000 radiocarbon years ago (Black and Rubin, 1967–68). This is the ". . . master topographic feature of the whole series of glacial deposits in eastern Wisconsin" (Alden, 1918, p. 235) which first attracted the attention of early explorers. The moraine consists of silt and sand and coarse, angular to well-rounded rock fragments of the local light grey Niagaran dolomite particularly, but also of rocks from northern Wisconsin, Upper Michigan, and Canada. The composition and texture of the drift comprising the moraine varies markedly from place to place within the area. The drift was dumped between the two lobes of ice as they butted against each other and was also deposited under and on top of the dirty ice along that junction during the final stagnation and destruction of the ice. Hence, some debris was deposited directly from the ice,

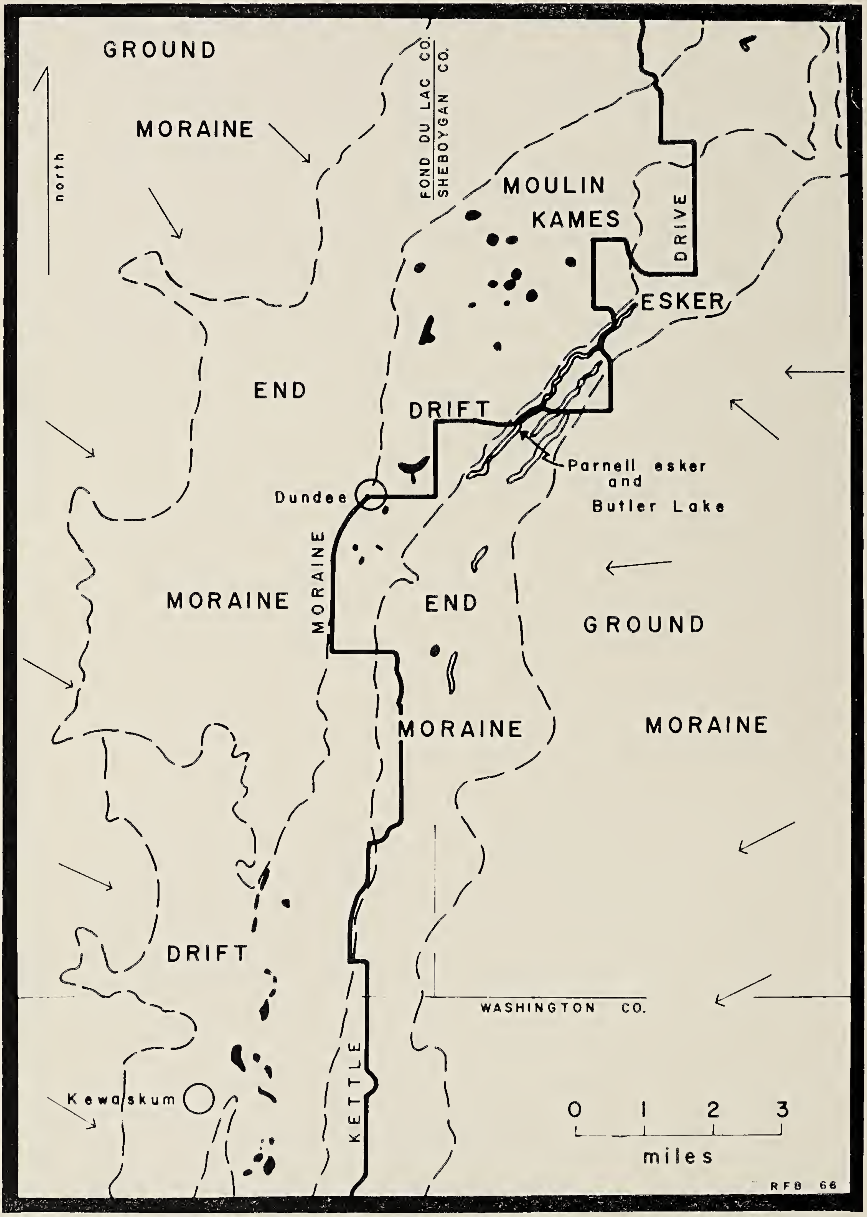



FIGURE 2. Part of the Northern Kettle Moraine State Forest and environs showing the Kettle Moraine Drive and its relation to the major glacial features. Local direction of ice movement is shown by arrows. Base from portions of Campbellsport and Kewaskum topographic quadrangles of the U. S. Geological Survey. Mapping was done largely from air photos, with local field checks.

FIGURE 3. Typical farm and wooded hills in the Kettle Interlobate Moraine, 1.5 miles south of Glenbeulah. Note light-colored, rounded cobbles of Niagaran dolomite.

but other material was displaced and reworked by gravity movements and running water. Glacial-fluvial and glacial-lacustrine deposits are especially common. The buried blocks of glacial ice subsequently melted out, pitting the surface with thousands of irregular kettles from a few feet (Fig. 5) to several miles in extent.

A privately owned area within the northcentral part of the Forest, northeast of Dundee (Fig. 2), contains one of the most striking groups of moulin kames (conical hills of drift deposited under the ice) to be found anywhere in the world (Figs. 6 and 7). [Moulin (moo'lăn') Fr., is defined by Webster's dictionary as "A nearly vertical shaft in a glacier into which a stream of water pours." The debris carried in by the water is piled up at the base of the moulin, building the moulin kame.] The kames should be protected immediately from further exploitation as they are the best examples to be found for hundreds of miles around. Several

FIGURE 4. Butler Lake, a kettle lake, as seen from the top of the Parnell esker, 2.5 miles northeast of Dundee.

less well developed or less "showy" moulin kames in another group east and north of Kewaskum have already been destroyed.

Relatively few studies have been made of the glacial phenomena in the Kettle Interlobate Moraine or of their detailed history. Much of what we know was learned 50 to more than 100 years ago when Wisconsin's outstanding glacial geologists of that heyday were active in their reconnaissance studies of the State. Far more information yet awaits discovery through detailed systematic investigations than we have learned in our various rapid reconnaissance observations. This means that even the interested layman may unearth critical discoveries which can perhaps provide important clues to the geologic history of the area. The serious student will use the following U. S. Geological Survey topographic maps in his

FIGURE 5. Knob and swale topography, 1.5 miles southwest of Dundee. Some rounded knobs are kames and others are till. The elongate ridges are crevasse fills; the ponds occupy kettles.

visit to the area: Kiel, Kewaskum, West Bend, Campbellsport, and Sheboygan Falls. The place names used herein refer to those maps, but they cannot be reproduced here.

The Kettle Interlobate Moraine was last mapped by Alden (1918) as part of a reconnaissance in southeastern Wisconsin and has hardly been touched since. Much study is needed to modify his findings significantly or to understand fully the history of individual forms or even of many large units. Different interpretations are possible within the framework of existing data. However, it seems clear that several local fluctuations of the two lobes were involved during Woodfordian time. The junction thus is a zone of partial mixing or interstratifying of material from each lobe. Outwash gravel and other glacial deposits were reworked and redeposited, commonly on pre-existing ice, as the junction shifted back and forth.

The area is so large and diverse that it is not feasible nor necessary for purposes of this report to describe each feature. Rather,

FIGURE 6. Moulin kames from left to right—McMullen Hill, Conner Hill, and Johnson Hill—northeast of Dundee.

part of the area is subdivided largely by air photo interpretation into mappable units or groups of similar geomorphic features (Fig. 2). These are not pure units because of the almost infinite detail available within any relatively small segment. Nonetheless, they serve to emphasize such features as end moraines and stagnate-ice or "dead-ice" moraine with knob and swale topography (Fig. 5), moulin kames (Figs. 6–8), outwash, eskers (Figs. 9 and 10), crevasse fills (Fig. 5), kettles (Figs. 4 and 5), and the like. These and other features are described more fully later.

Because of its variety and superb development of "text-book" features, its proximity to centers of population and heavy recreational use, and its historical importance in the development of concepts in glacial geology, this area is one of the most important in

FIGURE 7. Cut in Garriety Hill, a moulin kame northeast of Dundee.

the State. Further expansion of the Forest, in spite of high land values, is exceedingly desirable and cannot wait long before many features will be irrevocably lost.

## GENERAL DESCRIPTION OF THE MORAINE

In 1876 T. C. Chamberlin orally presented a paper to the Wisconsin Academy of Sciences, Arts, and Letters on the extent and significance of the Wisconsin Kettle Moraine (Chamberlin, 1878). In those days when great geologists were formulating principles of the concepts of glacial geology, Chamberlin was a true giant among them (Fenton and Fenton, 1952). Although today some of his words and phrases are no longer popular and editors would cut and prune his remarks in order to save space, Chamberlin's description of the moraine bears the test of time so well that this writer feels compelled to quote him directly. In describing the surface form of the moraine he wrote: "The superficial aspect of the formation is that of an irregular, intricate series of drift ridges and hills of rapidly, but often very gracefully, undulating contour,

FIGURE 8. A small moulin kame, 0.3 miles southeast of Dundee.

consisting of rounded domes, conical peaks, winding and, occasionally, geniculated ridges, short, sharp spurs, mounds, knolls and hummocks, promiscuously arranged, accompanied by corresponding depressions, that are even more striking in character. These depressions, which, to casual observation, constitute the most peculiar and obtrusive feature of the range, and give rise to its descriptive name in Wisconsin, are variously known as 'Potash kettles,' 'Pot holes,' 'Pots and kettles,' 'Sinks,' etc. Those that have most arrested popular attention are circular in outline and symmetrical in form, not unlike the homely utensils that have given them names. But it is important to observe that the most of these depressions are not so symmetrical as to merit the application of these terms. Occasionally, they approach the form of a funnel, or

FIGURE 9. Part of the Parnell esker and Butler Lake, as seen from the air, at a geologic marker.

of an inverted bell, while the shallow ones are mere saucer-like hollows, and others are rudely oval, oblong, elliptical, or are extended into trough-like, or even winding hollows, while irregular departures from all these forms are most common. In depth, these cavities vary from the merest indentation of the surface to bowls sixty feet or more deep, while in the irregular forms the descent is not unfrequently one hundred feet or more. The slope of the sides varies greatly, but in the deeper ones it very often reaches an angle of 30° or 35° with the horizon, or, in other words, is about as steep as the material will lie. In horizontal dimensions, those that are popularly recognized as 'kettles' seldom exceed 500 feet in diameter, but, structurally considered, they cannot be limited to this dimension, and it may be difficult to assign definite lim-

FIGURE 10. Part of the Parnell esker, near Butler Lake, as seen on the ground.

its to them. One of the pecularities of the range is the large number of small lakes, without inlet or outlet, that dot its course. Some of these are mere ponds of water at the bottom of typical kettles, and from this, they graduate by imperceptible degrees into lakes of two or three miles in diameter. These are simply kettles on a large scale.

"Next to the depressions themselves, the most striking feature of this singular formation is their counterpart in the form of rounded hills and hillocks, that may, not inaptly, be styled inverted kettles. These give to the surface an irregularity sometimes fittingly designated 'knobby drift.' The trough-like, winding hollows have their correlatives in sharp serpentine ridges. The combined effect of these elevations and depressions is to give to the surface an entirely distinctive character.

"These features may be regarded, however, as subordinate elements of the main range, since these hillocks and hollows are variously distributed over its surface. They are usually most abundant upon the more abrupt face of the range, but occur, in greater or less degree, on all sides of it, and in various situations. Not unfrequently, they occur distributed over comparatively level areas, adjacent to the range. Sometimes the kettles prevail in the valleys, the adjacent ridges being free from them; and, again, the reverse is the case, or they are promiscuously distributed over both. These facts are important in considering the question of their origin.

"The range itself is of composite character, being made up of a series of rudely parallel ridges, that unite, interlock, separate, appear and disappear in an eccentric and intricate manner. Several of these subordinate ridges are often clearly discernible. It is usually between the component ridges, and occupying depressions, evidently caused by their divergence, that most of the larger lakes associated with the range are found. Ridges, running across the trend of the range, as well as traverse spurs extending out from it, are not uncommon features. The component ridges are themselves exceedingly irregular in height and breadth, being often much broken and interrupted. The united effect of all the foregoing features is to give to the formation a strikingly irregular and complicated aspect." (Chamberlin, 1878, p. 202–204).

Chamberlin in actuality was referring to the surficial features of the end moraine of what is now called the late Woodfordian or Cary ice as it was deployed through the entire State of Wisconsin and not just the interlobate moraine in what is now the Northern Kettle Moraine State Forest. Nonetheless, his description can scarcely be improved upon for the area.

In speaking of the nature of the material, Chamberlin (1878, p. 205) emphasized that ". . . *all* the four forms of material common to drift, vis.: clay, sand, gravel, and boulders, enter largely into the constitution of the Kettle range, in its typical development. Of these, gravel is the most conspicuous element, *exposed to observation*." Chamberlin (1878, p. 210) further recognized that most bedrock units in Wisconsin and Upper Michigan were represented in any one section of the drift, including native copper from Keweenaw Peninsula, but that the bulk of the drift was derived locally. Thus, most gravel is composed of the local white to very light gray Niagara dolomite, well rounded by water work. However, we now know that more than one local advance of ice was involved and that reworking of outwash gravel by later advances was commonplace. Hence, some constructional forms contain non-stratified gravel instead of till. Deposition of the reworked gravel directly from ice without water working took place.

Other details of the moraine in Wisconsin were presented early, and it was compared with its counterpart in other states (Chamberlin, 1877 and 1883). In the latter paper, the term "interlobate moraine" was first introduced (Chamberlin, 1883, p. 276) and properly diagnosed as to origin in contrast to normal medial moraines. A reconstruction of the ice flow directions (Fig. 11) demonstrates conclusively the lobate character of the ice and the opposing movements of the junction of the two lobes. This gross story has changed little in the intervening 90 plus years.

Chamberlin's important role in the development of the concepts of glacial geology would not have been possible were it not for the clear observations and lucid writings of his predecessors. In connection with the Kettle Interlobate Moraine, Charles Whittlesey is singled out. It was he (White, 1964) who in the mid-1800's first recognized the "kettle moraine" and correctly interpreted the origin of the kettle holes to buried glacial ice rather than to drifting icebergs as was in vogue at the time. This was truly astonishing insight, and is but one of the major accomplishments of that amazing man.

The Greenbush Kettle, two miles south of Greenbush on the Kettle Moraine Drive, has been favored with a geological marker sign for years. It is one of the most symmetrical deep circular depressions visible from the road. Many others are more irregular (Figs. 4 and 5) but just as typical whether with or without water in them.

In brief, the Northern Kettle Interlobate Moraine is conspicuous because of its more abrupt irregularity and sharpness of feature compared with the undulating ground moraine with smoothly contoured drumlins and till-covered bedrock rises on both sides. The light grey gravel of the Interlobate Moraine also contrasts markedly with the reddish brown and light yellowish brown sandy till of the ground moraine. Neither its maximum elevation (1,311 feet at Parnell tower, 5.8 miles northeast of Dundee) nor its general relief of 100 to 200 feet are significantly different from the till plains and drumlins adjoining. However, it is characterized by major lowlands at 950 to 1,000 feet, such as that occupied by Long Lake and the East Branch of the Milwaukee River. The flatness of such lowlands and the abrupt rise of drift deposits flanking them also emphasize the glacial features. Farming of the lowlands contrasts with the wooded drift hills to spice the view.

## Drainage

The Kettle Interlobate Moraine lacks an integrated drainage network. Many closed depressions drain through the coarse gravel below and do not need surface streams. Others intersect the ground water table and have perennial ponds or lakes. Elkhart Lake, a large kettle north of the Forest, with high land around it, drains westward to Sheboygan Marsh and the Sheboygan River. Crystal Lake, next south of Elkhart Lake, has no outlet. However, Mullet River (see U. S. Geol. Survey topographic map—Kiel) flows by only ¼ mile to the southwest in its arc around the north end of the Kettle Moraine Forest. It continues southeasterly and eastward in a tortuous route to join the Sheboygan River at Sheboygan Falls. Interestingly, those two rivers have adjoining headwaters, and their uppermost courses are parallel yet flowing in opposite directions about one mile apart northwest of Long Lake. Both rivers have very intricate courses to Lake Michigan, probably in part controlled by fracture patterns in the stagnating ice which permitted the supraglacial streams to superpose themselves on the underlying drift and bedrock.

The East Branch of the Milwaukee River, flowing southward into the Milwaukee River southeast of Kewaskum, drains most of the Northern Kettle Moraine Forest proper. Its course follows the trend of the moraine and generally lies almost precisely on the reconstructed boundary between the two lobes of ice. (This is somewhat west of the boundary indicated by Alden, 1918, pl. 3). Probably its origin dates back to the initial abutment of the ice of the two lobes where it developed in the axial depression along that junction. It has remained apparently in that position since.

In the wastage of the Lake Michigan lobe, however, additional channels were formed on the stagnating ice. Mink Creek lies in a channel that starts about two miles northeast of Parnell and flows generally southerly past Beechwood in a course with abrupt right-angle bends. These seem also to reflect the fracture pattern of the ice as the initial stream was let down on the surface below. Many other examples exist in the area, but no detailed three-dimensional field study of any of them has been attempted. They need to be integrated into the history of the Moraine.

## Origin of the Glacial Features

Figure 2 shows the distribution of some glacial features that characterize certain parts of the area. For convenience in the classification, each unit is named for the most abundant or striking feature or features it contains. These units are: Ground moraine (and drumlins), drift, end moraine (or stagnate-ice or dead-ice moraine), and special features such as moulin kames and eskers. Ground moraine with drumlins and till-covered bedrock rises comprises most of the area up ice from the front of both lobes. Small stagnate-ice features in that unit are common. The orientation of drumlins, fluted forms, and striae recorded by earlier workers and summarized by Alden (1918, pl. 4) show clearly the regional movements of the ice of both lobes. Arrows on Figure 2 show local trends of the ice recorded by drumlinoid or fluted forms. Even though the general deployment of ice shown in Figure 11 and by Alden (1918, pl. 4) is not expected to be changed in gross form, detailed field work is needed to show ice movement in relation to individual segments of the moraine. Bedrock striae formed in early advances during Woodfordian time are not everywhere parallel with the alignment of molded forms—the last to be produced.

In the area of Figure 2, stratified drift, including outwash, glacial-lacustrine deposits and other water-formed features, are almost as prevalent as end moraine or stagnate-ice or dead-ice moraine formed more directly by the ice. The washed surfaces and deposits reflect in part the cleaner ice of the two lobes juxtaposed and in part the concentration of runoff along the junction of the two lobes. The normal surface gradient up ice in each lobe would have led water to the junction of the lobes, from which its escape could only have been to the south along that junction. Such water-worked stratified drift varies in size from the coarse, bouldery material of glacial streams to the sand, silt, and clay in ponded water. Drift obviously has formed in places on buried ice blocks to leave pitted outwash; elsewhere it seems that entire portions of stream beds or lake sediments have been dropped down as continuous ice below melted out. Most parts of the well-washed drift, however, were formed adjacent to ice, but not on it. Original stratification is preserved.

Even during deglaciation the widening and northward migrating gap between the two lobes effectively concentrated glacial-fluvial activity between the lobes. Thus, it was the locus for many striking forms. Eskers (Figs. 9 and 10) and moulin kames (Figs. 6 to 8) formed under the stagnate ice by subglacial streams fed through moulins or openings through the ice sheet. Their subglacial waters also flowed toward that same gap. Crevasse fills (Fig. 5), topographically commonly like short eskers, were formed in crevasses open to the sky in part by supraglacial streams and in part by mass movement of surface debris into the crevasses.

Small moulin kames are scattered throughout much of the area, but none is better developed or displayed than those in the group

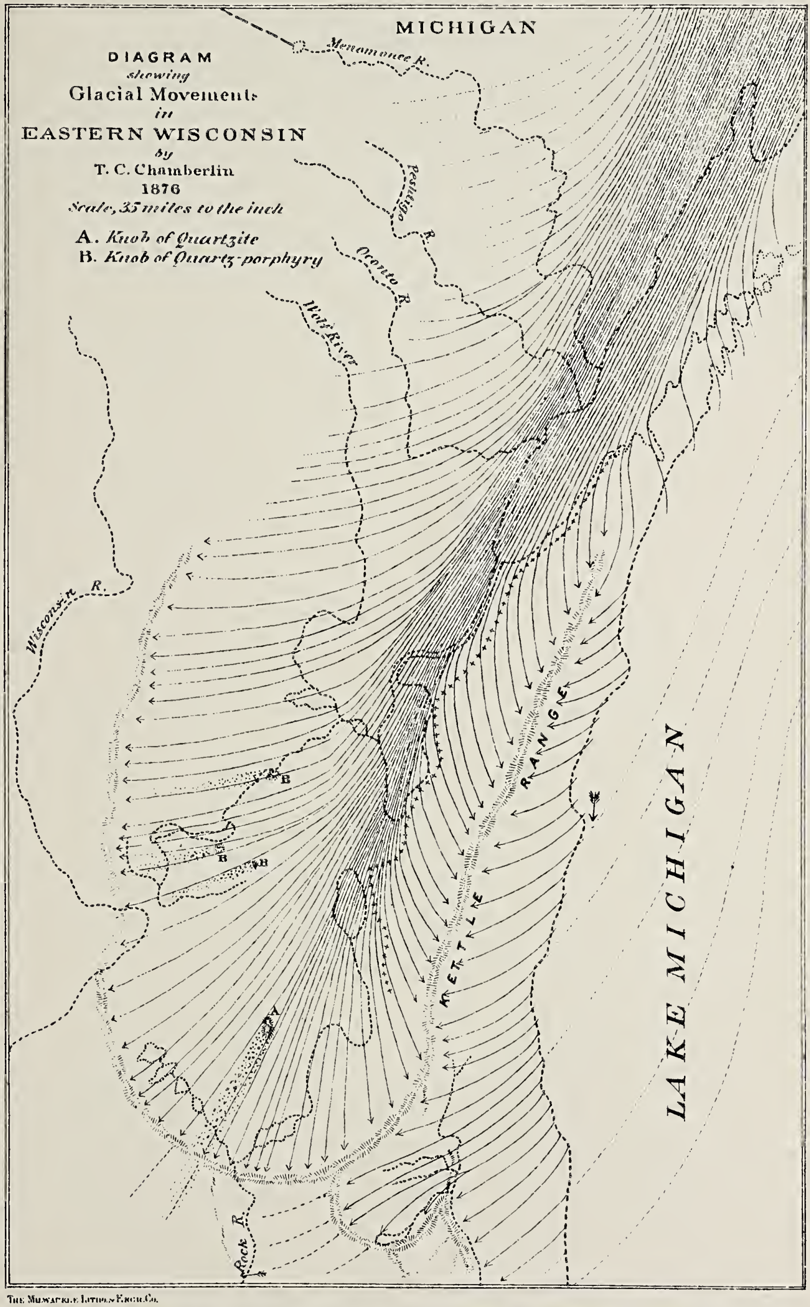



FIGURE 11. Diagram showing glacial movements in eastern Wisconsin by T. C. Chamberlin, 1876.

northeast of Dundee (Fig. 2). There, in the widest part of the washed drift area, are some of the best moulin kames to be found anywhere in the world. Beautifully conical hills, such as McMullen (Fig. 6), Garriety (Fig. 7), Conner, and Johnson, rise at the angle of repose of the material more than 100 feet above the flat, washed, drift plain surrounding them. Numerous smaller kames, only a few tens of feet high, are commonly less conspicuous among the drift ridges and are too small to show on Figure 2. Many are just as symmetrical as the larger ones in the lowlands. Other more irregular moulin kames, such as Dundee Mountain (which has a geologic marker), are also present and grade into crevasse fills or into ice-walled lake deposits (openings so enlarged that lakes formed within the glacial ice walls). Such forms originated where melt waters on the ice dropped through moulins or crevasses, dumping their detritus at the base. Openings ranged from nearly vertical, circular pipes (moulins) to very elongate fractures and rounded to irregular large openings; commonly, water and debris were fed into the fractures at more than one place along the sides and ends of crevasses, building irregular forms below the ice. Many large fractures were fed not just with running water, but also with mud flows, debris slides, and the like. Ponded water in some also trapped deltas and lacustrine sediments. Thus, the material in such features as moulin kames and crevasse fills ranges from normal till, through the available sizes of water-transported material, to ponded sediments. The cross section of Garriety Hill is typical (Fig. 7). It shows rounded to angular gravel, sand, silt and clay deposited as unsorted till in irregular masses, and as sorted sediment in alluvial flows, pond sediments, and the like. Water that formed the northern group of moulin kames drained westward under the ice to join the drainageway through Long Lake Valley. Their channels are readily discernible on aerial photographs.

End moraine and stagnate-ice or dead-ice moraine are not differentiated on Figure 2 because of their general similarity of origin. The terms are used loosely here for lack of detailed understanding of their genesis. They might have been subdivided for descriptive purposes into those areas characterized by elongate ridges and valleys and those with circular knobs and swales. In the interlobate area all are believed to result from ice stagnation and the melting out of blocks of ice of the appropriate geometry to fit the surface depressions. Such geometry is predicated on the movement of the ice at the time the ice and debris were mixed, on its fractures, or on the manner of burial by overriding ice, outwash, debris slides, etc.

The detailed deployment of the moraines in the Northern Kettle Interlobate Moraine is of considerable interest in the reconstruction of events as related to the flow of ice. From the vicinity of Kewaskum north to Dundee and to Long Lake, the trend of the Interlobate Moraine is almost north. From Long Lake the Interlobate Moraine turns fairly abruptly to the northeast to Elkhart Lake where it again swings to the north. At least part of the explanation of the bends may lie in the topography of the bedrock which unquestionably has exercised some control on the deployment of the ice. The deep pre-glacial valley at Sheboygan Marsh and Elkhart Lake must have provided relatively easy access for the ice of the Green Bay Lobe, leading it more rapidly and farther to the southeast than was possible over the bedrock hills south of that Marsh. The hills restrained the ice of the Green Bay Lobe, allowing the ice of the Lake Michigan lobe to push farther westward. Such kinks and bends in the terminal area are commonplace along the entire late Woodfordian front in Wisconsin. They are of considerable importance in understanding the development of such features as are found in the Northern Kettle Interlobate Moraine, but space does not permit their reconstruction here. Much fieldwork is called for to unravel the details of their history.

Small moulin kames in the stagnate-ice moraines are probably contemporaneous with the related features, immediately preceding kettle formation. However, the precise timing of the formation of the main group of moulin kames versus the main moraines to west and east is conjectural.

The writer hypothesizes that shortly after the two lobes butted together, the thickness of ice gradually increased from 100 to 300 feet at the start to a thickness perhaps of several thousand feet when the ice extended southward into the center of Illinois. Ablation (loss of ice) particularly by melting aided by a surface stream at the junction of the two lobes would be countered by ice movement from the base of the ice sheet diagonally upward to that junction at the surface. Upward flow at the terminal zones of glaciers is commonly at angles of 10 to 45 degrees, bringing debris from the base toward the surface to replace ice lost in the ablation zone and to maintain the surface profile of the glacier. When ice was at its maximum thickness at the junction, the basal debris may not have reached the surface. As the ice thinned during the waning of the late Woodfordian glaciation, it would intersect the surface. As thinning continued to perhaps 200 or 300 feet of ice, fractures penetrated in favorable places, aided by meltwaters, to the bottom of the glacier. In them the moulin kames, eskers, and crevasse fills began to grow. However, at that time the thicker ice away from the junction was continuing to move forward even though the terminal zone was stagnate. The shear planes and flow layers that brought debris up from the base presumably angled obliquely downward and away from the actual surface junction of the two lobes to the general location of the main moraines on both sides of the drift area. At the locus of the moraines, basal ice and debris were interstratified by flow of ice while the basal ice closer to the junction was stagnated and remained relatively free of debris. Thus, the two main moraines, one for each lobe, are in a sense end moraines even though they do not mark the terminal position of the ice nor were they deposited at the outer edge of the ice. They represent the outer edge of the *active* ice for each lobe and were separated by a zone of *stagnate* ice shaped like a very broad, low wedge with its apex upward, at least during the waning of the glaciation. It seems relatively clear that stagnation took place over much of the area because so many small ice-contact, washed-drift features are superposed on all other forms.

## Conclusions

Many details of the reconstruction of the events that led to the surface features in the Northern Kettle Interlobate Moraine are imperfectly known. New topographic maps and aerial photographs unavailable to Alden (1918) and earlier workers now permit an analysis of surface forms to be made in far more detail than was possible for him in his reconnaissance study. Surface analysis, however, is only part of the story. Serious mistakes have been made in the past in the interpretation of glacial forms by morphology alone. Sub-surface exploration must be carried on concurrently before a firm foundation can be laid that would permit us to change significantly the gross picture of the Kettle Interlobate Moraine as commonly accepted. Such detailed study has had little economic incentive, but should be undertaken before gravel pit operations remove or modify evidence that might be the key to part of the story. A beautiful story can be constructed on evidence available, but an even larger part of the story is still unsupported in fact. The prospects in future study are especially intriguing.

Thus, in brief, the heavy use of the area for recreation and consequent loss of land for cottages and commercial development require our immediate action to preserve many glacial forms, like kames, eskers, and stagnate-ice features. Demands for gravel are increasing and many glacial forms are being removed *en toto*. We must protect not only the many striking forms but also the "normal" forms now before they are exploited. Many shown in the mapped area of Figure 2 are outside of the Forest proper. It is hoped that some of the better ones ultimately will find their place in the public trust. If not, the gravelly deposits will disappear as have some moulin kames and crevasse fills immediately east of Kewaskum, on the north side of Highway 28.

## References Cited

ALDEN, WILLIAM C., 1918, The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 105, 356 p.

BLACK, ROBERT F., and RUBIN, MEYER, 1967–68, Radiocarbon dates of Wisconsin: Wis. Acad. Sci., Arts, and Letters, v. 56, p. 99–115.

CHAMBERLIN, T. C., 1877, Quaternary Formations—the drift: Chap. V, p. 199–246, in Geology of Wisconsin, v. 2, 768 p. Commissioners of Public Printing.

CHAMBERLIN, T. C., 1878, On the extent and significance of the Wisconsin kettle moraine: Wis. Acad. Sci., Arts, and Letters, Trans., v. 4, p. 201–234.

CHAMBERLIN, T. C., 1883, Terminal moraine of the second glacial epoch: U. S. Geol. Survey Third Annual Report, p. 291–402.

FENTON, CARROLL LANE and FENTON, MILDRED ADAMS, 1952, Giants of geology: Doubleday and Co., 333 p.

WHITE, GEORGE W., 1964, Early description and explanation of kettle holes: Jour. Glac., v. 5, p. 119–122.

WHITTLESEY, CHARLES, 1860, On the drift cavities, or "potash kettles" of Wisconsin: Amer. Assoc. Advancement Sci., Proc., 13th meeting, 1859, p. 297–301.

WHITTLESEY, CHARLES, 1866, On the fresh-water glacial drift of the northwestern states: Smithsonian Contr. Knowledge, No. 197, 32 p.

## Acknowledgements

Robert F. Black is Professor of Geology, the University of Wisconsin, Madison. Field work leading to this report was supported by the National Parks Service, by the National Science Foundation, by the Research Council of the University of Wisconsin Graduate School from funds supplied by the Wisconsin Alumni Research Foundation, by the Wisconsin State Highway Commission, and by the Wisconsin Geological and Natural History Survey.

# AGE AND GROWTH OF THE WALLEYE IN LAKE WINNEBAGO

*Gordon R. Priegel*
*Bureau of Research*
*Department of Natural Resources*
*Madison, Wisconsin*

## Introduction

The walleye, *Stizostedion vitreum vitreum* (Mitchill), is an abundant sport fish in Lake Winnebago and connecting waters and it attracts more fishermen to the Lake Winnebago area than any other sport fish. This report describes the age and growth of this species in Lake Winnebago and is part of a study on the life history of the walleye.

Maintenance stocking of walleyes is not practiced in the study area and accordingly this paper refers exclusively to a natural population.

## Materials and Methods

The 1,237 walleyes used in this study consisted of 1,017 yearling or older fish collected during October and November, 1960 and 220 young-of-the-year walleyes collected from June—October, 1961. All young-of-the-year fish were taken with 12-foot otter trawls while Lake Erie type trap nets, 12-foot otter trawls and an A.C. shocker unit were used to collect the older fish.

The length measurements of adult walleyes were made on fresh specimens. The total lengths were measured to the nearest tenth of an inch on a standard measuring board. The length measurements of young-of-the-year walleyes were made on preserved specimens (10 percent formalin). The weight of each fish was determined to the nearest hundredth of a pound; no young-of-the-year fishes were weighed. All fish, for which length and weight were recorded (1,017 fish), were used in the study of the length-weight relation.

Key scales from 1,237 fish were taken from above the lateral line on the left side and came from the intersection of the third row above the lateral line and the first scale row before the first dorsal spine. The scales were impressed on cellulose acetate slides, 0.03 inch thick, by a roller press similar to that described by Smith (1954). Butler and Smith (1953) demonstrated that this method of preparation does not affect the measurements of scales. The examination and measurements of scales were made by means of a micro-projector at the magnification 44X. The length of each scale and the distances from the focus to each annulus were measured along the anterior radius most nearly collinear with the focus as described by Hile (1954) and recorded to the nearest tenth of an inch.

Ages were determined by counting the annuli and are given in terms of completed years of life. They are expressed by Roman numerals corresponding to the number of annuli so that fish in the second year of life belong to age-group I (Hile, 1948).

Sex and state of maturity were determined for all fish except the 220 young-of-the-year fish collected in 1961. Determination of sex in adult walleyes is easy as the testes have a whitish-gray appearance, and the ovaries are yellowish with readily visible eggs. Size and shape of gonads, blood vessels on gonads, and color of gonads were used to sex immature fish (Eschmeyer, 1950). In fish of comparable size, the gonads are distinctly the wider in the female. The testis tapers towards the apical and over a considerable portion of its total length, while the region of tapering is much shorter in the ovary. Ordinarily, at least one of the ovaries tends to be translucent. The dorsal blood vessel of the testis lies in a groove; that of the ovary is on the surface. Veins are usually visible passing across the ovary, while this cross-venation is not found on the testis.

The fecundity of 130 walleyes over a size range of 16.6–25.2 inches in total length and a range of 1.39–6.00 pounds was determined. The ovaries from these walleyes were preserved in 10 percent formalin. The weight of each ovary was determined just prior to sampling and a transverse section was made through an ovary. The section was weighed, and the number of eggs within was determined by actual count. The section represented 1.2 to 7.4 percent of the entire ovary. The total number of eggs per fish was estimated on a proportional basis.

## Results and Discussion

### 1. Age and Growth

The precise time of annulus formation of Lake Winnebago walleyes was not established. Annulus formation probably occurs in May or early June. Carlander (1945) reports that walleyes form an annulus in late May or early June in Lake of the Woods, Minnesota and Cleary (1949) reported the same for Clear Lake, Iowa.

Use of the scale method to determine the age of the Lake Winnebago walleyes is justified by the following observations:

1. Fish known to be young-of-the-year had no annuli on the scales.
2. The number of annuli increased with the size of the fish.

The body-scale relationship was determined from the measurement of 1,237 walleyes which were grouped into half-inch groups from 1.0 to 24.5 inches. The mean body length for each group was plotted against the corresponding mean lengths of the anterior scale radii and the relationship may be expressed as:

$$L = 1.443 + 3.171\ (R)$$

where $L$ = total length in inches
and $R$ = anterior scale radius $\times$ 44

The body-scale relationship was linear.

The calculations of length at each annuli were made from measurements of the anterior radius applied in the formula:

$$L_1 = C + \frac{S_1}{S}(L - C)$$

where $L_1$ is the length of the fish at the time of each annulus formation, C is the length of the fish at the time of scale formation, $S_1$ is the length of the anterior radius of the scale at each annulus, S is the length of the anterior radius at capture and L is the total length of the fish at time of capture. The length of the fish at the time of scale formation is 40 millimeters (1.6 inch) as determined from close examination of 220 specimens (Priegel, 1964). The regression line of the body-scale relationship intercepts the abscissa at 1.443 which is slightly less than the value determined for body length at time of scale formation.

The average calculated lengths of males and females in different age groups of walleyes gave evidence of sex differences in growth rate so the data for males and females were kept separate (Tables 1 and 2.)

Two estimates of general growth are given in the bottom section of Tables 1 and 2. One is based on the grand average calculated total lengths and the second on the summation of the grand average annual increments of length. The present discussion is based on the sums of increments, since this curve should represent the average growth that walleyes might have if the population was not subjected to selective destruction of individuals with the more rapid growth. (Figure 1.)

TABLE 1. CALCULATED TOTAL LENGTH AT END OF EACH YEAR OF LIFE OF EACH AGE GROUP OF LAKE WINNEBAGO MALE WALLEYES AND AVERAGE GROWTH FOR THE COMBINED AGE GROUPS

| Age Group | Number of Fish | Length (Inches) at End of Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| I | 58 | 7.1 | | | | | | | |
| II | 27 | 5.8 | 11.7 | | | | | | |
| III | 62 | 5.2 | 10.2 | 13.6 | | | | | |
| IV | 60 | 5.4 | 9.9 | 12.7 | 14.8 | | | | |
| V | 89 | 5.6 | 9.9 | 12.2 | 13.7 | 15.2 | | | |
| VI | 80 | 5.4 | 10.1 | 12.5 | 13.7 | 14.7 | 16.0 | | |
| VII | 38 | 5.6 | 10.2 | 12.6 | 13.7 | 14.6 | 15.4 | 16.4 | |
| VIII | 11 | 5.6 | 10.2 | 12.6 | 13.9 | 14.8 | 15.4 | 16.0 | 16.8 |
| Grand average calculated length | | 5.6 | 10.2 | 12.7 | 14.2 | 15.1 | 15.6 | 16.2 | 16.8 |
| Mean annual increment | | 5.6 | 4.6 | 2.5 | 1.4 | 1.0 | 0.7 | 0.6 | 0.7 |
| Growth based on summation of increment | | 5.6 | 10.2 | 12.7 | 14.1 | 15.1 | 15.8 | 16.4 | 17.1 |

TABLE 2. CALCULATED TOTAL LENGTH AT END OF EACH YEAR OF LIFE OF EACH AGE GROUP OF LAKE WINNEBAGO FEMALE WALLEYES AND AVERAGE GROWTH FOR THE COMBINED AGE GROUPS

| Age Group | Number of Fish | Length (Inches) at End of Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| I | 111 | 7.6 | | | | | | | |
| II | 84 | 6.2 | 12.1 | | | | | | |
| III | 79 | 5.3 | 10.2 | 14.6 | | | | | |
| IV | 90 | 5.4 | 9.6 | 13.4 | 16.8 | | | | |
| V | 109 | 5.7 | 9.6 | 12.8 | 15.2 | 17.7 | | | |
| VI | 77 | 5.6 | 9.8 | 12.8 | 14.8 | 16.5 | 18.9 | | |
| VII | 36 | 5.8 | 9.7 | 13.5 | 14.6 | 15.9 | 17.3 | 19.3 | |
| VIII | 6 | 5.4 | 9.7 | 13.3 | 15.3 | 17.0 | 18.4 | 20.4 | 21.0 |
| Grand average calculated length | | 6.0 | 10.1 | 13.4 | 15.6 | 17.3 | 18.6 | 19.5 | 20.5 |
| Mean annual increment | | 6.0 | 4.1 | 3.2 | 2.2 | 1.8 | 1.6 | 1.2 | 1.0 |
| Growth based on summation of increment | | 6.0 | 10.1 | 13.3 | 15.5 | 17.3 | 18.9 | 20.1 | 21.1 |

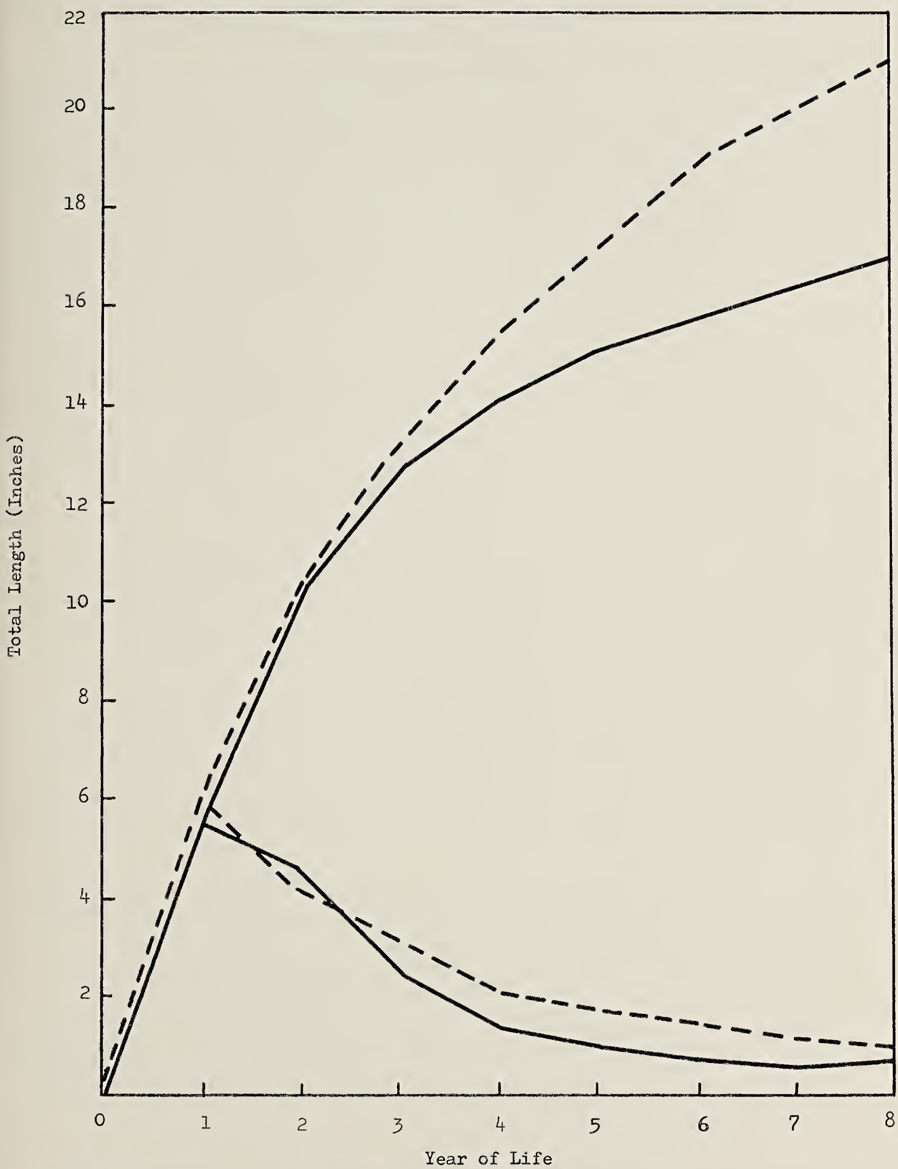



FIGURE 1. General growth in length and annual increment in length of Lake Winnebago walleyes. Males, solid line; females, broken line.

Comments on general growth and a comparison of the growth of the sexes are best made from Table 3 which was prepared from data of Tables 1 and 2.

The total lengths of the sexes in the first year of life showed a 0.4 inch advantage for the females but a 0.1 inch advantage for the males at the end of the second year of life. The advantage of the females increased from 0.6 inches at the end of the third year to 4.0 inches at the end of the eighth year. If the 13-inch size limit was still in effect, this difference in growth rate between male and female fish would have affected the age at which the legal size was reached. The male walleye took 4 years to reach legal size and the female 3 years.

The greatest increase in length for both sexes took place during the first year of life (6.0 inches for the females and 5.6 inches for the males). The amount of growth dropped during the second year, and the decrease continued for the females through the eighth year; but, the males made nearly the same amount of growth each year after the fifth year (0.6 inches to 0.7 inches).

Many authors have reported on the growth rates of walleyes in various bodies of water (Table 4). The walleye population in each individual body of water differs in growth rate from other bodies of water. The greatest growth occurred in southern reservoirs, Norris Reservoir and Clayton Lake.

The Lake Winnebago walleye is one of the slowest growing fish when compared to the walleye populations mentioned in Table 4. Only the growth rate of the walleye in Lake Gogebic, Michigan, is similar to the Lake Winnebago walleye. Lack of forage fishes and competition from other fish species (burbot, sauger and yellow

TABLE 3. CALCULATED TOTAL LENGTHS (INCHES) AND LENGTH INCREMENTS OF MALE AND FEMALE WALLEYES OF LAKE WINNEBAGO IN DIFFERENT YEARS OF LIFE

| YEAR OF LIFE | MALES | | FEMALES | | SIZE ADVANTAGE OF FEMALES |
|---|---|---|---|---|---|
| | Calculated Length | Increment | Calculated Length | Increment | |
| I | 5.6 | 5.6 | 6.0 | 6.0 | +0.4 |
| II | 10.2 | 4.6 | 10.1 | 4.1 | −0.1 |
| III | 12.7 | 2.5 | 13.3 | 3.2 | +0.6 |
| IV | 14.1 | 1.4 | 15.5 | 2.2 | +1.4 |
| V | 15.1 | 1.0 | 17.3 | 1.8 | +2.2 |
| VI | 15.8 | 0.7 | 18.9 | 1.6 | +3.1 |
| VII | 16.4 | 0.6 | 20.1 | 1.2 | +3.7 |
| VIII | 17.1 | 0.7 | 21.1 | 1.0 | +4.0 |

TABLE 4. CALCULATED GROWTH OF WALLEYES REPORTED FROM VARIOUS WATERS

| Locality | Number of Fish | Average Calculated Total Length (Inches) Reported from Various Waters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Present study | 411 (males) | 5.6 | 10.2 | 12.7 | 14.1 | 15.1 | 15.8 | 16.4 | 17.1 | — | — | — |
| | 585 (females) | 6.0 | 10.1 | 13.3 | 15.5 | 17.3 | 18.9 | 20.1 | 21.1 | — | — | — |
| Des Moines River, Iowa (Schmulbach, 1959) | 112 | 8.4 | 11.5 | 14.4 | 16.6 | 18.7 | 20.3 | 21.7 | 22.5 | 22.6 | — | — |
| Clear Lake, Iowa (Cleary, 1949) | 319 | 5.9 | 10.9 | 14.5 | 17.2 | 19.3 | 21.4 | 23.6 | 26.3 | 27.0 | 27.7 | 28.1 |
| Trout Lake, Wisconsin (Schloemer & Lorch, 1942) | 429 | 5.3 | 9.7 | 13.7 | 16.6 | 19.0 | 20.7 | 21.7 | 22.3 | 23.1 | 23.3 | — |
| Norris Reservoir, Tennessee (Stroud, 1949) | 2,898 | 10.3 | 16.4 | 18.7 | 19.9 | 20.8 | 21.0 | 22.1 | 24.9 | — | — | — |
| Minnesota Lakes (Eddy & Carlander, 1929) | 6,599 | 4.9 | 9.1 | 12.7 | 15.8 | 19.1 | 21.6 | 24.2 | 26.6 | 28.2 | — | — |
| Lake Gogebic, Michigan (Eschmeyer, 1950) | 252 (males) | 4.4 | 9.3 | 11.8 | 13.9 | 15.2 | 16.3 | 16.9 | 17.3 | 17.7 | 18.0 | — |
| | 267 (females) | 4.9 | 9.4 | 12.4 | 14.5 | 16.3 | 17.9 | 18.9 | 19.8 | 20.4 | 21.0 | — |
| Spirit Lake, Iowa (Rose, 1951) | 321 | 7.2 | 11.1 | 14.4 | 17.5 | 19.9 | 22.2 | 23.7 | 24.9 | 26.0 | 27.8 | — |
| Clayton Lake, Virginia (Roseberry, 1950) | 254 | 9.9 | 15.2 | 19.8 | 23.2 | 26.1 | 27.6 | 29.9 | 32.2 | — | — | — |
| Northern Green Way, Wisconsin (Balch, 1951) | 390 (males) | 6.6 | 10.0 | 12.8 | 15.1 | 17.2 | 18.6 | 19.7 | 24.8 | 25.8 | 26.8 | — |
| | 442 (females) | 6.7 | 10.2 | 12.9 | 15.7 | 18.1 | 19.8 | 21.1 | 26.8 | 27.9 | — | — |

perch) in Lake Winnebago are probably the limiting factors for the slow growth rate in the walleye. The long spawning migration (90 miles maximum) may also be a factor related to slow growth since these migrations must result in great energy loss.

## 2. Age At Maturity

Only those females showing eggs forming in the ovary were considered mature, and the males were considered mature if the testis showed the characteristic whitish-gray color. Since all fish were collected during the late fall, no difficulties were encountered between distinguishing immature and mature fish.

The information on the age and degree of maturity of the walleye included in this sample is presented in Table 5. The average age of maturity was considered as that age at which 50 percent of the fish reach maturity. (Table 5). The male walleye would generally be considered as mature at the end of the third year of life. At the end of the sixth year of life, all males were mature. The female walleye would be considered as mature at the end of the sixth year of life. Only at the end of the eighth year of life were all females mature. The males show a definite tendency to mature earlier in life.

The average total length at which more than 50 percent of the males are mature is 12.7 inches. The average total length at which more than 50 percent of the females are mature is 18.9 inches. Hile (1954) reported that 50 percent of the Saginaw Bay walleyes had reached sexual maturity at 15.5 inches for the male and 17.0 inches for the females. Eschmeyer (1950) for Gogebic Lake, Michigan, showed that males mature at 12.2 inches in total length and females at 15.4 inches. In Red Lake, Minnesota, males mature at age group

TABLE 5. SEX COMPOSITION OF AGE GROUPS OF LAKE WINNEBAGO WALLEYES AND (IN PARENTHESES) PERCENTAGE MATURE

| Age Group | Number of Males | Number of Females |
|---|---|---|
| I | 58 | 111 |
| II | 27 (37) | 84 |
| III | 62 (73) | 79 |
| IV | 60 (93) | 90 (8) |
| V | 89 (96) | 109 (32) |
| VI | 80 (100) | 77 (67) |
| VII | 38 (100) | 36 (81) |
| VIII | 11 (100) | 6 (100) |
| Total | 425 (77) | 592 (22) |

5 and females at age group 6 (Smith, Krefting, and Butler 1952). Balch (1951) reported that about one-half of the male walleyes are mature by the time they reach 15.5 inches and that one-half of the females in the 17-inch group were mature in Northern Green Bay waters of Lake Michigan.

3. Length-Weight Relation

Length-weight relation was calculated from fish grouped by half inch total length intervals from 7.0 to 24.5 inches. There was no significant difference between sexes so all fish were combined. Length-weight relation of Lake Winnebago walleyes is expressed by the regression:

$$\text{Log W} = -5.3596 + 3.2162 \text{ Log L}$$

where W = weight in pounds
and L = total length in inches

In the graphical representation of the length-weight relation (Figure 2) the smooth curve represents the calculated weights, and the dots the empirical ones. The agreement of the calculated and empirical weights was satisfactory. The discrepancies were more pronounced among the larger fish; but, on the whole, distribution of the disagreements had no particular trend. Discrepancies among the larger fish resulted from the smaller number of fish and actual weights were great enough to make relatively modest disagreements seem larger.

Calculated growth in weight (Table 6) was determined by applying calculated lengths (sum of the average increments of length) of Tables 7 and 8 to the length-weight relation. The annual increments of weight for the males increased irregularly, while the annual increments of weights for the females showed a gradual increase during the first six years. Increments in individual years of life for the females were 0.05 pounds in the first year of life to a maximum of 0.56 pounds in the sixth year of life. It took the males five years to reach 1 pound and the females slightly under 4 years to obtain 1 pound.

4. Fecundity

A few estimates have been published on the egg production of the walleye, but most of these estimates have been made on a small number of fish and the size range has been limited. Vessel and Eddy (1941) who had the largest sample (62 fish) from Cut-Foot Sioux Lake, Minnesota, estimated the egg production of walleyes from 1.5 to 5.0 pounds at 39,000–128,000 eggs. Eschmeyer (1950) estimated egg production from Lake Gogebic, Michigan, walleyes

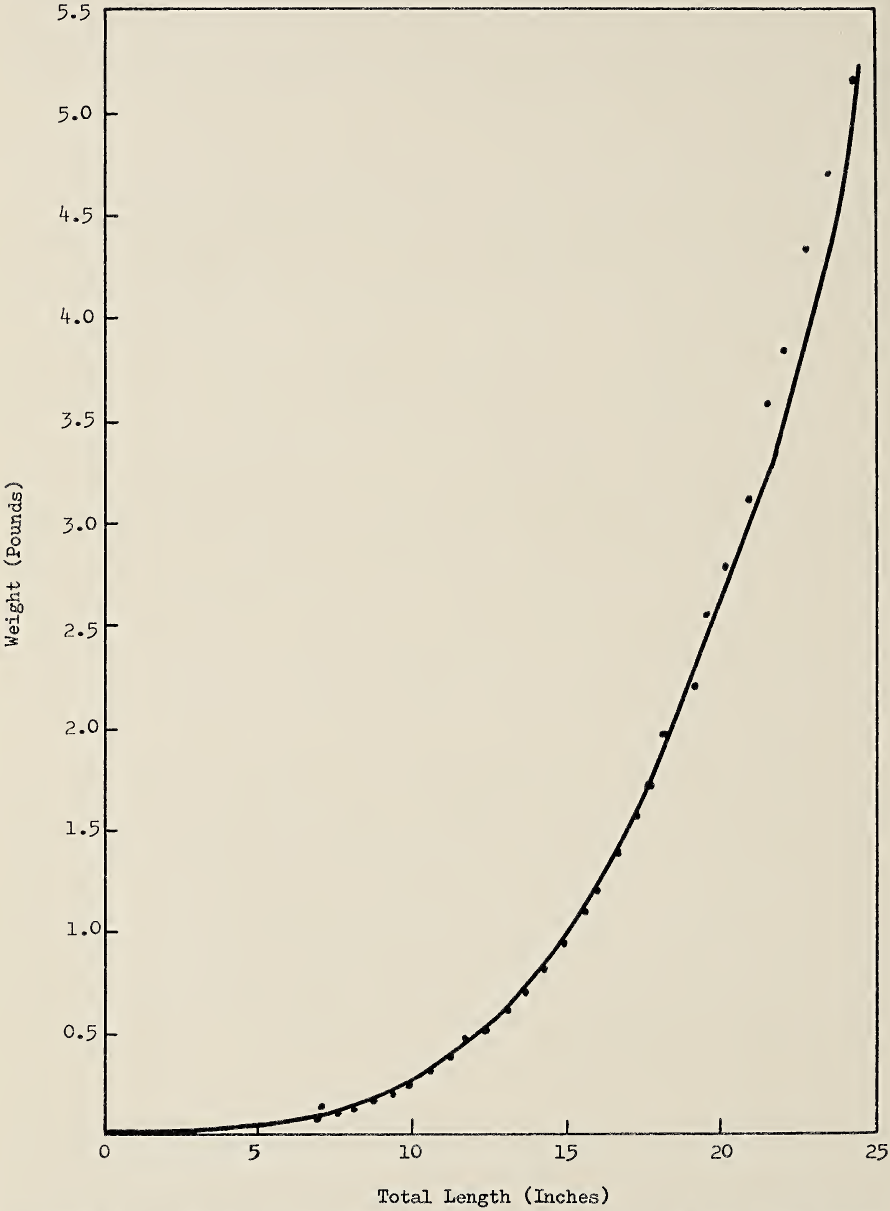



FIGURE 2. Length-weight relation of the Lake Winnebago walleyes. Dots represent the empirical data and the smooth curve is the calculated data.

TABLE 6. CALCULATED WEIGHTS IN POUNDS AT THE END OF EACH YEAR OF LIFE OF LAKE WINNEBAGO WALLEYES

| YEAR OF LIFE | MALE | | FEMALE | |
|---|---|---|---|---|
| | Calculated Weight | Increment | Calculated Weight | Increment |
| I | 0.04 | 0.04 | 0.05 | 0.05 |
| II | 0.28 | 0.24 | 0.27 | 0.22 |
| III | 0.60 | 0.32 | 0.68 | 0.41 |
| IV | 0.84 | 0.24 | 1.11 | 0.43 |
| V | 1.05 | 0.21 | 1.63 | 0.52 |
| VI | 1.20 | 0.15 | 2.19 | 0.56 |
| VII | 1.37 | 0.17 | 2.68 | 0.49 |
| VIII | 1.59 | 0.22 | 3.08 | 0.40 |

Weights are from the general length–weight relation and correspond to lengths at the end of year of life on the general growth curve for scales taken above the lateral line.

TABLE 7. ESTIMATED EGG PRODUCTION OF LAKE WINNEBAGO WALLEYES

| LENGTH GROUPS IN INCHES (T. L.) | NUMBER SAMPLED | AVERAGE WEIGHT OF FISH | AVERAGE WEIGHT OF OVARIES (GRAMS) | AVERAGE SAMPLE WEIGHT OF OVARIES (GRAMS) | AVERAGE PERCENTAGE OF OVARIES COUNTED | AVERAGE CALCULATED NUMBER OF EGGS |
|---|---|---|---|---|---|---|
| 16.5–16.9 | 1 | 1.39 | 38.1 | 2.0 | 5.2 | 62,617 |
| 17.0–17.4 | 1 | 1.50 | 24.4 | 1.8 | 7.4 | 43,255 |
| 17.5–17.9 | 6 | 1.95 | 64.5 | 1.9 | 3.2 | 65,616 |
| 18.0–18.4 | 6 | 2.12 | 57.8 | 1.9 | 3.3 | 77,832 |
| 18.5–18.9 | 11 | 2.34 | 74.2 | 2.3 | 3.3 | 93,532 |
| 19.0–19.4 | 15 | 2.61 | 89.3 | 2.3 | 2.7 | 98,904 |
| 19.5–19.9 | 24 | 2.73 | 94.7 | 2.5 | 2.8 | 105,417 |
| 20.0–20.4 | 21 | 2.89 | 104.4 | 2.7 | 2.6 | 108,052 |
| 20.5–20.9 | 12 | 3.18 | 117.2 | 3.5 | 3.1 | 114,738 |
| 21.0–21.4 | 13 | 3.60 | 141.1 | 3.3 | 2.4 | 138,414 |
| 21.5–21.9 | 7 | 3.94 | 159.9 | 3.2 | 2.0 | 148,913 |
| 22.0–22.4 | 6 | 4.04 | 158.9 | 3.2 | 2.1 | 143,794 |
| 22.5–22.9 | 2 | 4.67 | 243.7 | 4.0 | 1.6 | 89,377 |
| 23.0–23.4 | 3 | 4.63 | 189.0 | 3.1 | 1.7 | 169,250 |
| 24.0–24.4 | 1 | 5.20 | 291.9 | 3.5 | 1.2 | 227,181 |
| 25.0–25.4 | 1 | 6.00 | 155.1 | 3.6 | 2.3 | 127,569 |

(34 fish) at 36,871–154,906 eggs for fish from 16.0–22.9 inches in total length. Smith (1941) calculated that three Norris Reservoir walleyes of 25.0–26.5 inches in total length produced from 77,500–87,400 eggs.

The estimates of the egg production for walleyes by half-inch size groups are given in Table 7. The egg production ranged from 43,255 eggs for a 17.4 inch, 1.50 pound walleye to 227,181 eggs for a 24.2 inch, 5.20 pound walleye. The heaviest walleye (6.00 pounds and 25.2 inches) had a count of 127,569 eggs.

## Summary

1. Age determinations and growth histories were calculated by the scale method from a sample of 1,237 walleyes.

2. Body-scale relation is expressed by the formula:

$$L = 1.443 + 3.171 \ R$$

where $L$ = total length in inches
and $R$ = anterior scale radius $\times$ 44

3. Difference in growth rate for the sexes was noted. The advantage of the females increased from 0.6 inches at the end of the third year to 4.0 inches at the end of the eight year. If the 13-inch size limit was still in effect, it would take the male walleye four years to reach legal size and the female three years.

4. The annual increments of weight for the males increased irregularly while the annual increments of weight for the females showed a gradual increase during the first six years. It took the males five years to reach one pound and the females slightly under four years to obtain one pound.

5. The average age of maturity was considered as that age at which 50 percent of the fish reach maturity. The male walleyes would be considered as mature at the end of the third year of life. At the end of the sixth year of life, all males were mature. The female walleyes were considered as mature at the end of the sixth year of life. Only female fish at the end of the eighth year of life were all mature.

6. The Lake Winnebago walleye is one of the slowest growing walleye when compared to the walleye populations of other waters.

7. The egg production of the Lake Winnebago walleye ranged from 43,255 eggs for a 17.4-inch, 1.50-pound walleye to 227,181 eggs for a 24.2-inch, 5.20-pound walleye.

8. Length-weight relation is expressed by the formula:

$$\text{Log W} = -5.3596 + 3.2162 \text{ Log L}$$

where W = weight in pounds
and L = total length in inches

## Literature Cited


Balch, Robert. 1951. The age and growth of the yellow pike-perch, *Stizostedion v. vitreum* (Mitchill) in the Green Bay waters of Lake Michigan. Invest. Rpt. No. 652, Fish Mgt. Div., Wis. Cons. Dept., mimeo.

Butler, Robert L. and Lloyd L. Smith, Jr. 1953. A method for cellulose acetate impressions of fish scales, with a measurement of its reliability. Prog. Fish. Cult., 15:175–178.

Carlander, Kenneth D. 1945. Age, growth, sexual maturity, and population fluctuations of the yellow pike-perch, *Stizostedion vitreum vitreum* (Mitchill) with reference to the commercial fisheries, Lake of the Woods, Minnesota. Trans. Amer. Fish. Soc., 73:90–103.

Cleary, Robert E. 1949. Life history and management of the yellow pike-perch, *Stizostedion vitreum vitreum* (Mitchill) of Clear Lake, Iowa. Iowa St. Univ. J. Sci., 23(2):195–208.

Eddy, Samuel and Kenneth D. Carlander. 1939. Growth of Minnesota fishes. Minn. Conservationist 69:8–10.

Eschmeyer, Paul H. 1950. The life history of the walleye, *Stizostedion vitreum vitreum* (Mitchill) in Michigan. Bull. Inst. Fish. Res. (Mich.) 3:1–99.

Hile, Ralph. 1948. Standardization of methods of expressing lengths and weights of fish. Trans. Amer. Fish. Soc. 75:157–164.

———. 1954. Fluctuations in growth and year-class strength of the walleye in Saginaw Bay. U.S. Fish and Wildlife Service, Fish. Bull. 56:7–59.

Priegel, Gordon R. 1964. Early scale development in the walleye. Trans. Amer. Fish. Soc. 93(2):199–200.

Rose, Earl T. 1951. Notes on the age and growth of Spirit Lake Yellow pike-perch (*Stizostedion* v. vitreum). Proc. Iowa Acad. Sci. 58:517–526.

Roseberry, Dean A. 1951. Fishery management of Claytor Lake, an impoundment on the New River of Virginia. Trans. Amer. Fish. Soc. 80:194–209.

Schloemer, Clarence L. and Ralph Lorch. 1942. The rate of growth of the walleye pike, *Stizostedion vitreum vitreum* (Mitchill) in Wisconsin's inland waters, with special reference to the growth characteristics of the Trout Lake population. Copeia. No. 4, pp. 201–211.

Schmulbach, James C. 1959. Growth of the walleye in the Des Moines River, Boone County, Iowa. Proc. Iowa Acad. Sci., 66:523–533.

Smith, Charles O. 1941. Egg production of walleyed pike and sauger. Norris Reservoir fish differ from some species in other localities. Prog. Fish Cult. 54:32–34.

Smith, Lloyd L., Jr., Laurits W. Krefting and Robert L. Butler. 1952. Movements of marked walleyes, *Stizostedion vitreum vitreum* (Mitchill) in the fishery of the Red Lakes, Minnesota. Trans. Amer. Fish Soc. 81:179–196.

Smith, Stanford H. 1954. A method of producing plastic impressions of fish scales without the use of heat. Prog. Fish Cult. 16:75–78.

Strong, Richard H. 1949. Growth of Norris Reservoir walleye during the first twelve years of impoundment. Journ. Wildl. Mgt. 13(2):157–177.

Vessel, Matt F., and Samuel Eddy. 1941. A preliminary study of the egg production of certain Minnesota fishes. Minn. Bur. Fish Res. Invest. Rept. 26:26 pp.

# REGULARLY OCCURRING FLUCTUATIONS IN YEAR-CLASS STRENGTH OF TWO BROOK TROUT POPULATIONS

*Ray J. White and Robert L. Hunt**

During a 12-year period (1953–64) year class strength of wild brook trout *(Salvelinus fontinalis)* fluctuated rhythmically in two central Wisconsin streams, Lawrence Creek (Adams and Marquette Counties) and Big Roche-a-Cri Creek (Adams and Waushara Counties). In this paper we discuss the nature of these rhythmic year class fluctuations and examine some possible reasons for their regularity.

Population dynamics of trout have been studied since 1953 in Lawrence Creek primarily to test angling regulations (emphasis switched to trout habitat management in 1964), and since 1957 in the Roche-a-Cri to assess effects of trout habitat management. Normal statewide angling regulations for trout applied to the Roche-a-Cri: season from early or mid-May until September 7, a minimum legal size limit of 6 inches and a bag limit of 10 trout per day. Angling pressure was greatest during seasons when trout were most abundant. At Lawrence Creek, length of the fishing season was the same, but 6 combinations of experimental restrictions on size, bag and gear were tested in various parts of the stream during 1955–64. Changes in angling regulations caused angler exploitation of the trout population to vary greatly (Hunt, Brynildson and McFadden, 1962; Hunt and Brynildson, 1964; Hunt, 1964).

## Description of the Streams

Although the streams lie only 18 miles apart, their physical, hydrological and vegetational characteristics differ. Lawrence Creek usually has somewhat better living conditions for brook trout. The stream arises in a terminal moraine and flows eastward through a rolling landscape of glacial drift. Our study area, extending from the headwaters to an artificially impounded lake, comprises 3.4 stream miles. The Roche-a-Cri, directly north of Lawrence Creek, flows westward from the same moraine across a

* Mr. White, formerly a Biologist with the Wisconsin Conservation Division, is now at the Laboratory of Limnology, University of Wisconsin—Madison. Mr. Hunt is leader of the Trout Research Group of the Wisconsin Conservation Division.

glacial outwash plain. The study area covered in this paper includes the upper 6.1 miles of trout water. Each stream passes through patches of forest, marshy meadows and thickets of brush. Many distinct springs feed Lawrence Creek. Its discharge at the downstream end of the study area is about 25 cfs during periods of baseflow. The streambed falls an average of 11.5 feet per mile. In contrast, the Roche-a-Cri receives less ground water seepage and flows through flatter terrain (its gradient = ca. 7 ft./mile). At a point 4 miles below the stream's source, baseflows vary from 5 to 9 or more cfs depending on recent precipitation. Figure 1 contrasts the relatively stable discharge of Lawrence Creek with the greatly fluctuating streamflow of the Roche-a-Cri. Figure 2 shows monthly low-flows for the Roche-a-Cri. These low-flow data give some indication of varying limitations on space available to brook trout in that stream.

With its greater discharge and steeper gradient Lawrence Creek has larger areas of gravel streambed relatively free of sand and silt. In summer and fall an abundance of watercress *(Nasturtium officinale)* and veronica *(Veronica connata)* offer hiding cover for trout and support a rich trout food supply. In the Roche-a-Cri,

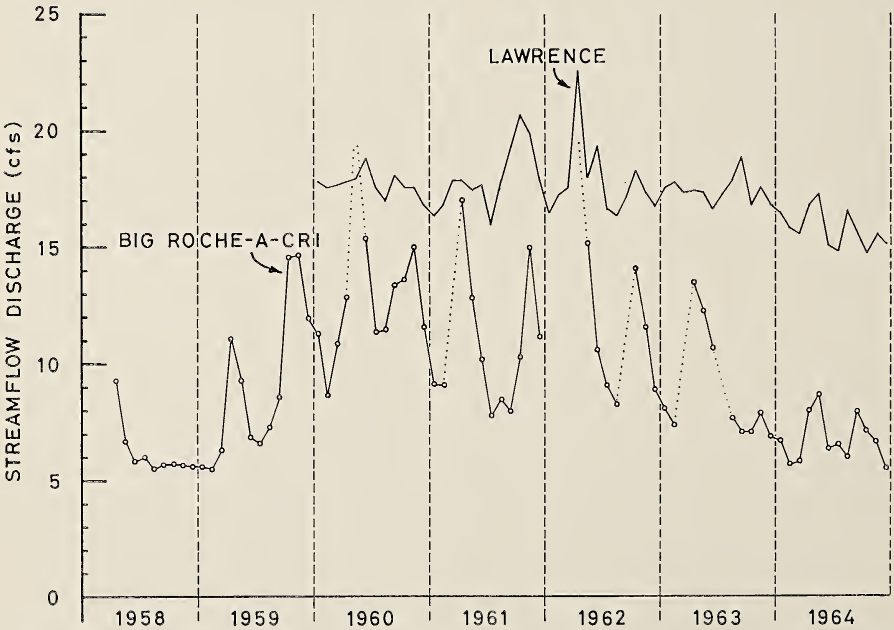



FIGURE 1. Monthly mean streamflow discharges at gaging stations on Lawrence Creek (2.5 miles below its source) and on Big Roche-a-Cri Creek (3.9 miles below source).

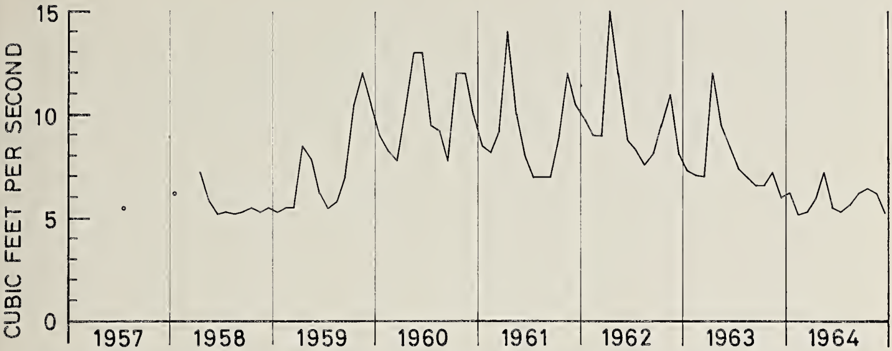



FIGURE 2. Lowest streamflow discharge recorded each month at the Big Roche-a-Cri Creek gage.

sand covers most of the bottom. Here, perhaps owing to the greater variability of streamflow, watercress beds often do not develop until autumn. Only in years of ample rainfall or during a general trend of streamflow increase, for instance in 1959–60 (Figures 1 and 4), does the Roche-a-Cri's cress flourish in springtime or early summer.

Three miles of the Roche-a-Cri that flowed through grazed land were fenced during 1956–58 to keep cattle away from the stream. Fencing allowed streambank vegetation to thrive and provide trout with hiding places among twigs and leaves that dangled into the water. From 1958 through 1962 current-deflectors and overhanging bank covers were constructed along 4 miles of stream in the study area. These devices added more cover for trout and concentrated the current to clean sand off streambed gravel.

## THE TROUT POPULATIONS

Wild brook trout are the predominant fish in both streams. During our investigations, trout population densities ranged from less than 20 pounds per acre in some sections of both streams in poor years to nearly 250 pounds per acre in upstream sections of both streams during favorable years. But on the average, Lawrence Creek maintained larger populations. The Roche-a-Cri's main concentration of brook trout occupies a section of stream approximately equal to Lawrence Creek in length, but this section has only half the surface area of Lawrence Creek.

Few wild brown trout *(Salmo trutta)* or rainbow trout *(S. gairdneri)* occur in the Roche-a-Cri, though at times during several decades prior to the study these species were heavily stocked in the study area as well as in the 20 or more miles of water tolerable to trout (but lacking spawning grounds) below the study area. Even within the study area where brook trout reproduce well, brown and rainbow trout spawn with poor success. At various times during the study small numbers of hatchery-reared brown and rainbow trout moved into the lower portion of the study area from stocking sites several miles downstream. During 1953–60 about 1,200 age-0 and age-1 hatchery-reared brook trout were also stocked annually in the study area as part of the routine fishery management program. However, in view of the usual high mortality of stocked trout during the first few weeks after release, this stocking was probably a minor supplement to the total springtime population of trout in the study area. Hatchery brook trout are not included in the data to be discussed since the 1% to 3% of such stocked trout that survived to maturity did not contribute significantly to total spawning. Other fishes common in the Roche-a-Cri are: mottled sculpin *(Cottus bairdi)*, pearl dace *(Margariscus margarita)*, creek chub *(Semotilas atromaculatus)*, brook stickleback *(Eucalia inconstans)* and white sucker *(Catostomus commersoni)*.

Lawrence Creek is free of brown trout and has only a sparse population of wild rainbow trout. The stream has not been stocked with hatchery trout since 1948. Other than trout, Lawrence Creek contains mottled sculpin, white sucker, creek chub, brook stickleback and blacknose dace *(Rhinichthys atratulus)*.

## Methods

Trout populations were estimated by mark-and-recapture electrofishing in April, prior to the angling season, and in September soon after angling ceased.

In this paper September estimates of age group 0 are used as initial measures of year class strength. Since age-0 trout are too small in April to be efficiently captured by our electrofishing gear, they could not enter into estimates at that time.

During electrofishings in September, 60% to 80% of the age-0 trout were marked by removing fins in combinations denoting year class, i.e., the year of birth. Population estimate procedures, precision of the estimates (± 2 to 6% for age group 0; ± 1 to 8% for age group I, but generally around ± 2 to 4% for both groups) and methods of calculating egg production annually are discussed by McFadden (1961), Hunt et al. (1962) and Hunt (1966).

## Results and Discussion

In both streams year-to-year fluctuations in abundance of age-0 brook trout followed a rhythm of alternating upward and downward turns, that is, one having 2 years between peaks (Figure 3; Table 1). Among the combined 20 data-years for the 2 streams, encompassing 18 between-year changes in population level, the pattern was interrupted only once: the 1956–57 interval at Lawrence Creek.

In Lawrence Creek numbers of age-0 brook trout present in September varied from 4,166 in 1958 to 22,646 in 1959. The mean number present during 12 successive Septembers was 10,712. The strongest year class was 5.4 times larger than the weakest year class and 2.1 times larger than the average numerical strength. In the Roche-a-Cri over an 8-year period, the number of age-0 brook trout present in September ranged from 2,012 in 1957 to 9,915 in 1960. Mean strength of the 8 year classes was 5,396. The strongest year class was 4.9 times as numerous as the weakest year class and 1.8 times larger than the mean abundance (Table 1).

Keith (1962) suggests that most biologists would favor the definition of "population cycle" as defined by Davis (1957):

> "In ecological usage the term 'cycle' refers to a phenomenon that occurs at intervals. These intervals are variable in length, but it is implied that their variability is less than one would expect by chance and that reasonably accurate predictions can be made."

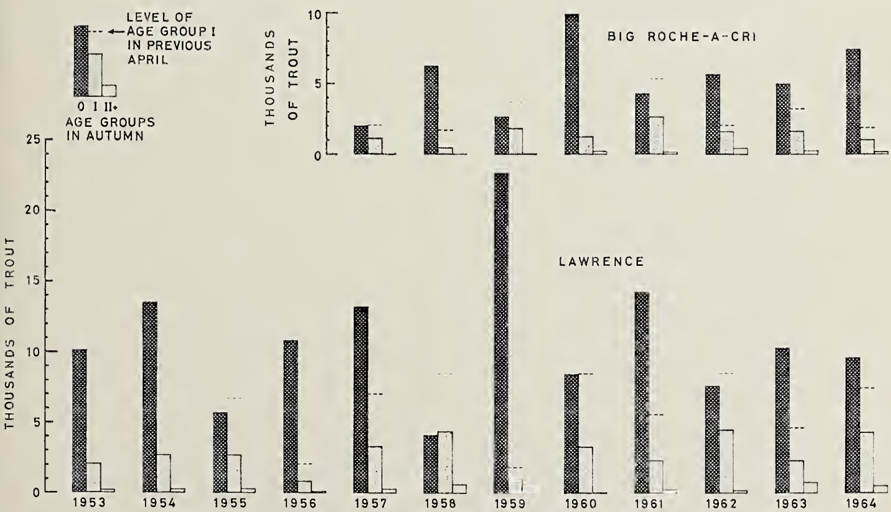



FIGURE 3. Numbers of brook trout in the study areas of Lawrence and Big Roche-a-Cri Creeks. (Although no inventory of the Roche-a-Cri population was made in spring, 1960, the number of age group I trout was probably low since the 1959 year class was a weak one.)

TABLE 1. AGE STRUCTURE OF APRIL AND SEPTEMBER POPULATIONS OF WILD BROOK TROUT IN LAWRENCE AND BIG ROCHE-A-CRI CREEKS

| Year | Lawrence Creek | | | | |
|---|---|---|---|---|---|
| | April | | September | | |
| | Age I | Age II+ | Age 0 | Age I | Age II+ |
| 1953 | — | — | 10,113 | 2,040 | 277 |
| 1954 | — | — | 13,523 | 2,749 | 296 |
| 1955 | 7,782 | 1,647 | 5,720 | 2,754 | 324 |
| 1956 | 2,012 | 1,207 | 10,853 | 816 | 133 |
| 1957 | 7,029 | 483 | 13,258 | 3,370 | 251 |
| 1958 | 8,485 | 2,069 | 4,166 | 4,393 | 635 |
| 1959 | 1,815 | 2,707 | 22,646 | 1,044 | 654 |
| 1960 | 8,510 | 409 | 8,507 | 3,324 | 51 |
| 1961 | 3,602 | 842 | 14,313 | 2,360 | 246 |
| 1962 | 8,567 | 1,221 | 7,611 | 4,523 | 225 |
| 1963 | 4,644 | 2,540 | 10,367 | 2,388 | 792 |
| 1964 | 7,489 | 1,669 | 9,680 | 4,382 | 569 |
| Average 1955–64 | 5,993 | 1,479 | 10,712 | 2,935 | 388 |

| Year | Big Roche-a-Cri Creek | | | | |
|---|---|---|---|---|---|
| | April | | September | | |
| | Age I | Age II+ | Age 0 | Age I | Age II+ |
| 1953 | — | — | — | — | — |
| 1954 | — | — | — | — | — |
| 1955 | — | — | — | — | — |
| 1956 | — | — | — | — | — |
| 1957 | 2,034 | 333 | 2,012 | 1,135 | 15 |
| 1958 | 1,743 | 634 | 6,229 | 474 | 24 |
| 1959 | 3,749 | 152 | 2,637 | 1,817 | 58 |
| 1960 | — | — | 9,915 | 1,257 | 220 |
| 1961 | 5,038 | * | 4,361 | 2,630 | 156 |
| 1962 | 2,030 | * | 5,632 | 1,609 | 422 |
| 1963 | 3,262 | * | 4,964 | 1,623 | 256 |
| 1964 | 1,925 | * | 7,420 | 1,072 | 218 |
| 1957–64 | 2,826 | — | 5,396 | 1,452 | 171 |

*Not yet calculated.

According to this definition the fluctuations we observed constitute cycles of offspring abundance. Both cycles followed 2-year intervals, the shortest possible interval for an animal that reproduces once annually. Although the frequency of fluctuation was regular, levels of abundance did not always swing above and below a long-term mean value, as would be necessary to meet the strict mathematical definition of a cycle. Our contention is, however, that there did seem to be a recurring ecological phenomenon worthy of critical examination.

The rhythmic fluctuations in the 2 streams, while of equal frequency, were out of phase. In the years when Lawrence Creek contained large numbers of age-0 trout, the Roche-a-Cri had low numbers. This phase difference persisted all 8 years of simultaneous study.

The cycles persisted in both streams despite somewhat different environmental characteristics and different general levels of trout populations and they persisted despite large changes in density of total stocks and in age composition of those stocks in each stream (Table 1). Great variation in percentage of brook trout stocks removed from Lawrence Creek by anglers also failed to upset the cycle. Under liberal angling regulations—toward the beginning of the study—anglers took 32% to 65% of preseason populations and as much as 129% by weight. Under very restrictive size and bag limits, angler exploitation fell to 1% by number and 7% by weight (Hunt et al., 1962). These relatively low angler harvests resulted in higher populations of older trout and egg production became less dependent upon age-I trout as more adults survived the fishing season to spawn a second or third time. These changes in survival rates and structure of the spawning stocks may have contributed to the lower amplitude of fluctuations in age group 0 populations in Lawrence Creek during the later years of our study. In the Roche-a-Cri, the cyclic fluctuations also diminished in amplitude toward the end of the study as populations of age-II and older trout increased (Table 1). Progress in the management of trout habitat may have induced these changes, but despite these trends of improvement in the trout habitat and the trout population, the cycle persisted.

It is especially interesting that the cycles were out of phase in the 2 streams. Consequently it is unlikely that a climatological factor was governing the cycles. If that component of the climate, whatever it may be, which is most influential on trout would have had an alternate-year fluctuation during the period of study, it should have affected both trout populations similarly.

This is not to say that climatological changes failed to affect the trout populations, and in particular age group 0. The highest age-0 population in the Roche-a-Cri, that of 1960, coincided with sharp increases in precipitation (Figure 4) and in streamflow (Figure 2) during autumn 1959 through summer 1960. Not only was volume of the Roche-a-Cri greater than usual in the spring and summer of 1960, but in-stream vegetation, particularly watercress, was comparatively lush during May, much earlier than in most years. Space and concealment for young trout was undoubtedly greater than normal—and, judging by Tarzwell's (1937) findings on the food-harboring capacities of underwater vegetation, the trout food supply was probably better too. Such rather sudden environmental improvements, coinciding with whatever factors cause the "even-year" (1958, 1960, 1962, etc.) peaking on the Roche-a-

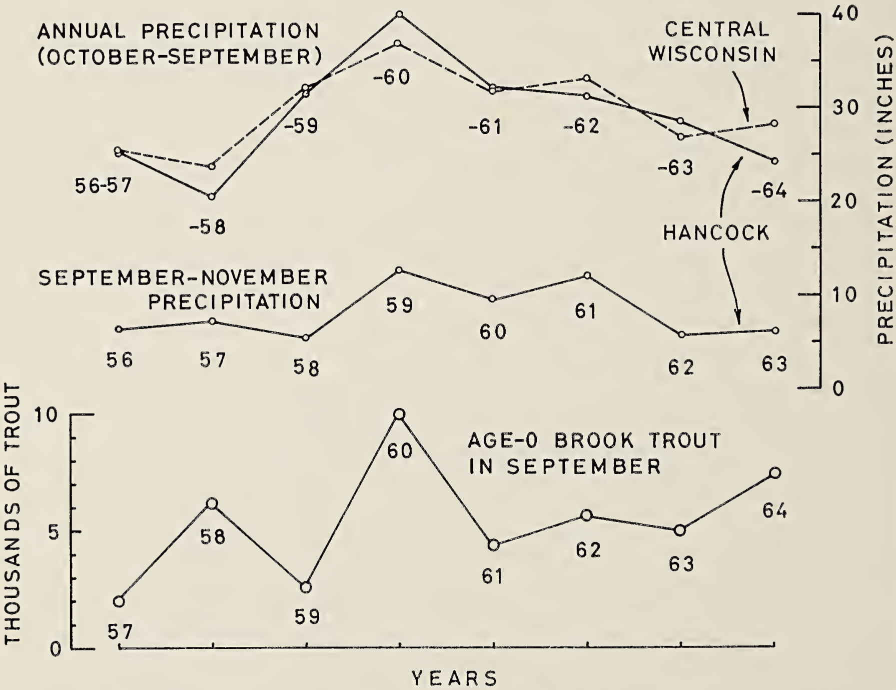



FIGURE 4. Numbers of age-0 brook trout in September in Big Roche-a-Cri Creek and records of precipitation from its vicinity. Plotted above each trout level are precipitation for September through November of the *preceding* year and precipitation during the 12 months (October–September) prior to trout inventory, i.e. the approximate period covered by development of age group 0. Precipitation data are from the Hancock Experimental Farm, 5 miles south of the stream and from the U. S. Weather Bureau compilation for central Wisconsin stations.

Cri, probably reinforced the upward amplitude for one year of the cycle. Lawrence Creek, with a more stable hydrological regime, appeared to have no unusual streamflow during 1960 (Figure 1). Similarly but conversely, an environmental event in Lawrence Creek could have accounted for the upset of the cycle in that stream during 1957. According to qualitative observations by one of the authors (White), watercress was unusually abundant in Lawrence Creek that year. While regional rainfall was low in 1956–57 (Figure 4) and it is unlikely that local variation was great enough to have stimulated aquatic vegetation through increased streamflow; nevertheless, throughout most of the study area the stream was walled with cress on each side to an extent not noted since. Perhaps at no other time during our study did age-0 brook trout in Lawrence Creek have such good hiding cover. Thus, there is some reason to suspect that a low phase of the population cycle was counteracted by an environmental change especially favorable to survival of young trout during 1957. In any event, the cycle was interrupted that year and thrown into a new phase, one having highs in odd numbered years. Environmental crises, on the other hand, might be expected to exaggerate cyclic lows and cancel highs, but no phenomenon of this sort was evident.

Despite the unlikelihood that climate maintained the cycles, monthly and seasonal streamflow data for the Roche-a-Cri (Figures 1 and 2), were examined to see if there were any patterns of fluctuation that coincided with the fluctuations of year class strength in that stream. No similarities were found. However, since our streamflow records did not cover the first year of the study and were not complete with respect to high flows, a search was made through precipitation data from a weather station near the Roche-a-Cri. (There is none near Lawrence Creek). One set of these data, precipitation during September through November, showed a pattern of year-to-year fluctuations resembling that of the trout cycle (Figure 4). While rainfall might be interpreted as having influenced streamflow at spawning time (October into early December) and hence as having affected success of natural reproduction, there is nothing in the streamflow data to support this contention. Neither is September–November precipitation significantly correlated with the following-year abundance of age group 0. Consequently, some mechanism intrinsic to both brook trout populations and acting after the egg stage seems a more likely regulator of the cycles.

If, as is the case in these two populations, age group I comprises the great majority of the "mature" (age I and older) trout, then such 2-year cycles could, given an initial disparity between any two consecutive year classes, be simply and directly maintained through the following processes: (1) domination of egg production by age group I which results in alternate-year variation similar to that of "even-year" and "odd-year" pink salmon *(Onchyrhynchis gorbuschka)* populations (Neave, 1952 and 1953), (2) a suppressive effect (predation and/or competition) of age group I on simultaneously occurring age-0 populations. Such suppression would be strong and weak in alternate years. Should both processes occur within the same population, they would complement each other, that is, act in synchrony. High egg production would push age group 0 upward one year and strong suppression by numerous age I trout from the same year class would push age group 0 downward the next year (Figure 5).

For these two brook trout populations, however, the first process seems unlikely. Even though most of the egg production in most years is attributable to age group I (Table 2), numbers of age 0 trout in September are not correlated with the numbers of eggs from which they originated (Figure 6). Since mortality at the egg and sac-fry stage is known to be less than 10% (McFadden, 1961) and since June inventories (Hunt, 1966) show that age-0 mortality progresses at a rather slow rate after the 4th or 5th free-swimming month, most age 0 mortality—and, in fact, the greater share of total mortality in the life of a year class—takes place during the first few months following emergence of fry into the stream.

The second regulatory mechanism, the suppression process, seems more plausible. Age-I trout could be preying on age-0 trout or could be limiting in some way the accessibility of a rather fixed environmental resource. Indeed, numbers of age-0 trout in Lawrence Creek are inversely and significantly correlated with numbers of simultaneously occurring age groups I (Figure 7 and Table 3). If age-I trout were determining the level of age-0 abundance, the time of this effect would most logically be during

---

→

FIGURE 5. Curves of numerical trends within year classes of a hypothetical brook trout population in which: (1) reproduction is entirely by age group I, (2) strong year classes, producing high numbers of eggs, spawn strong year classes, (3) weak year classes spawn weak ones, (4) many age-I trout are present during the fry stages of weak year classes and (5) few age-I trout exist during the fry stages of strong year classes. Survivorship after completion of spawning is approximated from Lawrence Creek data (Hunt, 1966, Appendix Table 22; and McFadden, 1961) and is kept uniform for all year classes, thus eliminating compensatory complications. Were age group I suppressing age-O abundance, survivorship curves of weak year classes should be considered steeper than shown here.

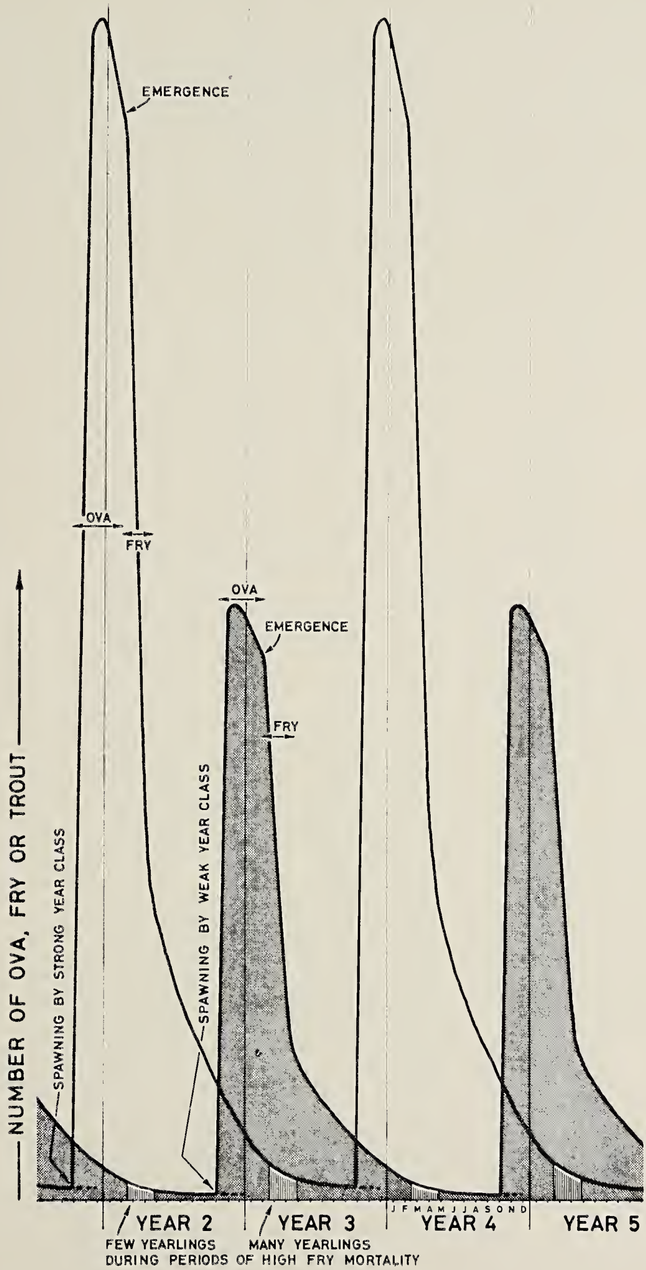

EMERGENCE
OVA
FRY
OVA
EMERGENCE
FRY
NUMBER OF OVA, FRY OR TROUT
SPAWNING BY STRONG YEAR CLASS
SPAWNING BY WEAK YEAR CLASS
J F M A M J J A S O N D
YEAR 2
YEAR 3
YEAR 4
YEAR 5
FEW YEARLINGS
MANY YEARLINGS
DURING PERIODS OF HIGH FRY MORTALITY

TABLE 2. ESTIMATED NUMBER OF EGGS PRODUCED BY BROOK TROUT OF VARIOUS AGE GROUPS IN LAWRENCE CREEK DURING AN ELEVEN YEAR PERIOD. PERCENTAGE OF TOTAL ANNUAL EGG PRODUCTION IN PARENTHESES

| YEAR | AGE GROUP | | | | | TOTAL |
|---|---|---|---|---|---|---|
| | I | II | III | IV | V and VI | |
| 1953...... | 439,531 (74) | 142,905 (24) | 8,837 (1.5) | —— | —— | 591,273 |
| 1954...... | 612,168 (79) | 150,762 (19) | 10,438 (1.3) | 2,318 (0.4) | —— | 775,686 |
| 1955...... | 458,081 (77) | 125,846 (21) | 11,246 (1.9) | —— | 1,218 (0.2) | 596,391 |
| 1956...... | 196,905 (74) | 66,243 (25) | 1,493 (0.6) | —— | 1,337 (0.5) | 265,978 |
| 1957...... | 739,295 (84) | 75,024 ( 8) | 68,683 (7.8) | —— | —— | 883,002 |
| 1958...... | 756,462 (74) | 243,424 (24) | 27,116 (2.6) | 2,200 (0.2) | —— | 1,029,202 |
| 1959...... | 191,745 (41) | 261,323 (55) | 18,821 (4.0) | —— | —— | 471,889 |
| 1960...... | 660,980 (96) | 18,980 ( 3) | 6,820 (0.9) | —— | —— | 686,780 |
| 1961...... | 489,092 (79) | 126,251 (21) | 2,096 (0.3) | —— | —— | 617,439 |
| 1962...... | 852,705 (89) | 93,754 (10) | 14,813 (1.5) | —— | —— | 961,272 |
| 1963...... | 513,519 (63) | 283,144 (35) | 16,250 (2.0) | 1,724 (0.2) | —— | 814,637 |
| Average... | 537,322 (76.8) | 144,334 (20.6) | 16,965 (2.4) | 567 (0.08) | 232 (0.03) | 699,420 |

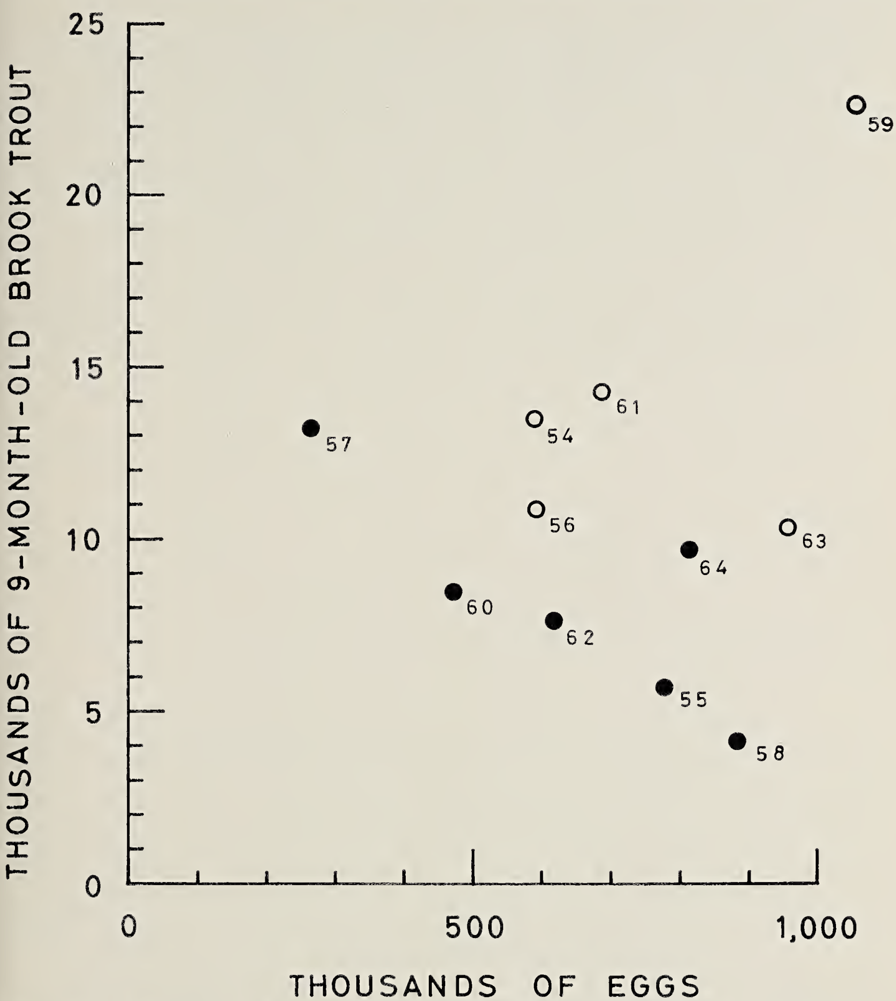



FIGURE 6. Numbers of age-0 brook trout in Lawrence Creek in September plotted against numbers of eggs from which they developed. Numbers by the points denote year classes. Solid points are those for year classes coinciding with lower-than-average April abundances of age group I.

spring when fry mortality is greatest. Hence, age-0 levels would be more closely correlated with springtime rather than autumn levels of age group I. The coefficient of correlation for age groups 0 against April age-I populations is higher than the correlation for age groups 0 against September age-I populations (Table 3), but with the low number of observations involved, the difference between the 2 coefficients is not statistically significant.

TABLE 3. COEFFICIENTS OF CORRELATION AND VALUES OF STUDENT'S *t* FOR REGRESSIONS OF NUMBERS OF AGE-0 BROOK TROUT IN SEPTEMBER ON NUMBERS OF OLDER TROUT IN LAWRENCE CREEK DURING 1953–64

| Regression of Number of Age 0 in September on: | Number of Years of Observations ($n$) | Coefficient of Correlation ($r$) | $t$-value ($df=n-2$) |
|---|---|---|---|
| April Populations | | | |
| Number of age I | 10 | −.753 | −3.218* |
| Number of age I plus older trout | 10 | −.732 | −2.977* |
| Number of age II plus older trout | 10 | .205 | 0.592 n.s. |
| Total weight of all trout | 9 | −.174 | −0.055 n.s. |
| September Populations | | | |
| Number of age I | 12 | −.608 | −2.421* |
| Number of age I plus older trout | 12 | −.564 | −2.161 n.s. |
| April and September Populations Averaged | | | |
| Number of age I | 10 | −.729 | −3.017* |
| Number of age I plus older trout | 10 | −.702 | −2.781* |

*Significant at the 0.05 confidence level.
n.s. = not significant at the 0.05 level.

Numbers of age-0 trout are not correlated with numbers of trout older than age-I. Perhaps body size or behavior of these older trout reduce interactions with post-emergent young.

Cannibalism or competition for space and/or food are the sorts of processes that would tend to cause an inverse correlation such as that in Figure 7.[1] Cannibalism has been cited in other studies as a factor accounting for changes in abundance of young fish, but conclusive evidence of cannibalism in our streams is lacking.[2] For

[1] A disease-crowding process would seem a further but less likely possible mechanism behind the observed relationship. All we know of disease in these streams is that almost every brook trout carries gill copepods *(Salmincola edwardsii)*, that emaciation of smaller trout due to this burden appears worse than that of larger trout, and that during times of high trout population density the number of copepods on each trout's gills appears greater than during population lows. It is thought that the passing on of relatively high infestations of copepods by the higher populations of age-I trout to fry would be too erratic to account for the inverse relationship of age-0 and age-I densities (Figure 8).

[2] Cannibalism was postulated as the governor of a possible 4-year cycle among brown trout in 2 New Zealand streams (Burnett, 1959—another out-of-phase cycle!). Survival of stocked fingerling brook trout increased when older brook trout were removed from a lake (Smith, 1956). When the number of larger trout in a small lake increased, survival of stocked fingerling rainbow trout decreased (Miller and Thomas, 1957). There are logical yet indirect indications that predation on sockeye fry *(Onchyrhynchus nerka)* by smolts and residual non-migrants of preceding strong year classes may cause the 4-year cycle of that salmon in the Fraser River (Ricker, 1950). In a mixed population of warm water fishes in an Illinois lake, 4- or 5-year cycles of abundance were attributed to predation by dominant broods of crappies (*Pomoxis* sp.) but no data on predation were furnished (Thompson, 1941).

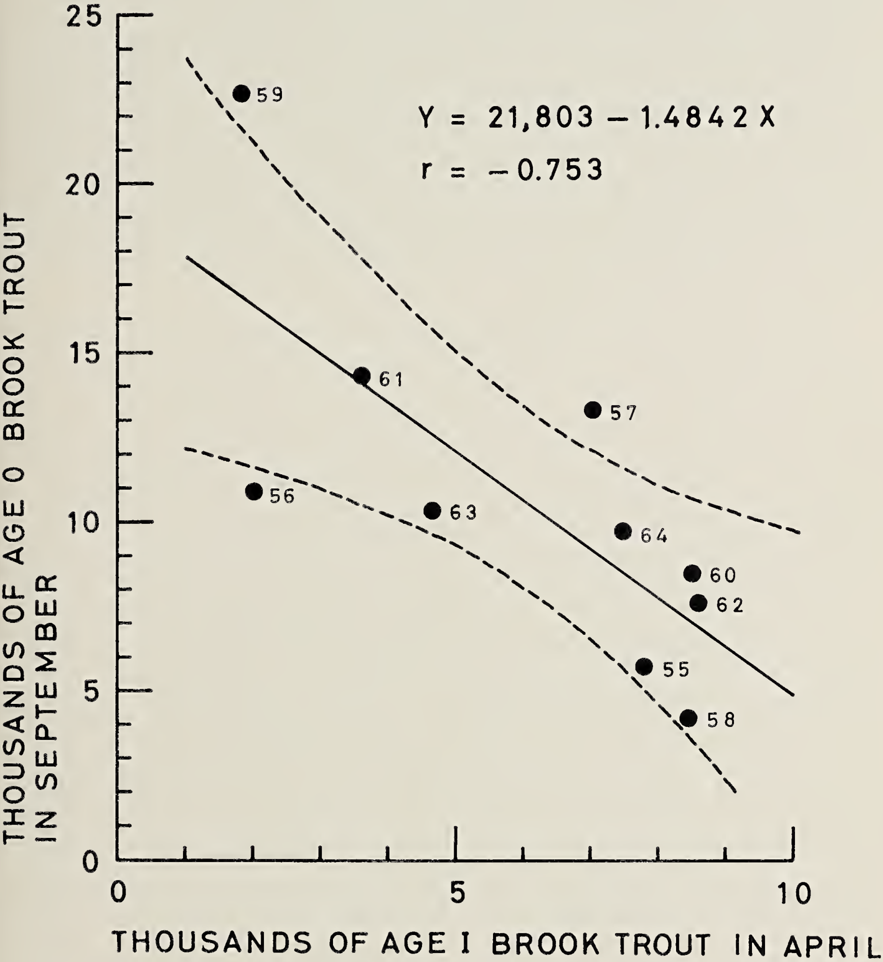



FIGURE 7. Numbers of age-0 brook trout in September plotted against age-I abundance during April of the same year in Lawrence Creek. Numbers by the points denote the year classes of age groups 0. Correlation is significant at the 0.05 confidence level (Table 2).

example, during 1960–66, we examined 1,400 stomachs of age-I-and-II brook trout collected in all seasons by daytime electrofishing and angling. Not a single case of cannibalism was found (unpubl. data of R. L. Hunt and D. A. White). To account for even 10% of the average mortality of age group 0 between emergence and mid-June, each fish in the average population of older trout during that time would have to consume approximately 15 fry per day. However, no fry were found in 160 stomachs collected from adult trout during such a 5-month period. Although cannibalism among brook trout has been demonstrated elsewhere,[3] there are no indication that it takes place on a scale sufficient to account for the hundreds of thousands of fry that perish in Lawrence Creek and Roche-a-Cri each spring.

Competition rather than predation seems a more likely relationship between age-0 and age-I brook trout, especially in view of the investigations of LeCren (1965) who varied the numerical density of brown trout fry in small experimental waterways and found their survival and growth to be inversely density-dependent. This result was apparently due to territorial behavior. Fry not able to secure a territory drifted downstream and died by starvation usually between 20 and 40 days before feeding began. Density-dependent "disappearance" of age-0 trout from Lawrence Creek is indicated in analyses of September age-0 levels as a function of egg production plus age-I abundance (McFadden, in press). A rough representation of such an analysis can be seen in the negative slope of the solid black points in Figure 6. Greater dispersal of young from main nursery areas in years of higher age-0 density (Hunt, 1965) implies that the apparent compensatory mortality in Lawrence Creek prior to September may be partially attributable to movement downstream out of the study area. If space competition from age-I trout is similarly affecting fry or fingerlings, this could account for the observed numerical relationships between the 2 age groups, and for the 2-year cycle of yearclass abundance.

Although the number of age-0 trout that disappear is not correlated with the number of contemporary age I trout (Figure 8), age

---

[3] Following release of several thousand brook trout fry into a small Ontario stream, collection of 16 age-I-and-II brook trout mainly by means of a flashlight and handnet at night revealed 4 stomachs containing fry, the greatest number in any one stomach being 8 (H. C. White, 1924). After stocking fry in a Prince Edward Island stream, 319 "adult and yearling" brook trout were captured, "those whose stomachs were distended" (number not reported) were examined, and only one fry was found (H. C. White, 1927). In sections of the same stream, screened to permit only certain types of predators to operate on fry stocks of known size, comparison of mortality rates led to the conclusion that "competition and cannibalism" by larger trout were greater menaces to fry than were predation by birds or sticklebacks *(Eucalia inconstans)*, but no proof of cannibalism was put forth (H. C. White, 1927 and 1930).

group I may act as a "level-setter" of year class strength. The "rather fixed environmental resource", be it space, food or whatever, could determine a general numerical density (carrying capacity) to which age group 0 must diminish each year regardless of the number of age-I trout. With this carrying capacity at a level of (for instance) 40,000 to 80,000 fry, the greatest share of post-emergence mortality has occurred by the time this level is attained. The amount of additional fry mortality that might be dependent upon the density of age I trout would be a relatively small component of total fry mortality but an important component in the ultimate determination of year class strength. While such a mechanism may bring cannibalism back into the realm of possi-

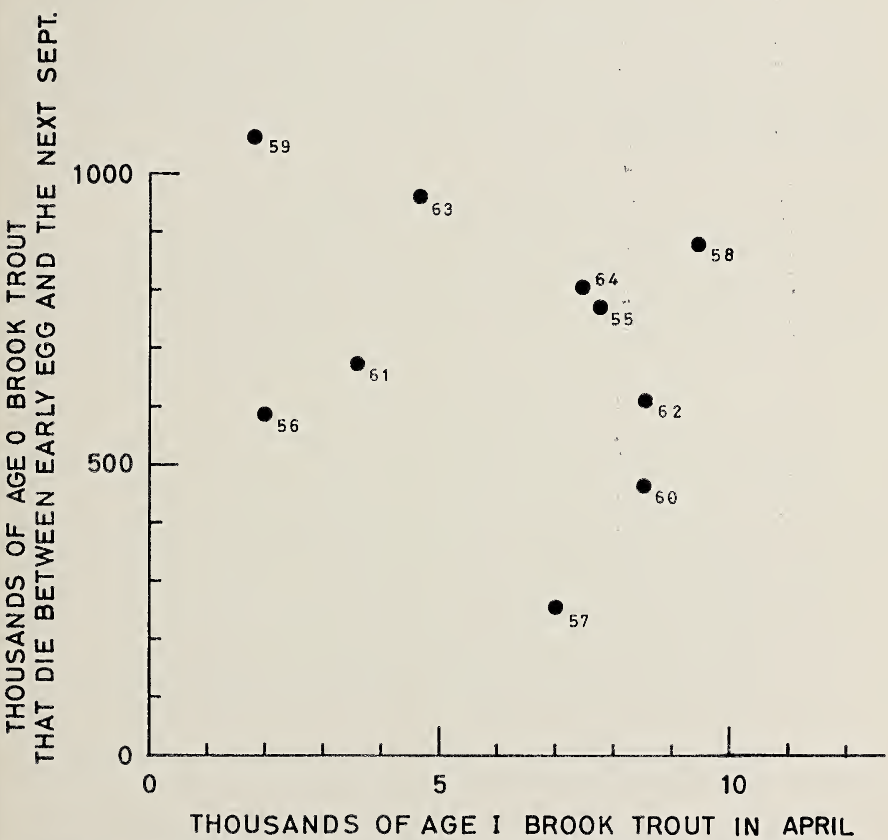



FIGURE 8. Absolute mortality of brook trout in Lawrence Creek during the 10 to 11 months from the egg stage to the next September plotted against number of age-I trout present during April of this period. Numbers by the points denote the year classes of age groups 0.

bility, the negative evidence regarding such predation in Lawrence Creek makes competition seem the more likely process needing further investigation.

To investigate more closely relationships between stocks of age-I and age-0 trout, experiments similar to those of LeCren (1965) should be conducted utilizing various sizes and densities of age-I trout introduced as factors modifying existing fry-space relationships. Suppression of age-0 brook trout by older brook trout could also be tested under the more natural conditions in our streams by measuring survival of trout fry at selected high and low springtime densities of older trout. Low densities of older trout could be achieved by electrofishing to remove them in winter after the spawning season. High densities could be attained by stocking wild brook trout from other nearby streams.

Our study points up the need for identifying the causes of mortality among wild trout fry and for direct observation of behavioral relationships between age groups and size groups of brook trout under wild conditions.

## Acknowledgements

For helpful suggestions during preparation of the manuscript, we are grateful to D. R. Thompson and W. S. Churchill of the Wisconsin Conservation Division, Madison, and to A. Bückmann, M. Gillbricht and G. Hempel of the University of Hamburg, Germany.

## References Cited

Burnet, A. M. R. 1959. Some observations on natural fluctuations of trout population numbers. N. Z. J. Sci. 2:410–421.

Davis, D. E. 1957. The existence of cycles. Ecology 38(1):163–164.

Hunt, R. L. 1964. Evaluation of fly-fishing-only at Lawrence Creek (a three-year progress report). Misc. Res. Rept. No. 10 (Fisheries). Wis. Conserv. Dept., Madison, Wis. (mimeo).

————. 1965. Dispersal of wild brook trout during their first summer of life. Trans. Am. Fish. Soc. 94(2):186–188.

————. 1966. Production and angler harvest of wild brook trout in Lawrence Creek, Wisconsin. Tech. Bull. No. 35. Wis. Conserv. Dept., Madison, Wis.

————, and O. M. Brynildson. 1964. A five-year study of a headwaters trout refuge. Trans. Am. Fish. Soc. 93(2):194–197.

————, O. M. Brynildson and J. T. McFadden. 1962. Effects of angling regulations on a wild brook trout fishery. Tech. Bull. No. 26. Wis. Conserv. Dept., Madison, Wis.

Keith, L. 1962. Wildlife's ten-year cycle. University of Wisconsin Press.

LeCren, E. D. 1965. Some factors regulating the size of populations of freshwater fish. Mitt. Internat. Verein. Limnol. 13:88–105.

McFadden, J. T. 1961. A population study of the brook trout, *Salvelinus fontinalis*. Wildl. Monog. No. 7.

————. (In press.) Dynamics and regulation of salmonid populations in streams. A symposium, "Salmon and Trout in Streams", sponsored by the H. R. MacMillan Lectures in Fisheries at the University of British Columbia, February 22–24, 1968.

Miller, R. B., and R. C. Thomas. 1957. Alberta's "pothole" trout fisheries. Trans. Am. Fish. Soc. 86:216–218.

Neave, F. 1952. "Even-year" and "odd-year" pink salmon populations. Trans. Roy. Soc. Canada XLVL:55–70.

————. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Bd. Can. 9(9):450–491.

Ricker, W. E. 1950. Cycle dominance among the Fraser sockeye. Ecology 31: 6–26.

Smith, M. W. 1956. Further improvement of trout angling at Crecy Lake, New Brunswick, with predator control extended to large trout. Can. Fish Culturist 19:13–16.

Tarzwell, C. M. 1937. Experimental evidence on the value of trout stream improvement in Michigan. Trans. Am. Fish. Soc. 66:177–187.

Thompson, D. F. 1941. The fish production of inland streams and lakes. *In* A symposium on hydrobiology. Univ. of Wis. Press: 206–217.

White, H. C. 1924. A quantitative determination of the number of survivors from planting 5,000 trout fry in each of two streams. Contr. Can. Biol. Fish. n. s. 2(9):137–139.

————. 1927. A preliminary report on trout investigation in Forbes Brook P. E. I. in 1925 and 1926. Contr. Can. Biol. Fish. n. s. 3(15):365–376.

————. 1930. Trout fry planting experiments in Forbes Brook P. E. I. in 1928. Contr. Can. Biol. Fish. n. s. 5(8):203–212.

# DISTRIBUTION, STANDING CROPS, AND DRIFT OF BENTHIC INVERTEBRATES IN A SMALL WISCONSIN STREAM[1]

*John J. Peterka*[2]
*Department of Natural Sciences*
*Wisconsin State University*
*Platteville, Wisconsin*

## Abstract

Bottom samples showed genera of *Tricorythodes, Stenonema, Cheumatopsyche* and *Chimarra* occurred more frequently at downstream than upstream stations, while *Neophylax* occurred only near the main spring. Principal organisms found in the stream drift were *Gammarus pseudolimneaus* Bousfield and *Baetis vagans* McDunnough. Both had higher drift rates at night than during the day. Total stream drift of *Gammarus* caught upstream apparently did not affect the drift caught 152 m downstream.

## Introduction

The many small spring-fed streams in southwestern Wisconsin appear to be excellent for studies of the ecology of an entire stream and its watershed. They are short (some less than 800 m) and narrow (some 0.3 m wide); they receive a constant supply of spring water; and they appear productive in benthic invertebrates. The purpose of this study, undertaken in one such stream, was (1) to determine the standing crops of its principal organisms and (2) to measure the kinds and quantities of organisms (drift) carried by the stream current.

Stream drift, an important source of food to fishes, has been reported by Needham (1938), Dendy (1944), Waters (1962 a), Miller (1963), and others. Waters (1962 b) used drift rates and standing crop measurements to determine the production of invertebrates appearing in the drift. The feasibility of using his method in this stream was examined.

---

[1] A grant from the Research Board of the State Universities of Wisconsin supported the research.

[2] Present address: Division of Natural Sciences, North Dakota State University, Fargo, North Dakota 58102.

## Description of the Stream

Samples were taken from Bear Branch (local name), a small stream in Grant County, Wis. (T3N, R2W, Sec. 32). The stream flows south and receives a constant supply of water from a spring located 1,675 m from the mouth at the Little Platte river. Stream widths range from .6 to 2.5 m. Average depths in riffle areas are 7 to 10 cm. Following rainstorms, water levels had extreme fluctuations. A normal discharge rate, during October 1965, was 0.21 $m^3$/sec. Above the spring, the stream is often dry and no samples were taken there.

The temperature of the spring water is fairly constant throughout the year, ranging from 9.0 to 9.5°C in 1965. During the summer, water temperatures increased rapidly downstream from the spring. For example, on 1 August 1965, temperatures were 14.0, 16.5, 19.0, 23.0, 24.0 and 28.0°C at the respective distances below the spring of 180, 240, 300, 485, 850 m and at the mouth. In the winter, relatively warm spring water resulted in higher temperatures near the spring than downstream. On 24 January 1965, the temperature dropped from 9.0°C at the spring to 7.0 and 4.0°C at 240 and 850 m, respectively, below the spring.

Because the stream is shallow, water temperatures fluctuate during the day. At 240 m below the spring, they were 13 to 15°C October 16, 8 to 10°C October 23, and 8 to 9°C November 19, 1965.

Total alkalinity of the stream water during July 1966 ranged from 303 to 308 ppm, as determined by titration with .02N $H_2SO_4$, and methyl orange as an indicator.

The upper 300 m of the stream is relatively straight, with pools, riffles and a growth of watercress, *Nasturtium officinale*. Below this, the stream meanders and widens. No trees or shrubs overhang it, and its banks are well-cropped by cattle.

## Materials and Methods

Bottom samples were collected in riffle areas of the stream with a sampler (Waters and Knapp, 1961), which encompassed 0.1 $m^2$ of bottom; the mesh size of its net was 256 $\mu$. Three stations were sampled. Stations 1 and 4, located 60 and 240 m, respectively, below the spring, will be referred to collectively as upstream areas; station 15, 910 m below the spring, as the downstream area.

Organisms found in the drift were captured with stationary nets (Waters, 1962 a,b). Each was made of 256 $\mu$ mesh Nytex[3] nylon netting, and fitted to a 0.3 $\times$ 0.2 m frame made of brass welding

[3] Trademark of Tobler, Ernst and Traber, Inc., New York.

rod. The nets were held in place by iron rods driven into the stream bed.

To establish the total daily drift passing from riffle areas, the stream was completely blocked by drift nets at the downstream end of the station 4 riffle for 24-hr periods on 7 June, 31 August–1 September and 22–23 October 1966, and at the downstream end of a riffle at station 2 (91 m below the spring) on 7 June. The nets were lifted, emptied and replaced in intervals usually ranging from 1 to 3 hrs.

Wet weights were determined by centrifuging the organisms in wire-mesh cones to remove surface moisture, and then weighing them to the nearest 0.0001 g on an optical analytic balance. Samples were preserved in 5% formalin and no corrections were made for weight loss caused by preservation.

## Results

### Qualitative Analysis of Bottom Samples

Invertebrates found in bottom samples from one station were sometimes scarce or absent at others. Nymphs of mayflies belonging to the genera *Tricorythodes* and *Stenonema* were common at station 15, infrequent at station 1 and absent at station 4 (Table 1). Those found at station 1 were probably carried from above the spring, where cursory inspection indicated their presence. The species *Baetis vagans* McDonnough, dominant mayfly nymph of the upstream stations, was less frequent and abundant downstream.

Table 1. Percent Frequency Occurrence of Invertebrates Found in 0.1 $m^2$ Bottom Samples Taken from September 1965 Through April 1966

| Organism | Percent Frequency Occurrence | | |
|---|---|---|---|
| | Upstream Stations | | Downstream Station |
| | Station 1 | Station 4 | Station 15 |
| *Gammarus* | 100 | 100 | 50 |
| *Baetis* | 82 | 100 | 75 |
| *Tricorythodes* | 9 | 0 | 50 |
| *Stenonema* | 18 | 0 | 100 |
| *Hydropsyche* | 90 | 90 | 100 |
| *Cheumatopsyche* | 0 | 64 | 75 |
| *Chimarra* | 0 | 9 | 100 |
| *Neophylax* | 36 | 0 | 0 |
| Number of bottom samples | 11 | 22 | 4 |

Of the Trichoptera larvae, the genera *Cheumatopsyche* and *Chimarra* were found more frequently downstream than upstream. *Hydropsyche* occurred with about equal frequency in both areas. *Neophylax* was restricted to station 1. *Gammarus pseudolimnaeus* Bousfield was always present in upstream areas, but less frequent downstream.

There was no detectable difference among stations in the frequency occurrence of the other major groups of organisms in the bottom samples: Turbellaria *(Dugesia)*; Annelida (Enchytraeidae); Decapoda *(Orconectes)*; Hydracarina; Hemiptera; Megaloptera *(Sialis)*; Coleoptra (Elmidae, Dytiscidae); Diptera *(Chrysops, Tipula, Antocha, Limnophora, Atherix)*; Simuliidae; Tendipedidae; Gastropoda *(Physa, Limnaea, Ferissia)*; and Pelecypoda *(Sphaerium)*.

## Quantitative Analysis of Bottom Samples

At station 1, *Gammarus* comprised 51% of the total weight of 11 combined samples, trichopteran larvae, 38%, *Baetis*, 2%. The remaining 9% was mostly chironomid larvae.

At station 4, *Gammarus* comprised 22% and trichopteran larvae 63% of the combined weight of 21 samples. *Baetis* comprised 2%; the remaining 13% was largely chironomid larvae.

At station 15, *Gammarus* comprised only 6%, trichopteran larvae 62%, mayfly nymphs 1% of the combined weight of 4 samples. The remaining 31% was mostly dipteran larvae of which chironomid larvae contributed a little more than half.

In the upstream areas, the maximum standing crop for any one sample collected from 11 September 1965 to 4 April 1966 was 0.36 g/0.1 $m^2$ at station 4 for *Baetis* nymphs on 2 April 1966. Two major emergences of *Baetis* were directly observed: one from late October through November and another from early April to early May. The maximum standing crop for trichopteran larvae, mostly *Hydropsyche*, was 7.4 g/0.1 $m^2$ at station 4 on 15 January 1966. For *Gammarus*, the maximum standing crop was 2.5 g/0.1 $m^2$ at station 4 on 14 November 1965 and 6 February 1966.

## Measurement of Drift

*Gammarus* and *Baetis* nymphs were the major components of the drift. Other organisms included chironomid larvae and adults and occasionally other dipteran larvae. Fig. 1 shows the hourly drift rates of *Gammarus* and *Baetis* on 7 June 1966, indicating greater total drift at night for both species. Drift rates of *Gammarus* were nearly identical at stations 2 and 4 (Fig. 1, Table 2),

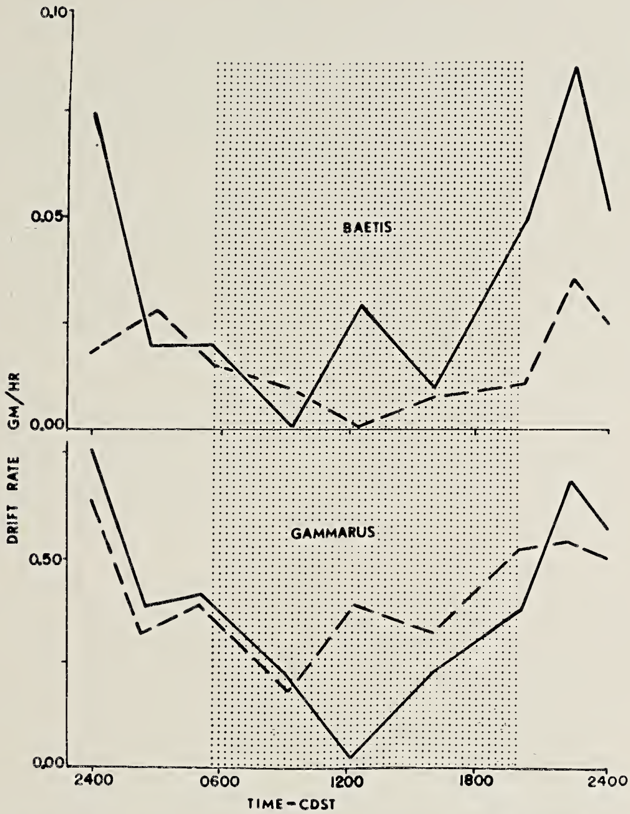



FIGURE 1. Drift rates of *Gammarus* and *Baetis* in g/hr at station 2 (solid line) and station 4 (broken line) on 7 June 1966. Stippled area indicates time of daylight.

whereas the hourly drift rates of *Baetis* were generally larger at station 2 than at 4.

The average standing crops, determined from two bottom samples taken at each station on 8 June 1966 were 0.10 (range 0.067 to 0.126 g) and 0.03 (range 0.040 to 0.019) g/0.1 m$^2$ for *Baetis* at stations 2 and 4, respectively; and 1.48 (range 0.12 to 2.85) and 1.21 (range 0.658 to 1.754) g/0.1 m$^2$ for *Gammarus* at stations 2 and 4, respectively. The higher drift rates of *Baetis* at station 2 may be the result of higher standing crop at that station, while the nearly uniform drift rates of *Gammarus* correspond to nearly identical standing crops at both stations.

The total stream drift of *Gammarus* is less variable than that of *Baetis* (Table 2), ranging from 2.7 to 13.3 g per day, a factor

TABLE 2. TOTAL STREAM DRIFT (G/DAY) OF *Gammarus* AND *Baetis*, FOR THREE 24-HR PERIODS, 1966

| Date, 1966 | Total Stream Drift in G/Day | | | |
|---|---|---|---|---|
| | Station 2 | | Station 4 | |
| | *Gammarus* | *Baetis* | *Gammarus* | *Baetis* |
| June 7 | 8.3 | 0.72 | 9.4 | 0.34 |
| Aug. 31–Sept. 1 | —* | —* | 13.3 | 5.00 |
| Oct. 22–23 | —* | —* | 12.8 | 1.30 |

*No samples taken.

of approximately 5; whereas the total stream drift of *Baetis* ranged from 0.34 to 5.00 g per day, a factor of approximately 15.

## Discussion

*Tricorythodes, Stenonema, Cheumatopsyche,* and *Chimarra* were more frequent at downstream than at upstream stations, while *Neophylax* occurred only near the spring. The principal organisms found in the stream drift were *Gammarus* and *Baetis*. While *Gammarus* is abundant in the drift during most of the year, *Baetis* occurs in significant quantities only during late winter—early spring and late summer—early fall, periods just preceding major emergences. The maximum standing crop of *Baetis* of 3.6 g/m$^2$ reported in this study is low when compared with the maximum standing crop of 10.0 g/m$^2$ reported in Valley Creek, Minn. (Waters, 1962 b). These low standing crops may limit the use of the drift method (Waters, 1962 b) for estimating production rates in Bear Branch.

A diurnal periodicity of drift rates for both *Gammarus* and *Baetis* agrees with results reported by several workers and reviewed by Waters (1965). A clearer picture of the diurnal periodicity might have resulted in this study if shorter sampling intervals had been used and if possible disturbances by cattle in the stream had been eliminated.

The complete blockage of the stream with drift nets at station 2 on 7 June 1966 did not influence the drift of *Gammarus* entering the nets which also completely blocked the stream at station 4. This suggests the drift is not accumulative from upstream to downstream areas for distances of at least 152 m.

## ACKNOWLEDGEMENTS

I am grateful to Robert F. Meyers for his help in collecting and processing the data and Bryon L. Stephens for his permission to conduct the study on his land.

## LITERATURE CITED

DENDY, J. S. 1944. The fate of animals in stream drift when carried into lakes. Ecol. Monogr. 14:333–357.

MÜLLER, KARL. 1963. Diurnal rhythm in "organic drift" of *Gammarus pulex*. Nature. 198:806–807.

NEEDHAM, P. R. 1938. Trout streams. Comstock Pub. Co., Ithaca, New York. 233 pp.

WATERS, T. F. 1961. Standing crop and drift of stream bottom organisms. Ecology. 42:532–537.

———. 1962 a. Diurnal periodicity in the drift of stream invertebrates. Ecology. 43:316–320.

———. 1962 b. A method to estimate the production rate of a stream bottom invertebrate. Trans. Am. Fish. Soc. 91(3):243–250.

———. 1965. Interpretation of invertebrate drift in streams. Ecology. 46(3): 327–334.

———., and R. J. KNAPP. 1961. An improved stream bottom fauna sampler. Trans. Am. Fish. Soc. 90(2):225–226.

# BIOLOGY OF THE COREIDAE IN WISCONSIN

*T. R. Yonke*[1] *and J. T. Medler*[2]

From July 1, 1962, through June 15, 1967, numerous observations and collections were made of various members of the order Hemiptera. Special interest centered around species in the alydid-coreid-rhopalid complex. Much of the literature in these groups has been of a taxonomic nature with relatively little or no work reported on the biologies and field histories of the respective species. To fill this void in the knowledge of the Coreoidea a study was initiated on the biologies and field histories of members of the Alydidae, Rhopalidae and Coreidae that are found in Wisconsin.

Previously information was reported on the biologies of 4 species of Alydidae in Wisconsin, including *Megalotomus quinquespinous* (Say) (Yonke and Medler, 1965); *Alydus conspersus* Montandon, *A. eurinus* (Say) and *A. pilosulus* Herrich–Schaeffer (Yonke and Medler, 1968). Limited observations have been conducted on 2 Rhopalidae, *Corizus crassicornis* (Linnaeus) and *Harmostes reflexulus* (Say) (Yonke and Medler, 1967).

This is a report on the study of the Coreidae in Wisconsin. Ten species have been recorded for the state. Three species were extremely rare—*Anasa armigera* (Say), *Chariesterus antennator* (Fabricius), and *Leptoglossus oppositus* (Say). *Coriomeris humilis* Uhler and *Merocoris distinctus* Dallas were uncommon. Five species frequently encountered were *Acanthocephala terminalis* (Dallas), *Anasa tristis* (DeGeer), *Archimerus alternatus* (Say), *Catorhintha mendica* Stål, and *Euthochtha galeator* (Fabricius). The first 4 species mentioned were not collected by the authors, but were represented in the Department of Entomology Museum, University of Wisconsin.

Of the latter 5 species the squash bug, *A. tristis,* has been thoroughly studied. The squash bug is of economic importance on the cucurbits. The most comprehensive work to date was that of Beard (1940). Also, the biology of *C. mendica* has been adequately determined (Balduf, 1942, 1957). For the other 3 species, however,

---

[1] Instructor, Department of Entomology, University of Wisconsin. Presently Assistant Professor, Department of Entomology, University of Missouri, Columbia, Missouri. Information given in this paper was submitted in partial fulfillment of the requirements for the degree Doctor of Philosophy in Entomology at the University of Wisconsin.

[2] Professor, Department of Entomology, University of Wisconsin, Madison.

there is no published information on the biologies except for Blatchley (1926) who presented only a few brief notes. The principal part of this text reports studies conducted on *A. terminalis, A. alternatus,* and *E. galeator.*

## Methods and Materials

Collection trips were made throughout southern Wisconsin from April until December in order to obtain field information. The principal collection sites were at Gibraltar Rock, Columbia County; Devils Lake State Park, Ferry Bluff and Parfreys Glen in Sauk County; and Wyalusing State Park, Grant County.

Surveys were made by net-sweeping of prairie, woodland, and disturbed "weedy" habitats to determine if the bugs were present. If encountered, a more intensive search of the area was made to determine the host plants and make observations.

The term, host plant, is used here to denote the actual feeding of the bug on a particular plant in the field. A "collection record" signifies only that the specimen was collected from a particular plant which may or may not have been a host plant and for which no feeding was observed.

A special attempt was made to collect parasitized specimens and rear out the adult parasites. All adults and nymphs observed in the field with Dipterous eggs on them were brought back to the laboratory, and the specimens placed in rearing cartons where they were held until the parasites emerged. Field collected eggs were also placed in laboratory rearing cartons in an attempt to obtain Hymenopterous parasites. All stages of coreids found in the field were brought alive to the laboratory in Madison and placed in 1 pint rearing containers. This technique was developed by Scheel, Beck, and Medler (1956). The substitute food used in the laboratory cartons consisted of fresh green beans (Fig. 1). The food was changed 2 or 3 times a week or as needed. Nymphs and adults of *E. galeator* and later instar nymphs and adults of *A. alternatus* and *A. terminalis* fed well on this diet.

Rearings in the laboratory were used to complement field information and to some degree determine the biology of these bugs. The term "laboratory biology" is employed to designate that the bugs were reared under laboratory conditions and on a substitute non-natural food. The cultures were maintained at room temperature ($25 \pm 4°C$), and approximately normal daylight.

Daily records were kept on preoviposition period, the number of eggs produced, incubation period, oviposition period, time spent in each instar, copulation frequency and duration, and adult longevity. Notes were made on any peculiar or interesting habits exhibited

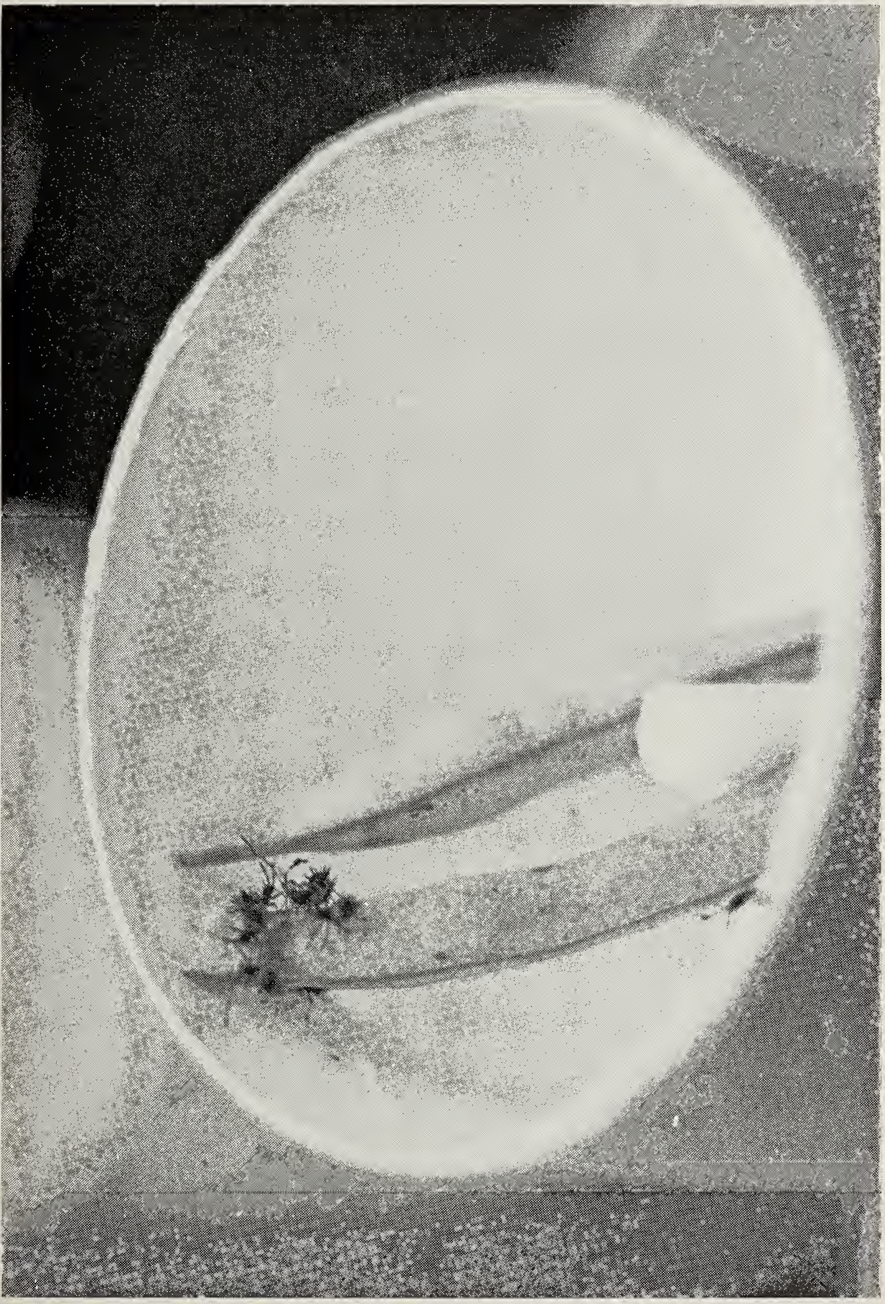


FIGURE 1. Feeding aggregation of 7 second-instar nymphs of *Euthochtha galeator* on the laboratory diet of fresh green bean.

by these insects. The old cartons and cotton rolls were replaced with fresh ones approximately every 3 weeks or as needed to reduce contamination.

## Results and Discussion

### *Acanthocephala terminalis* (Dallas)

The main field study area for this species was at Ferry Bluff (Sauk County) where it was collected from June through September. Additional observations and collections were made at Wyalusing State Park, Devils Lake State Park, and Parfreys Glen.

Figure 2 shows the seasonal occurrence of *A. terminalis* in southern Wisconsin during 1962–1967. There was 1 generation per year. Adults appeared June 13 and were found throughout the summer until September 24. Members of the overwintered generation were collected and brought to the laboratory where gravid females oviposited bright whitish eggs. No eggs or first-instar nymphs could be found in the field; therefore, the data for these stages were obtained from eggs laid by females while transporting them to, or in, the laboratory. No eggs were oviposited by females collected from the field after July 15. Of 47 eggs obtained in this manner all but 2 hatched in from 7–14 days ($\bar{x} = 9.68$). Data presented for Instar 1 were determined by recording the dates of eclosion. Second-instar nymphs were collected in the field from June 30–August 11; third-instar nymphs from June 30–August 11; fourth-instar nymphs from July 8–August 11; and fifth-instar

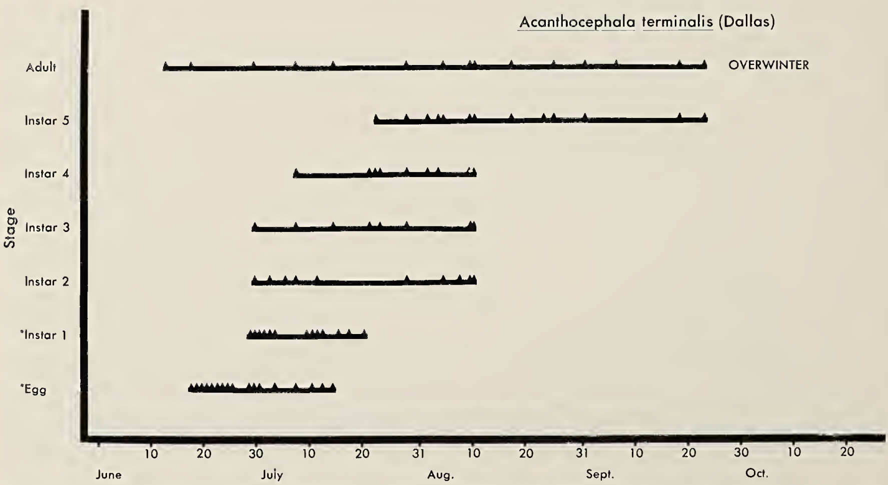



FIGURE 2. Seasonal occurrence of *Acanthocephala terminalis* in Wisconsin, 1962–1967, showing inclusive dates and actual collection records (peaks).

nymphs from July 23–September 24. Eggs and first- and second-instar nymphs would have to occur in the field earlier, and third- and fourth-instar nymphs later than figure 2 shows. Also, it was expected that there was an overlap in late July and August of the occurrence of the overwintered adults and the new summer generation adults. Fifth-instar nymphs collected from the field and brought into the laboratory began molting into the adult stage as early as July 27. On August 10, 1966, 1 second-, 3 third-, 4 fourth-, and 4 fifth-instar nymphs were collected on *Vitis riparia* Michx. at Ferry Bluff.

Three host plants were established for the nymphs and adults of *A. terminalis* (Table 1). Four females were found at Wyalusing State Park feeding on the tender shoots of staghorn sumac, *Rhus typhina* L., on June 18, 1964; as was a second-instar nymph on July 12, 1965. Second- through fifth-instar nymphs and adults were collected over the entire season at Ferry Bluff from both *V. riparia*, river grape, and *Physocarpus opulifolius* (L.) Maxim., nine-bark. Fifth- instar nymphs and adults were also collected from *V. riparia* at Parfreys Glen on August 18, 1966. Both nymphs and adults were observed feeding on the succulent stems and petioles of these plants. One fourth-instar nymph was found feeding on the upper surface of a leaf of *V. riparia*.

Adults were easily disturbed and were very rapid fliers. Immatures were occasionally found resting on the upper surfaces of leaves but more frequently they were hidden under leaves or along the main stems of the plants. This secretive habit along with their dark color made them somewhat difficult to find. At no time were they in great abundance.

Immatures and adults were also collected from *Fraxinus* sp. (ash), *Rubus (Eubatus)* sp. (blackberry), *Tilia americana* L. (basswood), *Desmodium acuminatum* (Muhl.) Wood (tick tree-foil), *Ulmus rubra* Muhl. (slippery or red elm) (Table 1). No feeding was observed in any of these instances so that no definite host plant association could be made; however, it was possible that any or all were fed on and could have served as hosts.

No parasites were obtained from either nymphs or adults, and no parasite eggs were found on any of the bugs.

Field collected specimens were brought to the laboratory and placed on green beans in the cartons. Although individuals from the first-instar nymph to the adult stage fed on this diet they did not do well. Nymphal mortality was very high from the second-instar through the fifth. Only 2 individuals went through their entire development from egg to adult on beans. One female spent 3, 9, 6, 8, and 17 days in each of the 5 respective stadia for a total of 43 days; the other, a male, spent 4, 9, 7, 13, and 28 days in the

TABLE 1. HOST PLANT RECORDS OF *Acanthocephala terminalis*, *Archimerus alternatus*, AND *Euthochtha galeator*

| STAGE[1] | *Acanthocephala terminalis* | | | *Archimerus alternatus* | | | *Euthochtha galeator* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Egg | Nymph | Adult | Egg | Nymph | Adult | Egg | Nymph | Adult |
| Host Plants | | | | | | | | | |
| *Achillea millefolium* | — | — | — | — | — | — | — | — | X* |
| *Agrimonia gryposepala* | — | — | — | — | — | — | — | 5 | X* |
| *Ambrosia artemisiifolia* | — | — | — | — | 5* | — | — | — | — |
| *A. trifida* | — | — | — | — | 5* | X | — | — | — |
| *Amphicarpa bracteata* | — | — | — | — | 2–5* | X* | — | 3 | — |
| *Aster ericoides* | — | — | — | — | — | — | X | 1 | — |
| *A. pilosus* | — | — | — | — | — | — | — | 5* | — |
| *A. sagittifolius* | — | — | — | — | — | X* | — | — | — |
| *Aster* spp. | — | — | — | — | — | X | — | 5 | — |
| *Aureolaria grandiflora* var. *pulchra* | — | — | — | — | — | — | — | 3–4 | — |
| *Carya* spp. | — | — | — | — | — | — | — | — | X |
| *Cryptotaenia canadensis* | — | — | — | — | 5* | — | — | — | — |
| *Desmodium acuminatum* | — | 5 | — | X | 1–5* | X* | — | 2* | — |
| *D. canadense* | — | — | — | — | 5* | — | — | — | — |
| *D. dellenii* | — | — | — | — | 4–5* | — | — | — | — |
| *Erigeron annuus* | — | — | — | — | 5* | X* | — | — | — |
| *Eupatorium rugosum* | — | — | — | — | 5* | — | — | — | — |
| *Fraxinus* spp. | — | — | X | — | — | — | — | — | — |
| *Galium concinnum* | — | — | — | — | — | X* | — | — | — |
| *Graminae* spp. | — | — | — | — | — | — | X | — | — |
| *Helianthus decapetalus* | — | — | — | — | — | X* | — | — | — |
| *Monarda fistulosa* | — | — | — | — | — | X* | — | — | X* |

TABLE 1 *(Continued)*

| STAGE[1] | *Acanthocephala terminalis* | | | *Archimerus alternatus* | | | *Euthochtha galeator* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Egg | Nymph | Adult | Egg | Nymph | Adult | Egg | Nymph | Adult |
| Host Plants | | | | | | | | | |
| *Physocarpus opulifolius* | — | 2–5* | X | — | — | — | — | — | — |
| *Podophyllum peltatum* | — | — | — | X | — | — | — | — | — |
| *Prunus americana* | — | — | — | — | — | — | X | — | — |
| *Quercus ellipsoidalis* | — | — | — | — | — | — | — | 2* | X* |
| *Rhus glabra* | — | — | — | — | — | — | X | — | — |
| *R. typhina* | — | 2 | X* | — | — | — | — | — | — |
| *Robinia pseudoacacia* | — | — | — | — | — | X | — | — | — |
| *Rubus (Eubatus)* spp. | — | 4–5 | — | — | — | — | — | — | — |
| *Solidago altissima* | — | — | — | — | — | X* | — | — | X |
| *S. gigantea* | — | — | — | — | — | X | — | — | — |
| *Solidago* spp. | — | — | — | — | — | X | — | — | — |
| *Symplocarpus foetidus* | — | — | — | — | — | X* | — | — | — |
| *Tilia americana* | — | 3–4 | — | — | — | — | — | — | — |
| *Ulmus rubra* | — | 5 | X | — | — | — | — | 3,5 | — |
| *Urtica dioica* | — | — | — | — | — | — | X | — | — |
| *Vitis riparia* | — | 2–5* | X* | — | — | — | — | — | — |

[1]1–5 = nymphal instars. *Definitely associated host plant (feeding observed in the field).

5 stages for a total of 61 days. Out of 66 adults, both field collected and laboratory reared, 34 were males and 32 were females. The time spent in nymphal development was 58.2 days (Table 2) based on accumulated mean values. Values for Table 2 were compiled primarily from data on second- through fifth-instar nymphs collected from the field and brought to the laboratory.

Growth ratios were fairly consistent (Yonke and Medler, In Press, a). The closeness of fit for the values indicated a uniform growth rate, and therefore tended to substantiate the data presented in Table 2 on the time required for nymphal development. However in comparing laboratory data from Table 2 with field occurrence records in Figure 2, the time required for nymphal development would appear to be longer in the laboratory than in the field.

### *Anasa tristis* (DeGeer)

The following observations in Wisconsin were consistent with the biology of this species as determined by Beard (1940) in Connecticut. The squash bug was not especially abundant in the state. On July 23, 1963, 7 eggs were collected from the upper surface of a leaf of a squash plant. Four hatched on July 27, and 1 on July 28. They molted to the second instar on July 30, but then died. Two fifth-instar nymphs collected from squash plants on September 17, 1963, molted to the adult on September 29.

Four adults were also collected and placed on green bean in the laboratory. They were observed copulating frequently, but no eggs were laid. They lived for 42, 183, and 190 days, respectively. Eleven fourth- and fifth-instar nymphs and 4 adults were collected from squash on September 21, 1963. A Dipterous larva emerged from an adult squash bug and pupated on October 8. After 76 days an adult *T. pennipes* emerged. Another *T. pennipes* was

TABLE 2. DURATION OF NYMPHAL STADIA OF *Acanthocephala terminalis* IN THE LABORATORY

| INSTAR | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| NUMBER OF OBSERVATIONS | 67 | 42 | 14 | 7 | 8 |
| Range (days) | 3–7 | 7–18 | 6–18 | 8–13 | 14–28 |
| Mean ± standard deviation | 3.6±0.81 | 12.9±3.13 | 12.8±3.74 | 9.9±2.27 | 19.0±5.37 |
| Accumulated mean days | | 16.5 | 29.3 | 39.2 | 58.2 |

placed in the carton and the 2 were observed copulating twice; however, no eggs were deposited on the coreids.

*Archimerus alternatus* (Say)

The main study areas for this species were at Parfreys Glen, Wyalusing State Park, Ferry Bluff, Gibraltar Rock in Columbia County, and Devils Lake State Park. This was the most abundant species of the Coreidae found in Wisconsin.

Figure 3 shows the seasonal life history of *A. alternatus* in Wisconsin during 1962–1967. There was 1 generation per year with overwintering in the adult stage. Adults were found continuously from June 2–October 8. This species was well represented in the museum collection of the Department of Entomology, University of Wisconsin. These records showed its occurrence from May 12–October 9. An overlap of overwintered adults and those of the new summer generation probably occurred in late July and August. Eggs were found in the field on June 13, 15, 29, and July 1 and 13.

First-instar nymphs were collected in the field from June 28–July 13; second-instar nymphs from June 18–August 11; third-instar nymphs from June 29–August 27; fourth-instar nymphs from July 8–September 1; and fifth-instar nymphs from July 15–September 26. Eggs and first-instar nymphs would have to occur in the field earlier and first-and fourth--instar nymphs later than is shown in Figure 3.

Table 1 lists the plants on which eggs, nymphs, and adults of *A. alternatus* were collected in Wisconsin from 1964–1967. Adults

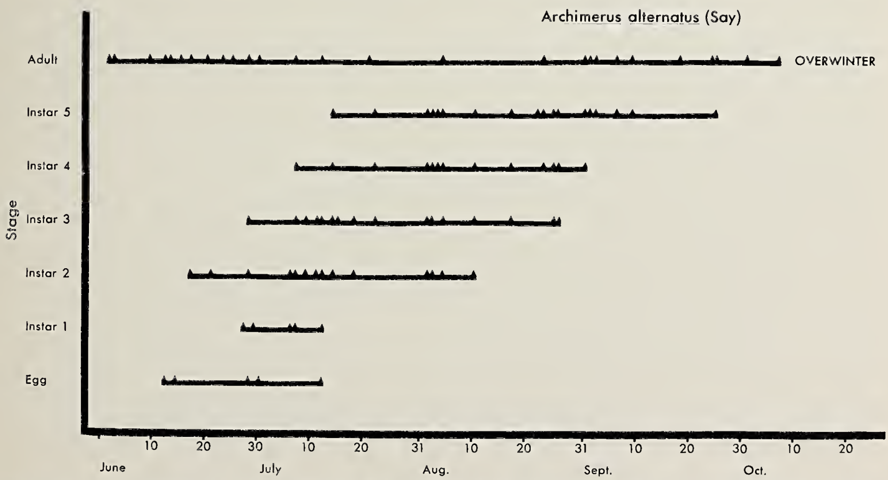



FIGURE 3. Seasonal occurrence of *Archimerus alternatus* in Wisconsin, 1962–1967, showing inclusive dates and actual collection records (peaks).

of this species tended to aggregate on certain species of plants in June. On June 13, numerous adults were found copulating on ragweed, *Ambrosia trifida* L., and goldenrod, both *Solidago gigantea* Ait. and *S. altissima*. Adults were found feeding in the apical region of the stem of *S. altissima*. These plants grew in open fields or near the edges of woods. On June 14, 1966, in a stand of oak with a maple-basswood understory located 5 miles south of Platteville in Grant County, 4 pair of adults were found feeding on *Aster sagittifolius* Willd. (Figure 4) and 1 male on bedstraw, *Galium concinnum* T. & G. However, no eggs were found on any of the plants in the area. In an open area at Parfreys Glen on July 15, more than 40 adults were found on a group of *Desmodium acuminatum* (Muhl.) Wood plants. From 2 to 7 adults were found feeding a few inches below the apex of each of the developing stems. Their feeding caused wilting and death of the stem. Many pairs of adults were copulating and 7 individually laid eggs were found, of which 2 were on the upper surface and 5 on the under surface of leaves of *D. acuminatum*. They were collected and brought to the laboratory where they hatched—2 on July 28 and 30, and July 1, and 1 on July 2. Adults continued to be found predominantly on *D. acuminatum* throughout the entire season. This same group of plants was examined on July 16, 1966, and over 30 adults, but no eggs, were found. An abundance of adults were also found on them on June 24 of that year. These observations would indicate that *A. alternatus* migrated to *D. acuminatum* in June. Oviposition occurred primarily on these plants, but eggs could also be found scattered over plants growing nearby. One egg was found on the stem of *Agrimonia gryposepala Wallr.* growing right next to the clump of *D. acuminatum*. Females also frequently oviposited on the dorsal surfaces of the head, thorax or wings of other females or males in the vicinity. The eggs would be carried on these adults until they hatched. This would undoubtedly aid in dispersal of the insect.

Adults were also found feeding on horse-mint, *Monarda fistulosa* L., and the sunflower, *Helianthus decapetalus* L., in June. In addition adults were collected from, but not observed feeding on, *Aster* sp. and *Robinia pseudoacacia* L. in June. One egg was found on the underside of a leaf of may apple, *Podophyllum peltatum* L.

Nymphs were predominant in the months of July and August. That the second through fifth nymphal stages were especially abundant on *D. acuminatum* (Table 1) was indicated by the respective numbers present: July 7, 1965, 13 second- and 1 third-instar nymphs; July 8, 1964, 6 second-, 29 third- and 9 fourth-instar nymphs; July 8, 1966, 44 second- and 3 third-instar nymphs; July 22, 1966, 17 second-, 21 third-, and 1 fourth-instar nymphs;

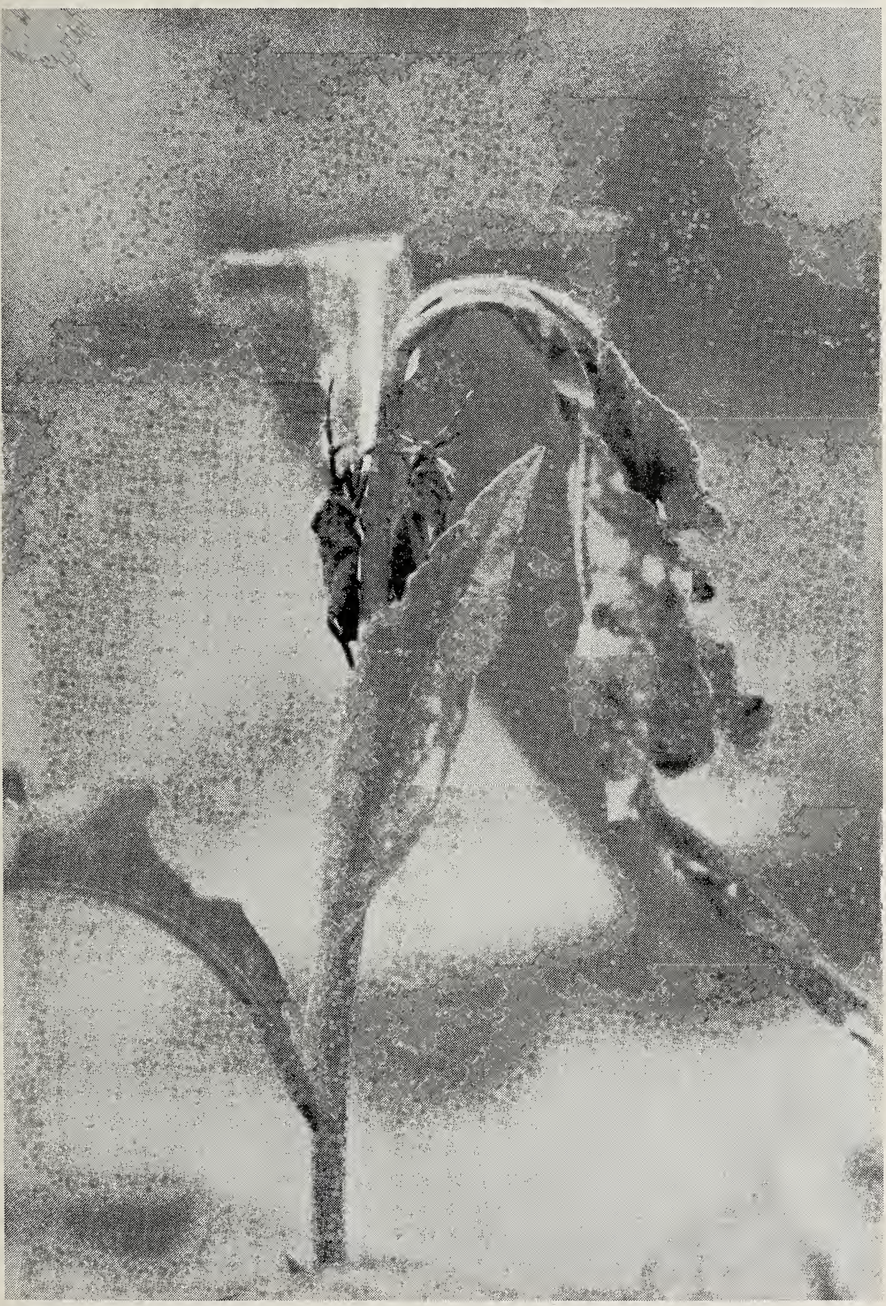


FIGURE 4. *Archimerus alternatus* adults feeding on *Aster sagittifolius* on June 13, 1966, Grant County, Wisconsin.

August 3, 1965, 1 second-, 10 third-, and 16 fourth-instar nymphs; and on August 24, 1966, 8 fourth- and 58 fifth-instar nymphs. Two other legumes also served as host for second- through fifth-instar nymphs. They were readily found on hog-peanut, *Amphicarpa bracteata,* (L.) Fern. and fourth- and fifth-instar nymphs less frequently on *D. dellenii* Darl. On August 18, 1966, 5 fourth- and fifth-instar nymphs were found feeding on the latter species in the apical portion of the stem and on leaf petioles. Nymphs in all stages were generally found in a resting position, inclined anterior to posterior at about a 30° angle, whenever they were not feeding.

First- through fourth-instar nymphs appeared to be obligophagous. In contrast, fifth-instar nymphs exhibited an interesting feeding habit in that the number of host plant species that they fed on increased, therefore, being similar to the polyphagous habits of the adult stage.

It was not until the fifth-instar that nymphs appeared to move about much over the vegetation. No early-instar nymphs were found on any plants except the host plants as previously noted. However, fifth-instar nymphs were found resting and feeding on ragweed, both *A. artemisiifolia* L. and *A. trifida;* on honewort, *Cryptotaenia canadensis* (L.) D. C.; and on *D. canadense* (L.) D. C. On September 1, 1966, they were observed feeding on white snakeroot, *Eupatorium rugosum* Houtt. Also, many fifth-instar nymphs continued to feed on *D. acuminatum* even after seeds were produced (Fig. 5).

The distribution of *A. alternatus* may eventually be shown to coincide with the distribution of *D. acuminatum.* This would be over the entire eastern United States and include the southern two-thirds of Wisconsin (Fassett, 1939).

Adults collected in September were found feeding on the daisy, *E. annus* and on skunk cabbage, *Symplocarpus foetidus* (L.) Nutt. Adults were also found on *Aster* sp., *A. trifida,* and *Solidago* spp.

The reactions of all of the plants were similar where feeding pressure was great, that is, where 2 or more bugs fed for a prolonged period. Adults feeding in June (Figure 4) and second- through fifth-instar nymphs were all found to produce the same effect. The terminal portion of from 2 to 6 inches above the feeding loci gradually turned black and died. Where feeding pressure was severe early enough in the season no flower or seed production occurred.

Adults exhibited a death feign whenever they were disturbed. They would drop from the plants and remain motionless in the litter for as long as 5 minutes.

Two new parasite records were obtained from eggs of *A. alternatus.* Two eggs of this species were collected at Wyalusing State

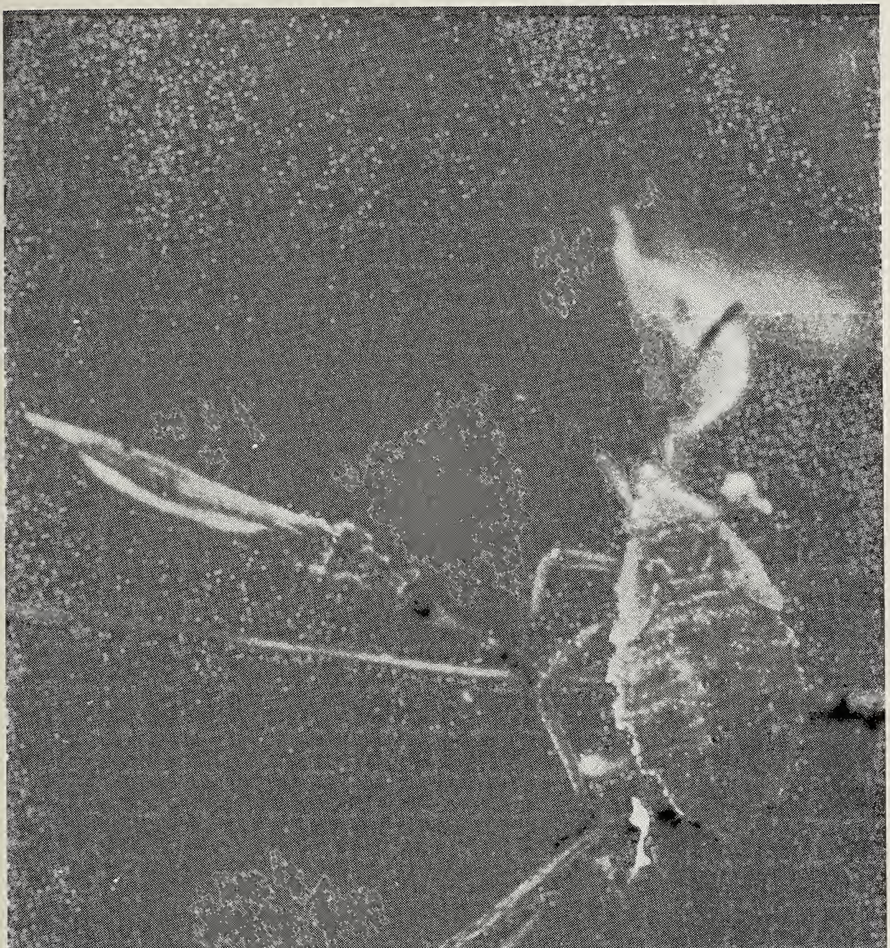


FIGURE 5. Fifth-instar nymph of *Archimerus alternatus* feeding on the seed petiole of host, *Desmodium acuminatum.*

Park on June 29, 1964. One was from the underside of a leaf of may apple. From it 7 Hymenopterous parasites, both males and females, of *Ooencyrtus clisiocampae* (Ashm.) (Encyrtidae), emerged on July 12. These adults were placed in a rearing carton with 5 eggs of *A. alternatus* oviposited in the laboratory and another generation of parasites was obtained from these eggs. Egg parasitism will be discussed in greater detail under *Euthochtha galeator.*

Another Hymenopterous parasite, a female *Anastatus pearsalli* Ashm., emerged from the other field collected egg of *A. alternatus.* The date of emergence was not known. On July 13, 1965, while collecting along a roadside 3 miles west of Sauk City 1 egg of *A. alternatus* was found on a blade of grass. It was brought to the laboratory and on September 8, 1965, a female *A. pearsalli* emerged.

Six adult *T. pennipes* were reared from *A. alternatus* in Wisconsin. The only previous report of this parasite-host relationship was given by Patton (1958) who listed it from Florida.

The following specimens were all obtained at Wyalusing State Park. One female collected on June 14, 1963, produced a Dipterous larva on June 22. It spent 11 days in the pupal stage and emerged into an adult on July 3. A male collected on June 18, 1964, produced a larva on June 22, which spent 12 days in pupation before it emerged an adult. Another male collected August 5, 1964, produced a larva on August 11. It spent 14 days in pupation. In addition 3 *T. pennipes* adults were obtained from field collected fourth- or fifth-instar nymphs that were reared to the adult stage in the laboratory. The parasites emerged on August 17 and 24, and September 9, and spent 13, 12, and 16 days, respectively, in pupation. Upon examination of the exuviae of these bugs no parasite eggs were found, indicating that they had been parasitized in the field at least 1 instar prior to when they were collected. They then molted and carried the larva with them until they emerged an adult. The presence of the parasite, therefore, does not necessarily result in the death of the nymph. This is consistent with the observations of Beard (1940) on the behavior of the larva in nymphs of the squash bugs.

Out of 27 second- and third-instar nymphs collected on June 29, 1964, at Wyalusing State Park, 2 second-instar nymphs were each found to have 1 Dipterous parasite egg on the dorsal surface of the abdomen. One molted to the third instar on July 1, and the other on July 2, leaving the parasite eggs on their cast skins. Examination under the microscope showed that 1 was in the process of cutting its way out of the egg and the other was still intact within the egg. These eggs fit the description of Worthley (1924) for *T. pennipes* and were probably of that species.

*Trichopoda pennipes* adults mated in the rearing cartons and 1 female deposited 15 eggs on an adult female of *A. alternatus*. A Dipterous larva emerged after 15 days, pupated, and spent 15 days in the pupal stage before molting into an adult.

*Desmodium acuminatum* plants were collected from the field on July 16, 1965, placed in pots, and brought into the laboratory to facilitate observation of the behavior of the first 3 instars of *A. alternatus*.

Groups of 5 bugs which hatched on the same day and were all of the same instar were placed on each set of plants. A set consisted of 3 to 5 stems per pot. Three groups of 5 first-instar nymphs each were placed on the upper surfaces of the leaves of 3 sets of plants. All 15 bugs remained for 3 or 4 days on the leaves where they were placed. Three of the 15 were observed with their stylets inserted through the leaf surface, and most nymphs showed a distended abdomen indicating that they fed in the first instar. Shortly after molting, the second-instar nymphs began to migrate over the plants. Eight were feeding on the petioles of the flowers or seeds within 1 day after molting. The other 7 nymphs escaped from the plants.

Second- and third-instar nymphs after being removed from the rearing cartons and placed on the leaves immediately began moving over the plants, but again they were always found feeding on the stem or petioles within 2 days after release.

On July 2, 1966, plants of *D. acuminatum* were collected from the field, potted, and brought into the laboratory. They were placed in 1 of 2 rearing cages. Again nymphs were observed. Five first-instar nymphs from the laboratory cartons and 2 second-instar nymphs collected the same day from the field were released on the bottom of the cage. The first instars remained there for 2 days and then moved onto the plants and took the "resting position" on the undersides of leaves. However, within 10 minutes 1 of the second-instar nymphs had moved onto the plant and began feeding on the main stem about 4 inches down from the tip of the 18-inch long stem. Two days later the other second-instar nymph assumed a position immediately next to the first. The 2 bugs remained together for 3 more days before moving. Behavior of the third-instar nymphs was similar to that of the second.

Nymphs and adults would gather together and feed at about the same position on the stem even though other stems in the same set of plants were free of any bugs. This aggregation behavior was found in the field. It was also found in the laboratory on *D. acuminatum* in the rearing cages, and on green bean in the rearing cartons (Figure 6). The bugs produced the same feeding stress on the plants grown in the laboratory as was found in the field, causing the apical portions of the stems to die above the feeding loci.

Some observations were conducted on these bugs in the rearing cartons in the laboratory. Third- through fifth-instar nymphs and adults fed well on green beans; however, the development of the second-instar nymphs on this diet was impaired.

Cultures were established each year from eggs obtained from females or nymphs collected in the field in June. Adults were observed copulating frequently in the rearing cartons. Eggs of this species were oviposited singly as were those of *A. terminalis.* Heidemann (1911) reported that the eggs of *Archimerus calcarator* (Fabricius) were laid in a row, but not joined. Although occasionally *A. alternatus* would lay a few eggs in an irregular row there was no definite oviposition pattern. He also reported 14 "chorial processes" for the egg. The number of micropylar processes found for *A. alternatus* were considerably greater, as noted under the description of the egg of this species (Yonke and Medler, In press b). A mean of 2.1 eggs per day (n = 17, range = 1.0–4.5) were oviposited by females in the laboratory, with a mean value of 57 eggs (n = 17, range = 10–128) for the total number of eggs oviposited per female. The maximum number of eggs laid in any 1 day by a single female was 15. The mean oviposition period was 37.2 days (n = 17, range = 5–120). Although it may not be applicable to a univoltine species overwintering in the adult stage, a mean preoviposition period of 33.5 days (n = 17, range = 22–58) was observed in the laboratory.

The mean incubation period of 67 eggs was 13.4 days with a range of from 10–20 days. Out of 258 eggs oviposited in the laboratory 85.3% hatched.

Eclosion took place by means of a pseudopercular cap. The bug forced it open by means of a series of pulsating movements. The cap split first at its most ventral point and then proceeded posteriodorsally. This took only a few minutes.

Nymphal development took 48.6 days (Table 3) based on an accumulation of the means. The values, except for those of Instar 2, employed in construction of Table 3 were obtained from observations on nymphs feeding on green beans in the rearing cartons. Since this species did not develop from egg through to adult on beans the values for Instar 2 were obtained from observations of second-instar nymphs that developed on *D. acuminatum* in the laboratory rearing cages. The time spent in nymphal development agreed favorably with the data presented on seasonal history in Figure 3.

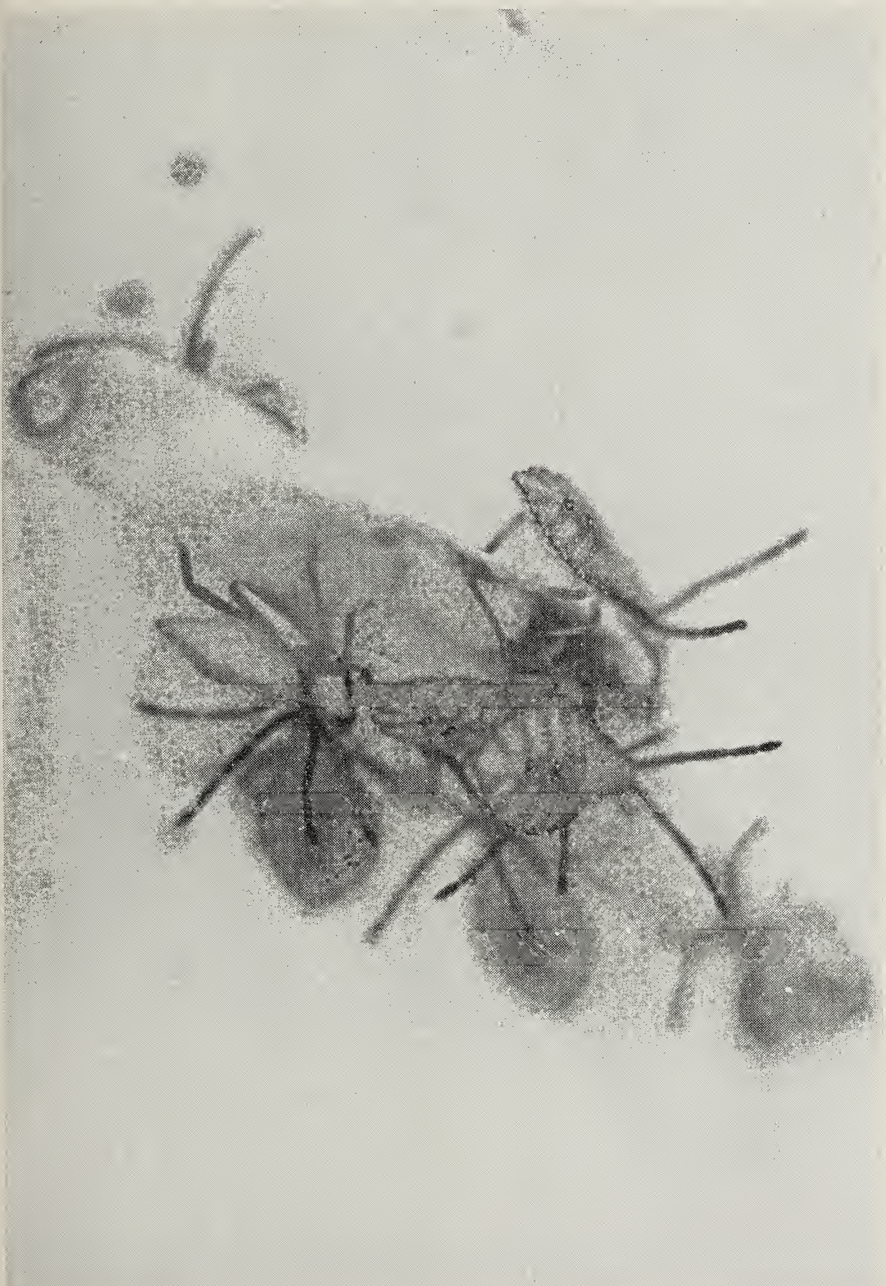


FIGURE 6. Feeding aggregation of 8 second-instar nymphs of *Archimerus alternatus* on the laboratory diet of fresh green beans.

TABLE 3. DURATION OF NYMPHAL STADIA OF *Archimerus alternatus* IN THE LABORATORY

| INSTAR | 1 | 2[1] | 3 | 4 | 5 |
|---|---|---|---|---|---|
| NUMBER OF OBSERVATIONS | 54 | 7 | 26 | 54 | 54 |
| Range (days) | 3–7 | 5–10 | 4–16 | 7–17 | 10–30 |
| Mean ± standard deviation | 4.6 ± 0.92 | 7.6 ± 1.89 | 8.3 ± 2.72 | 11.2 ± 1.86 | 16.9 ± 5.11 |
| Accumulated mean days | | 12.2 | 20.5 | 31.7 | 48.6 |

[1]Values presented for Instar 2 were taken from observations of the bugs on *Desmodium acuminatum* in rearing cages.

The growth ratios were very constant for this species. (Yonke and Medler, In press b). The closeness of fit for the values indicated a uniform growth rate and, therefore, tended to substantiate the data presented in Table 3.

Out of 484 adults either collected in the field or reared in the laboratory 231 were males and 253 were females.

Deformed antennae in the form of a reduction in the size and number of segments were observed on some bugs reared in the laboratory. It was thought that this might have been due to the non-host diet. However, examination of field collected adults also produced specimens with similar abnormalities.

### *Catorhintha mendica* Stål

Adults, eggs, and nymphs were collected from *Mirabilis nyctaginea* growing on railroad embankments in Dane, Jefferson, Rock, and Sauk counties. They were not found on any other plant. Early-instar nymphs were collected from under the involucral bracts which enclosed the flowers and seeds, and later-instar nymphs fed on the petioles. Additional observations of this bug and its host were made at Kankakee, Illinois. On September 3, 1966, many adults and 151 nymphs were collected of which there were—1 first-, 8 second-, 56 third-, 78 fourth-, and 9 fifth-instar nymphs. Adults and nymphs were collected from the field and brought alive to the laboratory where they were placed on green beans. Adults fed readily and lived from 3–85 days, but the nymphs did not survive. Females laid from 2–7 eggs per batch ($n = 20$, $x = 3.5$). They hatched in from 5–8 days ($n = 28$, $x = 6.4$). These data are in agreement with the data presented by Balduf (1942) for this species.

### *Euthochtha galeator* (Fabricius)

The main field study area for this species was at Parfrey's Glen. Additional observations and collections were made at Wyalusing State Park, as well as a few other locations.

Figure 7 shows the seasonal occurrence of *E. galeator* in Wisconsin during 1962–1967. There was 1 generation a year with overwintering in the adult stage. Adults were found from May 25–October 8. No adults were found between July 6 and August 11 indicating that the overwintered adults died off at about that time. This species was well represented in the museum collection of the Department of Entomology, University of Wisconsin. These records showed its occurrence from May 5–October 27. There were no records between July 13 and August 6. Field collected nymphs brought back to and reared in the laboratory began molting into the adult stage on July 25.

Eggs were found in the field from June 13–July 20. First-instar nymphs were collected in the field from June 13–July 13; second-instar nymphs from June 13–August 3; third-instar nymphs from July 13–August 10; fourth-instar nymphs from July 18–August 10; and fifth-instar nymphs from July 24–September 19. Eggs and first-instar nymphs would have to occur in the field earlier, and third- and fourth-instar nymphs later than Figure 7 shows.

On June 13, 1963, while collecting at Wyalusing State Park, 13 eggs and first-instar nymphs of *E. galeator* were found on the upper surface of a leaf of *Aster ericoides* L. growing in an open field. The bright red nymphs were still aggregated about the eggs

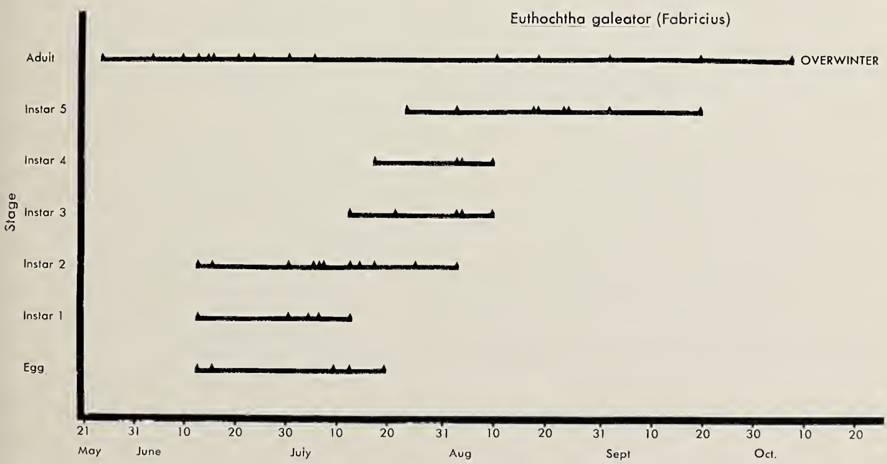



FIGURE 7. Seasonal occurrence of *Euthochtha galeator* in Wisconsin from 1962–1967 (peaks).

when they were collected. On the same date a cluster of 13 more eggs were found on *Urtica dioica* L., nettle. They were brought back to the laboratory and placed in a rearing carton. Eight first-instar nymphs hatched on June 29 and 1 on June 30. Also on June 28, 12 encyrtid parasites, *O. anasae* (Ashm.), emerged from 4 of these eggs. This constituted a new host record for *O. anasae*, there being no previous published association of this parasite and host. These adults were placed in a carton with eggs of *E. galeator* obtained from females in the laboratory. The adult parasites died by July 20, and were removed from the carton. On July 30, the eggs were examined under the microscope and found to have many small oval masses about the inner surfaces of the chorions. They also were dark in color, in contrast to the reddish or gold color of the normal eggs. More than 70 adult parasites emerged from the eggs on August 1; 17 more parasites on August 2; 4 on August 4; and 1 on August 5. Some parasites escaped from the carton so an exact count could not be made. Both males and females of *O. anasae* were obtained. An unsuccessful attempt was made to obtain another laboratory generation of parasites.

Six eggs of *E. galeator* were found on June 16, 1964, on a blade of grass growing on the sandy bank along the Wisconsin river at the Mazomanie Wildlife Refuge, Dane County. They were positioned in a line, end to end. Five hatched on June 22 and 1 on June 23.

On July 10, 1965, 6 eggs were found oviposited on the upper surface of a leaf of wild plum, *Prunus americana* Marsh. Closer observations revealed slightly raised brown spots on the leaf where 7 more eggs had been laid but were no longer attached. One adult Hymenopterous parasite, *Anastatus pearsalli*, emerged from 1 egg of *E. galeator* on August 11, and 5 more emerged, each from a single egg, on August 12. *Anastatus pearsalli* failed to parasitize laboratory reared eggs and they died by August 14.

Two additional batches of eggs were found. In 1 there were 11 eggs that had already hatched, and in the other there were 14 eggs. Ten eggs of the latter batch hatched in the laboratory on July 16, and 4 hatched on July 17. All 3 batches of eggs were found in a disturbed weedy habitat at Parfrey's Glen. In the same area on July 13, 1965, 8 first-instar nymphs were observed in aggregation resting on the upper surface of a leaf of *Rhus glabra* L. and 9 eggs that had hatched were found on the underside of the leaf.

On July 12, 1964, 7 encyrtid parasites, *O. clisiocampae*, obtained from an egg of *A. alternatus* collected in the field on June 29, 1964, were placed in a rearing carton with 20 laboratory eggs of *E. galeator*. The parasites were observed on the eggs and on July 27, numerous parasites emerged from all 20 *E. galeator* eggs. A total of 124 parasites were obtained from these and 5 additional laboratory eggs of *A. alternatus* which were also present in the carton.

Six host plants were found for nymphs and adults of *E. galeator* (Table 1). They were determined by observations of the bug feeding on the respective plants in the field. The host plants were *Agrimonia gryposepala* Wallr. or roots fibrous, *Achillea millefolium* L., *Aster pilosus* Willd., *M. fistulosa* or horsemint, *D. acuminatum,* and *Quercus ellipsoidalis* E. J. Hill. Of these plants, adults were found feeding and copulating most frequently on *A. gryposepala.* Since adults had been found frequently at Parfrey's Glen on *A. gryposepala* in June of 1966, special trips were made in June of 1967 to see if the bugs could be located on these plants again. On June 4, 4 pairs of bugs were found on 4 separate clones of *A. gryposepala,* 5 were feeding and 2 pair were copulating. On June 15 another pair was found copulating on this plant.

While a male *E. galeator* was being observed feeding on a petiole of *A. millefolium,* a female flew to the plant and approached the male, but flew away when disturbed. Adults were often found in June resting on the leaves of composites. Both males and females were swept with a net from *Solidago altissima* Mill. on June 13, 1966, at the Mt. Hope Conservation Area in Grant County.

Second-instar nymphs were found feeding on *Q. ellipsoidalis* and *D. acuminatum* and fifth-instar nymphs on *A. pilosus* and *A. gryposepala.*

Nymphs and adults were collected also from *A. bracteata, Aureolaria grandiflora* var *pulchra* (Benth.) Pennell, *Carya* sp., and *Ulmus rubra* Muhl. Therefore, it would appear that *E. galeator* is not monophagous, but rather can and does utilize a number of host plants representing different families.

Adults exhibited a death feign. Whenever disturbed they would either drop from the plant and remain motionless, or fly away quickly.

Nine adult Dipterous parasites, *T. pennipes,* were reared in the laboratory from 4 male and 5 female field collected adults. There were no previous published records of *T. pennipes* from *E. galeator.* Four parasites were obtained from adults collected at Parfreys Glen on June 24, 1966. Larvae emerged from the bugs and pupated on June 27, July 2, 10, and 20, 1966; and spent 18, 15, 14, and 20 days respectively, in their pupal stages. Adult parasites did not live longer than 7 days and although they were observed copulating they did not oviposite on the bugs in the rearing cartons. One female *E. galeator* that was parasitized laid 3 batches of 19, 10, and 12 viable eggs. A female and a male collected on July 1, 1966, each produced a parasite on July 6 and 12, respectively.

The 1 obtained from the female emerged an adult on July 26, but that from the male died in the pupal stage.

On August 4, 1964, a fifth-instar nymph of *E. galeator* was collected at Parfreys Glen and brought to the laboratory where it molted into an adult male on August 25. On September 3, a Dipterous larva, *T. pennipes,* emerged from it and pupated. No parasite egg was found on the exuvium of the fifth instar indicating that it had been parasitized in an earlier instar and had successfully molted with the larva inside. A female was collected from Mazomanie Wildlife Refuge on August 23, 1963. A larvae emerged from it and pupated on August 24 and emerged to an adult on September 9.

One male *E. galeator* was collected from Kankakee, Illinois, on August 6, 1965, brought back alive to Madison, and placed in a rearing carton. On August 9, a parasite emerged, pupated, and on August 27 emerged as an adult.

From 1 to 5 parasite eggs were found randomly oviposited over the bodies of the bugs.

Some observations were conducted on the bugs in the rearing cartons to gain information on their biology. Both nymphs and adults fed readily on the laboratory diet of fresh green beans.

Cultures were established each year from eggs obtained from females, eggs, or nymphs collected from the field in June. This species oviposited its eggs in batches similar to those of *A. armigera* and *A. tristis,* with a mean number of 16.0 eggs per batch (number of batches = 62, range = 2–32). In 22 observations individual females oviposited from 3–19 batches of eggs with a mean of 8.2 batches per female. The greatest number of eggs oviposited by a single female in the laboratory was 259.

A mean time of 6.0 days (n = 60, range = 1–24) elapsed between oviposition of individual batches of eggs. Generally when only 1 or a few days passed between oviposition fewer eggs were oviposited per batch. In 14 observations a mean time of 40.7 days were spent in the oviposition period, with a range of from 11–89 days.

A delayed preoviposition period ranging from 26–143 days (n = 5, x = 95.6) was observed for females reared in the laboratory from the nymphal stage. These females would have normally overwintered and not copulated or oviposited until the following spring. This delayed preoviposition time was a reflection of that behavior. In fact, a preoviposition period, if defined as the time elapsing between the molting of the insect to the adult stage until first oviposition, would not be a pertinent part of the biology of a univoltine species that overwinters as an adult.

The period of incubation for 566 eggs oviposited in the laboratory ranged from 7–17 days with a mean time of 12.9 days. Out of a total of 720 eggs obtained in the rearing cartons 636 hatched, or 88.3%.

Eclosion took place by means of the pseudopercular cap. The bug forced it open by means of a series of pulsating movements. The cap split first at its most ventral point and then proceeded posterio-dorsally. This took only a few minutes.

First-instar nymphs were observed in the rearing cartons with their stylets inserted in green beans. It was assumed that they were feeding; however, they would successfully develop in the absence of any food during that stadium as long as moisture through the wick was available. In fact these nymphs were lethargic and frequently aggregated on or near the eggs until they molted into the second instar. Second- through fifth-instar nymphs spent much of the time feeding.

Nymphal development took 54 days, with the second, third, and fourth stadia being about equal (Table 4). This was based on an accumulation of the means. These laboratory data agreed fairly well with the field occurrence records given in Figure 7.

The growth ratios were fairly consistent (Yonke and Medler, In press c). The closeness of fit for the values indicated a uniform growth rate, and therefore tended to substantiate the data presented in Table 4.

Frequently nymphs aggregated while feeding. Figure 1 shows an aggregation pattern of 7 second-instar nymphs feeding in a relatively small area on 1 of the 2 green beans present in the rearing carton. One additional bug was present in the carton.

Out of 206 adults either collected in the field or reared in the laboratory 102 were males and 104 were females. Adults generally

TABLE 4. DURATION OF NYMPHAL STADIA OF *Euthochtha galeator* IN THE LABORATORY

| INSTAR | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| NUMBER OF OBSERVATIONS | 136 | 80 | 51 | 54 | 42 |
| Range (days) | 2–5 | 6–18 | 6–18 | 5–18 | 8–28 |
| Mean ± standard deviation | 3.4 ± 0.83 | 11.1 ± 3.13 | 10.2 ± 3.12 | 12.2 ± 3.43 | 17.1 ± 5.49 |
| Accumulated mean days | | 14.5 | 24.7 | 36.9 | 54.0 |

survived for a long time. Two adults collected from the field in June lived 204 and 212 days under laboratory conditions.

### *Merocoris distinctus* Dallas

This species occurs in Wisconsin, although nowhere common. Adults occurred from June 9–October 26. Also, 1 adult was recorded for "April."

One adult was collected while sweeping Midway Prairie, La Crosse County, on June 15, 1967. Another adult was observed on June 17, 1967, at Crex Meadows, Burnett County, associated with a carrion spot on the pavement of a road. One fifth-instar nymph was collected September 1, 1964, while sweeping a disturbed weedy area at Parfreys Glen; however, continued sweeping and investigation of individual plants did not produce more. It was held on green bean in the laboratory, molted into an adult on October 5, and died on October 17. There is apparently 1 generation per year in Wisconsin with overwintering in the adult stage. One adult each was collected on September 30, 1963, and October 2, 1965, on goldenrod, from Curtis Prairie, University of Wisconsin, Arboretum, Madison.

## Summary

From July 1, 1962, through June 15, 1967, numerous observations and collections were made of coreid species found in Wisconsin. Ten species were recorded. *Anasa armigera* (Say), *Chariesterus antennator* (Fabricius), and *Leptoglossus oppositus* (Say) were extremely rare. *Coriomeris humilis* Uhler and *Merocoris distinctus* Dallas were uncommon. Five species frequently encountered were *Acanthocephala terminalis* (Dallas), *Anasa tristis* (DeGeer), *Archimerus alternatus* (Say), *Catorhintha mendica* Stal, and *Euthochtha galeator* (Fabricius).

The field histories and laboratory biologies were determined for *Acanthocephala terminalis, Archimerus alternatus* and *Euthochtha galeator*. All 3 species went through 1 generation a year in Wisconsin and overwintered in the adult stage.

Adults of *Acanthocephala terminalis* were collected in the field from June 13 to September 4. No parasites were found for this species. Three host plants determined for nymphs and adult were *Physocarpus opulifolia* (L.) Maxim., *Rhus typhina* L., and *Vitis riparia* Michx. Eggs had an incubation time of 7 to 14 days (mean =9.7). The mean time spent in nymphal development was 58.1 days.

Adults of *Archimerus alternatus* were collected in the field from June 2 to October 8. They were found feeding on *Solidago altis-*

*sima* Mitt., *Aster sagittifolius* Willd., and *Galium concinnum* T. & G. in early June. They moved from these plants to *Desmodium aciminatuo* (Muhl.) Wood, tick trefoil, on which oviposition generally occurred. First-through fourth-instar nymphs were restricted to *D. acuminatum,* D. *dilienii* Darl., and *Amphicarpa bracteata* (L.) Fern., hog peanut. Fifth-instar nymphs fed on these 3 plants and also fed on a number of other plants, including *Ambrosia artemisiifolia* L., *Ambrosia trifida* L., *Cryptotaenia canadensis* (L.) D.C., *Desmodium canadense* (L.) D.C., and *Eupatorium rugosum* Houtt. Host plants of the summer generation adults included those recorded for the immatures, and in addition *Erigeron annus* (L.) Pers., dairy; and *Symplocarpus foetidus* (L.) Nutt., skunk cabbage. Feeding on all plants occurred on the stems and petioles, causing the terminals above to wilt.

Two hymenopterous parasites were obtained from field-collected eggs of *A. alternatus.* They were *Ocencrytus clisiocampae* (Ashm.) (Encyrtidae) and *Anastatus pearsalli* Ashm. (Eupelmidae). These were new records. Adults of the dipterous parasite, *Trichopoda pennipes* Fabricius (Tachinidae), were reared from field-collected adults.

Feeding aggregations of *Archimerus alternatus* were observed both in the field and in the laboratory for nymphs and adults. A mean number of 2.1 eggs per day was oviposited by females in the laboratory. Incubation took 13.4 days. The mean time spent in nymphal development was 48.4 days.

*Euthochtha galeator* adults were collected in the field from May 25 to October 8. The 6 host plants found for nymphs and adults were *Agrimonia gryposepala* Wallr., *Achillea millefolium* L., *Aster pilosus* Willd., *Monarda fistulosa* L., *D. acuminatum* (Muhl.) Wood, and *Quercus ellipsoidalis* Hill.

Three parasite species were obtained from field-collected eggs and adults of *E. galeator.* They included 2 Hymenoptera, *A. pearsalli* Ashm. and *Ooencyrtus anasae* (Ashm)., and 1 Diptera, *T. pennipes* Fabricius. These were new records. In addition, *C. clisiocampae* parasitized *E. galeator* eggs in the laboratory.

A feeding aggregation was also observed for nymphs of *E. galeator.* This species oviposited its eggs in batches (mean = 16.0 eggs per batch). A mean time of 6.0 days elapsed between oviposition of individual batches of eggs. Incubation of eggs took 7 to 18 days (mean = 12.9). The mean time spent in nymphal development was 54 days.

## References Cited

Balduf, W. V. 1942. Bionomics of *Catorhintha mendica* Stål. (Coreidae, Hemiptera). Bull. Brooklyn Entomol. Soc. 37:158–166.

———. 1957. The spread of *Catorhintha mendica* Stål. (Coreidae, Hemiptera). Proc. Entomol. Soc. Wash. 59:176–185.

BEARD, R. L. 1940. The biology of *Anasa tristis*, DeGeer with particular reference to the tachinid parasite, *Trichopoda pennipes* Fabr. Conn (New Haven) Agr. Exp. Sta. Bull. 440:594–679.

BLATCHLEY, W. S. 1926. Heteroptera or true bugs of Eastern North America. The Nature Publishing Co., Indianapolis. 1116 p.

FASSETT, N. C. 1939. The leguminous plants of Wisconsin. Univ. Wis. Press, Madison. 157 p.

HEIDEMANN, O. 1911. Some remarks on the eggs of North American species of Hemiptera–Heteroptera. Proc. Entomol. Soc. Wash. 13:128–140.

PATTON, C. N. 1958. A catalogue of the larvaevoridae of Florida. Fla. Entomol. 41:29–39, 77–89.

SCHEEL, C. A., S. D. BECK, AND J. T. MEDLER. 1956. Feeding and nutrition of certain Hemiptera. Proc. Tenth Int. Congr. Entomol. 1956: 303–308.

WORTHLEY, H. N. 1924. The biology of *Trichopoda pennipes* Fab. (Diptera, Tachinidae), a parasite of the common squash bug. Psyche 31:7–16, 57–77.

YONKE, T. R., AND J. T. MEDLER. 1965. Biology of *Megalotomus quinquespinosus* (Say). Ann. Entomol. Soc. Amer. 58:222–224.

———. 1967. Observations on some Rhopalidae (Hemiptera). Proc. N. Central States Branch Entomol. Soc. Amer. 22:74–75.

———. 1968. The biologies of 3 species of *Alydus* in Wisconsin (Hemiptera: Alydidae). Ann. Entomol. Soc. Amer. 61:526–531.

———. In Press a. Description of the immature stages of Coreidae: 1. *Euthochtha galeator*. Ann. Entomol. Soc. Amer

———. In Press b. Description of the immature stages of Coreidae: 2. *Acanthocephala terminalis*. Ann. Entomol. Soc. Amer

———. In Press c. Description of the immature stages of Coreidae: 3. *Archimerus alternatus*. Ann. Entomol. Soc. Amer.

# HOST RECORDS AND PHENOLOGY OF LOUSE-FLIES ON WISCONSIN BIRDS

*Nancy S. Mueller, Helmut C. Mueller, and Daniel D. Berger*

## INTRODUCTION

Louse-flies (Diptera: Hippoboscidae) are ectoparasites which feed on the blood of birds and mammals. Most species infest birds and are agile, elusive creatures that spend most of their lives well hidden and protected by the feathers of their hosts. Reproduction depends on at least one mating and involves the production of one young at a time. Embryonic and larval development of the offspring occurs within the body of the female fly. Shortly before pupation the larva is dropped from the fly and falls from the bird to the ground. Some species overwinter as pupae, while others emerge in one to several months. Each new adult must find a suitable host within a few days after emergence, and mating depends on the presence of both sexes on the same host. These interesting flies are relatively rare in collections because few entomologists have access to large numbers of living, wild birds and most ornithologists who handle wild birds have neither the time nor the interest to devote to the ectoparasites.

A list of records of louse-flies for Wisconsin and surrounding states as well as some information about the habits of the flies is found in MacArthur (1948). Bequaert's (1952–1956) monograph on the Hippoboscidae of North America provides an exhaustive compilation and analysis of all aspects of the life histories, distribution and taxonomy of Hippoboscidae in North America. Our present knowledge of the life history, distribution and host relations of the louse-flies which live on passerine birds has benefited from the recent increase in the use of mist-nets and Helgoland traps for capturing wild birds. Bennett (1961) collected louse-flies from passerine hosts in Algonquin Park, Ontario, between mid-May and mid-September in 1957–1960 and kept some of the flies on captive birds to study their longevity and host preferences. Workers in Britain (Corbet, 1956b, 1961; Hill, 1962, 1963) and in Scandinavia (Hill *et al.*, 1964) studied the distribution, life histories and host preferences of three species of *Ornithomyia* during the summer, when these louse-flies are most abundant. Much less is known about the louse-fly infestation of migrating and wintering birds or about the louse-flies of raptorial birds at all seasons of the year.

In the present study we have analyzed records of louse-flies collected in Wisconsin from a wide variety of raptorial and passerine birds. Most of the specimens were taken during spring and autumn migration, but we also collected flies on hawks and owls in winter. This report is based on data from a total of 1,281 individuals of eight species of Hippoboscidae taken on 695 individuals of 60 species of birds.

## Techniques

Raptorial and passerine birds have been trapped regularly during spring and autumn migration at the Cedar Grove Ornithological Station, located on the western shore of Lake Michigan about 64 km north of Milwaukee, Wisconsin. A description of the station area is found in Mueller and Berger (1966). Birds were checked for Hippoboscidae during a total of 11 autumns and 6 spring seasons, beginning in 1955; during this period 4,393 raptorial birds and 53,979 passerine birds and woodpeckers were handled.

A concerted effort was made to check each captured raptorial bird for the presence of Hippoboscidae. Hawks were trapped individually in nets and usually removed from the netting immediately after capture. The usual method of checking for louse-flies on hawks and owls was to blow on the feathers or to spread them by hand. The disturbed flies darted among or on the feathers, seeking shelter in another region, or flew to the person handling the bird or, less frequently, to a window of the banding laboratory. A few flies were certainly overlooked or otherwise escaped capture. The flies were captured manually and immediately doused with alcohol or water to immobilize them momentarily until they could be secured in small vials.

Passerines and a few smaller raptorial birds, such as the Sharp-shinned Hawk and small owls, were taken in mist-nets set in dense brush. The mist-nets were checked at approximately 40 minute intervals, and the birds removed from the netting as quickly as possible. Passerine birds were transported to the laboratory in opaque containers, and then segregated according to species in sorting cages made of wire screen of 0.2 mm mesh. Some transfer of flies from one bird to another may have occurred as the birds were being transported to the laboratory; however, we believe that the darkness in the containers drastically reduced the activity of the birds and probably also the movements of the flies. Most flies that remained on their hosts until they reached the laboratory became a part of our collection. Undoubtedly more flies would have been collected from passerine hosts if the birds had been checked for ectoparasites immediately on capture and prior to their removal from the nets, but the time and facilities available did not permit a more thorough collection of flies from passerine birds.

Hawks and owls were also obtained from the State Experimental and Game Farm at Poynette, Wisconsin, during the period of autumn through early spring in the years of 1958 through 1963 and on several occasions in the autumns of 1956 and 1964. A total of 475 hawks and 137 owls was handled. These birds had been taken in steel traps set on poles, and they were held for one to several days in aviaries before examination, with separate enclosures for owls and hawks. Most of the birds were Great Horned Owls (135) and Red-tailed Hawks (316), although 7 other raptorial species were represented. The birds were transported in individual burlap bags to Madison, Wisconsin, where they were checked for ectoparasites, measured, banded and released.

In addition, hawks and owls were captured with the Bal-chatri trap (Berger and Mueller, 1959) in the central and southern part of Wisconsin, principally during the spring migrations. Species from which louse-flies were collected were the Red-tailed Hawk, Broad-winged Hawk, Sparrow Hawk, Great Horned Owl, Barred Owl and Long-eared Owl. They were either checked immediately for flies, banded, etc., or they were first transported to a suitable banding laboratory. A number of persons contributed flies taken from birds caught in a number of localities, and we have no accurate record of the number of hawks and owls handled.

Louse-flies which were collected prior to 1958 were pinned and dried. Since dried debris and badly shrunken abdomens made sexing difficult, subsequent collections were preserved in 70 per cent ethanol, with each vial containing all flies taken from a single host. Except for the few individuals which had been mutilated at the time of capture, those louse-flies preserved in alcohol remained in excellent condition for determination of species, sex, and occurrence of phoresy and mites. MacArthur's (1948) key to the Hippoboscidae of the Eastern United States was used for preliminary identification of the flies. The more exhaustive key of Bequaert (1954, 1955, 1956) was used to reexamine all individuals which appeared in any way unusual. Specimens of *Ornithomyia* were checked against the key of Hill *et al.* (1964). Woodman's (1954) key was used for the identification of Mallophaga.

## Host Records

Eight species of Hippoboscidae were collected, but only three of these were at all common: *Lynchia americana* (896 specimens), *Ornithomyia fringillina* (267), *Ornithoica vicina* (102), *Ornithoctona erythrocephala* (7), *Lynchia nigra* (5), *Lynchia angustifrons* (1), *Lynchia albipennis* (1), and *Microlynchia pusilla* (1). *M. pusilla* is a new record for Wisconsin and neighboring states (cf. MacArthur, 1948). Louse-flies were found on 11 species of Falconiformes, 6 species of Strigiformes, 2 species of Piciformes and 41 species of Passeriformes. Many of these are new host records for Wisconsin and neighboring states (cf. MacArthur, 1948), indicated by a superscript "a" in Table 1. Host records new to North America (cf. Bequaert, 1956; Bennett, 1961) are indicated by superscript "b".

The number of birds of each species on which flies were found and the total number of birds handled provide a crude minimum estimate of infestation (Table 1). These data are incomplete for the following reasons: (1). A plus (+) mark notation in the "No. Handled" column of Table 1 indicates that additional members of this species were trapped by the Bal-chatri and the exact number is not known. (2). Passerine birds were not examined as thoroughly as were raptorial birds. (3). No data are presented for species of birds from which no louse-flies were taken. A complete list of the passerine birds taken in autumn at Cedar Grove can be found in Mueller and Berger (1968).

The sex could be determined for 1,107 of the 1,281 specimens; the condition of the rest of the specimens, most of which were collected prior to 1958, precluded determination of sex. Taking the sample as a whole, 88 per cent of the flies were females. This unbalanced ratio in our sample is undoubtedly a result of our collecting in late summer and autumn; since females live longer than males, they dominate samples taken after the period of emergence of the adults (cf. Bennett, 1961; Hill, 1963).

*Ornithoica vicina* is an extremely small louse-fly that is easily overlooked. We first observed this species in August 1959 in the ears of a Great Horned Owl. A total of 120 Great Horned Owls has subsequently been checked for the presence of louse-flies, and 23 individuals yielded a total of 71 female and 2 male *O. vicina*, all from the ears. Seven specimens of this fly were found in the ears of a Barred Owl, and one specimen each was found in the ear of a Screech Owl and a Saw-whet Owl. A variety of other raptorial birds and passerines harbored this fly on the body plumage, but not in the ears (Table 1). We found no other species of louse-fly in the ears of any bird. Although *O. vicina* was reluctant to move from the ear of an owl, this fly was observed to escape from passerines caught in mist-nets, alighting momentarily on the person handling the bird before flying away. Because of their small size, these flies were harder to find on body plumage than in the ears. Despite this

TABLE 1. HOST RECORDS FOR HIPPOBOSCIDAE COLLECTED IN WISCONSIN, 1955–65

| HOST° | NO. HANDLED | NO. INFESTED | SEXES/FLIES | | TOTAL NO. FLIES* |
|---|---|---|---|---|---|
| | | | ♀♀ | ♂♂ | |
| A. *Ornithoica vicina* | | | | | |
| Red-tailed Hawk | 940† | 1 | 1 | 0 | 1 |
| Sparrow Hawk[a] | 170† | 1 | 1 | 0 | 1 |
| Screech Owl[a, b] | 10 | 2 | 2 | 0 | 2 |
| Great Horned Owl[a] | 138† | 26 | 71 | 2 | 74 |
| Barred Owl[a] | 10† | 1 | 5 | 2 | 7 |
| Long-eared Owl[a] | 17† | 1 | 1 | 0 | 1 |
| Saw-whet Owl[a] | 234 | 2 | 1 | 1 | 2 |
| Eastern Kingbird[a, b] | 19 | 1 | 1 | 0 | 1 |
| Catbird[a] | 2,650 | 1 | 1 | 0 | 1 |
| Veery[a] | 835 | 1 | 1 | 0 | 1 |
| Swainson's Thrush[a] | 9,845 | 1 | 0 | 1 | 1 |
| Ruby-crowned Kinglet[a] | 1,721 | 1 | 1 | 0 | 1 |
| Rusty Blackbird[a, b] | 2 | 1 | 1 | 0 | 1 |
| Song Sparrow[a] | 723 | 1 | 1 | 0 | 1 |
| Unknown Host | | 4 | 7 | 0 | 7 |
| TOTALS—*Ornithoica vicina* | | 45 | 95 | 6 | 102 |
| B. *Ornithomyia fringillina* | | | | | |
| Sharp-shinned Hawk[a] | 1,860 | 10 | 8 | 0 | 12 |
| Red-tailed Hawk[a, b] | 940† | 2 | 2 | 0 | 2 |
| Marsh Hawk[a] | 308 | 1 | 1 | 0 | 1 |
| Pigeon Hawk | 241 | 1 | 1 | 0 | 1 |
| Great Horned Owl[a] | 138† | 1 | 1 | 0 | 1 |
| Saw-whet Owl[a] | 234 | 2 | 1 | 0 | 2 |
| Yellow-shafted Flicker[a] | 197 | 5 | 5 | 0 | 5 |
| Yellow-bellied Sapsucker[a] | 268 | 1 | 1 | 0 | 1 |
| Traill's Flycatcher[a] | 1,363 | 1 | 1 | 0 | 1 |
| Blue Jay[a] | 91 | 1 | 0 | 1 | 1 |
| Black-capped Chickadee[a] | 953 | 3 | 3 | 0 | 3 |
| Red-breasted Nuthatch[a, b] | 83 | 1 | 1 | 0 | 1 |
| Catbird[a] | 2,650 | 15 | 10 | 2 | 15 |
| Brown Thrasher[a] | 206 | 5 | 5 | 0 | 6 |
| Robin | 400 | 3 | 2 | 0 | 3 |
| Wood Thrush[a] | 103 | 1 | 1 | 0 | 1 |
| Hermit Thrush | 2,475 | 24 | 24 | 0 | 25 |
| Swainson's Thrush[a] | 9,845 | 52 | 43 | 4 | 55 |
| Gray-Cheeked Thrush[a] | 2,109 | 9 | 9 | 0 | 9 |
| Ruby-crowned Kinglet[a] | 1,721 | 1 | 1 | 0 | 1 |
| Cedar Waxwing[a] | 613 | 3 | 2 | 0 | 3 |
| Solitary Vireo[a] | 140 | 1 | 1 | 0 | 1 |
| Red-eyed Vireo[a] | 2,600 | 5 | 5 | 0 | 5 |
| Philadelphia Vireo[a] | 624 | 2 | 0 | 1 | 2 |
| Myrtle Warbler[a] | 1,015 | 1 | 1 | 0 | 1 |
| Bay-breasted Warbler[a] | 77 | 1 | 1 | 0 | 1 |
| Blackpoll Warbler[a] | 399 | 1 | 1 | 0 | 1 |
| Ovenbird[a] | 1,069 | 3 | 3 | 0 | 3 |
| Northern Waterthrush[a] | 1,111 | 3 | 2 | 0 | 3 |
| Mourning Warbler[a] | 203 | 2 | 2 | 0 | 2 |
| Redstart[a] | 1,930 | 3 | 3 | 0 | 3 |
| Scarlet Tanager[a] | 87 | 2 | 1 | 1 | 2 |
| Cardinal | 121 | 1 | 1 | 0 | 1 |
| Rose-breasted Grosbeak[a] | 505 | 2 | 2 | 0 | 2 |

TABLE 1. HOST RECORDS FOR HIPPOBOSCIDAE COLLECTED IN WISCONSIN, 1955–65—(Continued)

| HOST[o] | NO. HANDLED | NO. IN-FESTED | SEXES/FLIES ♀♀ | SEXES/FLIES ♂♂ | TOTAL NO. FLIES* |
|---|---|---|---|---|---|
| Evening Grosbeak[a] | 320 | 1 | 1 | 0 | 1 |
| Purple Finch[a] | 422 | 1 | 1 | 0 | 1 |
| Pine Siskin[a,b] | 143 | 1 | 1 | 0 | 1 |
| Rufous-sided Towhee[a] | 125 | 1 | 1 | 0 | 1 |
| Slate-colored Junco | 1,940 | 3 | 3 | 0 | 3 |
| Tree Sparrow[a] | 693 | 1 | 1 | 0 | 1 |
| White-crowned Sparrow[a] | 152 | 1 | 0 | 0 | 1 |
| White-throated Sparrow | 3,615 | 20 | 19 | 1 | 22 |
| Fox Sparrow[a] | 1,068 | 2 | 2 | 0 | 2 |
| Lincoln's Sparrow | 233 | 1 | 1 | 0 | 1 |
| Swamp Sparrow | 889 | 2 | 2 | 0 | 2 |
| Song Sparrow | 723 | 8 | 7 | 0 | 8 |
| Unknown Passerine | | 47 | 38 | 3 | 47 |
| TOTALS—*Ornithomyia fringillina* | | 258 | 222 | 13 | 267 |
| C. *Ornithoctona erythrocephala* | | | | | |
| Sharp-shinned Hawk[a] | 1,860 | 1 | 1 | 0 | 1 |
| Broad-winged Hawk | 14† | 4 | 1 | 3 | 4 |
| Pigeon Hawk[a] | 241 | 1 | 0 | 0 | 1 |
| Unknown Hawk | | 1 | 1 | 0 | 1 |
| TOTALS—*Ornithoctona erythrocephala* | | 7 | 3 | 3 | 7 |
| D. *Lynchia americana* | | | | | |
| Goshawk[a,b] | 136 | 17 | 26 | 4 | 35 |
| Sharp-shinned Hawk[a] | 1,860 | 28 | 20 | 6 | 32 |
| Cooper's Hawk | 229† | 9 | 6 | 2 | 10 |
| Red-tailed Hawk | 940† | 159 | 216 | 56 | 355 |
| Red-shouldered Hawk[a] | 40† | 4 | 2 | 3 | 5 |
| Broad-winged Hawk[a] | 14† | 14 | 16 | 0 | 22 |
| Swainson's Hawk[a,b] | 3 | 1 | 0 | 0 | 1 |
| Golden Eagle[a] | 2 | 1 | 1 | 0 | 1 |
| Marsh Hawk[a] | 308 | 2 | 1 | 0 | 2 |
| Sparrow Hawk[a,b] | 170† | 1 | 0 | 0 | 1 |
| Barn Owl[a] | 1 | 1 | 1 | 0 | 1 |
| Screech Owl[a] | 10 | 1 | 1 | 0 | 1 |
| Great Horned Owl | 138† | 99 | 315 | 25 | 361 |
| Barred Owl | 10† | 6 | 4 | 1 | 6 |
| Long-eared Owl | 17† | 1 | 0 | 0 | 1 |
| Evening Grosbeak[a,b] | 320 | 1 | 0 | 1 | 1 |
| Unknown Hawk | | 47 | 45 | 7 | 61 |
| TOTALS—*Lynchia americana* | | 392 | 654 | 105 | 896 |
| E. *Lynchia angustifrons* | | | | | |
| Broad-winged Hawk | 28† | 1 | 0 | 1 | 1 |

TABLE 1. HOST RECORDS FOR HIPPOBOSCIDAE COLLECTED IN WISCONSIN, 1955–65—(Continued)

| Host° | No. Handled | No. Infested | Sexes/Flies ♀♀ | Sexes/Flies ♂♂ | Total No. Flies* |
|---|---|---|---|---|---|
| F. *Lynchia nigra* | | | | | |
| Sharp-shinned Hawk | 1,860 | 2 | 1 | 1 | 2 |
| Broad-winged Hawk[a,b] | 14† | 1 | 0 | 0 | 1 |
| Sparrow Hawk[a] | 170† | 1 | 0 | 1 | 1 |
| Unknown Hawk | | 1 | 0 | 1 | 1 |
| TOTALS—*Lynchia nigra* | | 5 | 1 | 3 | 5 |
| G. *Lynchia albipennis* | | | | | |
| Unknown Hawk | | 1 | 0 | 1 | 1 |
| H. *Microlynchia pusilla*[a] | | | | | |
| Catbird[a,b] | 2,650 | 1 | 0 | 1 | 1 |
| TOTALS—60 species | | 695[x] | 975 | 134 | 1,281 |

[a]New record for Wisconsin and neighboring states (cf. MacArthur, 1948).
[b]New record for North America (cf. Bequaert, 1952-56; Bennett, 1961).
*Total includes flies not sexed because the specimen was mutilated or dessicated.
†Represents a minimum number of birds of this species handled; we have no record of the number of birds trapped by the Bal-chatri.
[x]Sixteen birds harbored more than one species of fly.
°Scientific names of birds are given in the appendix.

bias in collection probabilities, we feel strongly that owls are important hosts for this species. This was suggested, but with reservations, by Bequaert (1953).

*O. vicina* is apparently not very selective as to host; it is quite adaptable to life on a number of species, both passerine and raptorial. On the Great Horned Owl and the Barred Owl infestations may be heavy, and the same bird is likely to harbor *Lynchia americana* on the body plumage. We found 14 cases of Great Horned Owls infested with both species of fly, and one individual caught at Wild Rose, Wisconsin, in August carried 14 *O. vicina* in the ears and 7 *L. americana* on other parts of the body. We collected no more than one individual *O. vicina* from any passerine bird, and Bennett (1961) found that *O. vicina* was much less common on passerine birds in Algonquin Park than *Ornithomyia fringillina*.

*Ornithomyia fringillina* is resident on a variety of birds; it prefers passerines, but shows little host specificity (cf. Bequaert, 1954). We have records from 6 species of raptorial birds, 2 woodpeckers, and 38 species of passerine birds (Table 1). This louse-fly is not common on raptorial birds, even on those such as the Sharp-shinned Hawk which feed principally on passerines; only 10 of 1,860 Sharp-shinned Hawks caught at Cedar Grove were infested with this species. Our collection indicates no pronounced preferences among passerine hosts, and infestations of all species were light (cf. Table 1). Our data from passerine birds are in no way comparable with those of Bennett (1961) for Algonquin Park. The relative infrequency of even the most common louse-flies on passerine birds at Cedar Grove (Table 1) can be attributed both to the collecting techniques and to the fact that we handled birds after the peak of infestation (cf. Bequaert, 1954: 137–138; Bennett, 1961).

Bennett (1961) felt that certain passerines were favored over others, particularly those Fringillidae, blackbirds, and thrushes that inhabit the environment near the ground. In Britain and Scandinavia, where there are three species of *Ornithomyia,* there may be stronger host-preferences than those of *O. fringillina* in the New World (cf. Hill, 1962b). According to Hill (1962b) and Hill *et al.* (1964) the "important hosts" for *O. fringillina* in the Old World are *exclusively* small passerines, mostly hedgerow species; on larger passerines and on raptorial birds *O. fringillina* appears to have been supplanted by the larger fly, *O. avicularia,* whereas *O. chloropus* prefers birds which frequent moorlands.

We found *Ornithoctona erythrocephala* only on hawks. This very large louse-fly was found on the Sharp-shinned Hawk, the Broad-winged Hawk, and the Sparrow Hawk (Table 1). One Sharp-shinned Hawk had both *O. erythrocephala* (1 individual) and *L. americana* (2 individuals), and a Broad-winged Hawk had one *O. erythrocephala* and one *L. americana.* These are our only records of infestation of an individual host by more than one species of fly, excepting those Great Horned Owls that carried *O. vicina* and *L. americana.*

*Lynchia americana* was found on 15 species of raptorial birds (Table 1). The only specimen from a passerine was on an Evening Grosbeak on 10 November 1963, and this individual (a male) could have been a stray which took up temporary residence on the grosbeak. These flies were generally reluctant to vacate their raptorial hosts even when the bird's feathers were disturbed; most specimens were collected as they darted among the feathers, although some flew to the person handling the bird. Infestations were often heavy, e.g. 17 Great Horned Owls, 8 Red-tailed Hawks and 3 Goshawks had more than 6 *L. americana:* the greatest individual infestation was 23 *L. americana* on a Great Horned Owl.

*L. americana* prefers large raptorial birds with large-feathered, loose plumage which provides both a good hiding place and an environment which does not deter movement of flies as does a densely feathered, compact plumage. Only one *L. americana* was found on a falcon, on a Sparrow Hawk on 7 September 1956; none were found on 241 Pigeon Hawks and 81 Peregrine Falcons, both of which have relatively compact plumage. The Great Horned Owl is clearly favored; nearly 60 per cent of the Great Horned Owls captured at Poynette and Cedar Grove carried on the average four of these flies. Other species on which this fly is common are the Red-tailed Hawk and the Goshawk and probably the Swainson's Hawk and the Barred Owl. Small hawks and owls are much less likely to harbor *L. americana:* for example, only 1.5 per cent of 1,860 Sharp-shinned Hawks and one of 234 Saw-whet Owls were infested.

Until recently *Lynchia fusca* (Macquart 1845) was considered a distinct species; MacArthur (1948) called it "The Owl Fly" (also cf. Bequaert, 1953:264). However, after reexamination of the specimens, Bequaert (1955) was convinced that *L. fusca* is conspecific with *L. americana,* and Maa (1963:35) supports this synonomy. Using MacArthur's (1948) key we found that these *Lynchia* were in fact difficult to distinguish and that the one host on which louse-flies consistently showed the characters of *L. fusca* was not an owl but the Broad-winged Hawk (specimens of "*L. fusca*" were found on 9 of the 12 Broad-winged Hawks from which *L. americana* were taken in the spring). Other flies with characters of "*fusca*" were on a Sharp-shinned Hawk (in April), a Red-tailed Hawk (in August) and three Great Horned Owls (September, November and December). MacArthur (1948) reported no "*L. fusca*" from Wisconsin and only one record for a neighboring state (on a squirrel in Michigan!). We see no reason why *L. fusca* should not be considered conspecific with *L. americana.*

We have collected 5 *Lynchia nigra* in Wisconsin; two from Sharp-shinned Hawks (1 May and 9 May 1964), one from an unknown hawk on 29 April 1965, one from a Broad-winged Hawk on 4 May 1958 and one from a Sparrow Hawk on 4 April 1958. We also found a *L. nigra* on a Sparrow Hawk in Zapta County, Texas, on 7 January 1956. According to Maa (1963:115) this species is essentially Neotropical; the Wisconsin specimens were most likely transported some distance on their hosts during spring migration. Two other species of *Lynchia* were taken from hawks in Wisconsin: a male of *L. albipennis* on a hawk on 12 May 1965 and a male of *L. angustifrons* on a Broad-winged Hawk on 5 May 1961. Since *L. albipennis* apparently prefers Ciconiiformes (cf. MacArthur, 1948; Maa, 1963), it is unusual to find one on a hawk. Spring and summer records of *L. angustifrons* from the United States and southern Ontario are probably strays (cf. Maa, 1963).

A male *Microlynchia pusilla* was found on a Catbird at Cedar Grove on 4 May 1965. This is the only record of *M. pusilla* from Wisconsin (cf. MacArthur, 1948) and the northernmost record for North America (cf. Bequaert, 1955; Maa, 1963). Also present in our collection is an individual of this species from a Harris Hawk *(Parabuteo unicinctus)* in Kennedy County, Texas, on 22 January 1956. This species is fairly common in southwestern United States (Bequaert, 1955), but its presence on a hawk is unusual (cf. Bequaert, 1955; Maa, 1963).

## Phenology

We found only one species of louse-fly, *Lynchia americana,* to be present in the adult stage all year round in Wisconsin. One species, *Ornithoica vicina,* was found in every season except spring; *Ornithomyia fringillina* was present only in late spring, summer and fall. Four species *(Ornithoctona erythrocephala, Lynchia albipennis, Lynchia angustifrons,* and *Lynchia nigra)* were found only in spring and presumably were carried into Wisconsin on migratory hosts that winter in southern areas. The occurrence of *Microlynchia pusilla* can be considered accidental. A detailed account of the seasonal occurrence of the eight species of louse-flies follows, based on our collections and supplmented with information from Bequaert (1952–1956) and Bennett (1961).

*Ornithoica vicina* was absent from birds trapped in Wisconsin during late winter and spring; our earliest record was from an Eastern Kingbird on 14 June 1958, six weeks earlier than Bennett (1961) found it in Algonquin Park. This species was present, but not common, on passerine birds during fall migration. The only heavily infested individuals were owls in August and throughout fall and early winter. The latest date on which a male was taken was 23 October, but females were taken as late as 24 January in the ears of Great Horned Owls. Since these flies were not found in late winter and throughout the spring, our data cannot support Bequaert's (1953:265) hypothesis that owls represent a temporary reservoir of overwintering flies that are held in reserve to infect passerine migrants in the spring.

In Algonquin Park, Bennett (1961) reported the peak of abundance in late August and none later than early October. Bennett (1961:401) found that at a constant temperature of 75° F the time required for metamorphosis in *O. vicina* varied considerably around a mean of 78 days and that developmental time at 75° was prolonged by interspersing an extended period of chilling at

45° F. Apparently females of this species live for at least 4 months, but males may not live longer than one month (Bennett, 1961:396).

Our data and those of Bennett (1961) suggest that the population of *O. vicina* gradually builds up during the summer by the emergence and reproduction of flies that overwinter as pupae, not by overwintering adults or by the introduction of any significant number of flies from the south on spring migrants. The persistence of adults into late January argues for the emergence of flies during the fall, presumably from pupae deposited during the summer. The last males die in late fall and no females survive beyond mid-winter. It is possible that there is an alternation of diapause and non-diapause generations in northern North America such that adults emerging from diapause pupae during June and July give rise to a non-diapause generation that emerges in August or September and reproduces until December or January, giving rise to a second generation that overwinters in a pupal diapause. Alternatively, the overwintering pupae may not have a true diapause, which requires chilling, but they may simply remain dormant through the cold season and resume development with the return of warm weather.

*Ornithomyia fringillina* is rare in Wisconsin in spring; from nearly 9,500 passerine birds trapped between 1 April and 10 June we collected only three specimens of this fly, two in late May and one in early June. These are more than a month earlier than previous records for northern North America (cf. Bequaert, 1954; Bennett, 1961). We caught more passerine birds during September than during any other month, and it is not surprising that most of our collections of *O. fringillina* are also from September. We found no males after late September and no females after early November. In Algonquin Park, Bennett (1961) collected no *O. fringillina* until mid-July; he reported the peak of abundance in the two-week period around August 1. Assuming an early August peak for *O. fringillina* in Wisconsin, then the decline in infestation of passerines was already well underway when we began netting birds in late August at Cedar Grove.

The absence of this species in late fall and through the winter and its extreme rarity in spring and early summer argues against the overwintering of adults, even on migrant hosts in their winter home, and against the introduction of any significant number of adults on spring migrants. According to Bequaert (1954) *O. fringillina* is confined to cool temperate areas, occurring in northeastern United States from 3 July to 6 November. Bennett (1961) and Hill (1963) present evidence that this species has an obligatory diapause with a period of chilling necessary for development to resume. We suspect that as metamorphosis occurs through June and July the numbers gradually build up until mid-August and then slowly decline as adult mortality proceeds without further emergence of adults in fall. In this way the emergence of flies appears to coincide with the reproduction of the hosts (cf. Hill, 1963). In Algonquin Park, Bennett (1961) found *O. fringillina* on 10 per cent of adult passerine birds and 17.5 per cent of immatures; he presents experimental evidence that these flies, when confined with birds in small cages, select immature birds over adults, and he suggests that adults may be more efficient at catching and eating the flies. In nature these flies may not actively select immature birds, but they may be more frequently found on immature birds because these hosts are both more accessible and more abundant than adults at the time the flies emerge.

*Ornithoctona erythrocephala* was occasionally found on hawks in spring. Bequaert (1954) considers this genus essentially tropical with little evidence that the adults or pupae can withstand cool temperate winters in North America. He suggests (p. 200) "that it is introduced there afresh every spring on some migratory breeding host".

The incidence of infestation of raptorial birds by *Lynchia americana* shows a peak during the fall, with fairly large numbers of females and a few males present through the winter and spring, particularly on the Red-tailed Hawk and the Great Horned Owl (Table 2). Although we have very few summer records because of very little trapping, males appear to be as common as females in late July and during the first half of August, with an increasing preponderance of females in the fall and winter. The persistence of both sexes suggests that breeding may occur year-round, but with the number of adults gradually decreasing during the winter. Some adults are undoubtedly brought up from the southern states on migrant hosts in spring, but the population is not substantially augmented until eclosion of new adults in summer.

Bennett (1961:396) found that adult females of *L. americana* survived in captivity for 4–5 months, whereas most males lived only 15–20 days. The length of the pupal stage is temperature dependent and interrupted without ill effect by prolonged chilling at 45° F (p. 401). If reproduction does occur in Wisconsin in winter, it would seem that the pupae must be resistant to temperatures far below 45°, even below freezing, for prolonged periods. It would seem that development of this species does not depend on a period of chilling but that cool temperatures are not deleterious to development.

TABLE 2. INCIDENCE OF *Lynchia americana* ON HAWKS AND OWLS TAKEN AT CEDAR GROVE AND POYNETTE

| Host Species | Fall | | | Winter | | | Spring–Summer | | |
|---|---|---|---|---|---|---|---|---|---|
| | August–November | | | December–February | | | March–July | | |
| | No. Birds | % Infested | Avg. No. Flies | No. Birds | % Infested | Avg. No. Flies | No. Birds | % Infested | Avg. No. Flies |
| Goshawk | 121 | 12 | 1.8 | 8 | 13 | 4.0 | 1 | 0 | — |
| Sharp-shinned Hawk | 1,828 | 1 | 1.1 | 0 | — | — | 32 | 9 | 1.2 |
| Cooper's Hawk | 128 | 5 | 1.0 | 0 | — | — | 101 | 0 | — |
| Red-tailed Hawk | 769 | 19 | 2.5 | 74 | 4 | 1.0 | 98 | 0 | — |
| Red-shouldered Hawk | 18 | 11 | 1.0 | 1 | 0 | — | 21 | 0 | — |
| Swainson's Hawk | 1 | 100 | 1.0 | 0 | — | — | 2 | 0 | — |
| Marsh Hawk | 104 | 0 | — | 1 | 100 | 1.0 | 203 | 0 | — |
| Sparrow Hawk | 68 | 1 | 1.0 | 0 | — | — | 102 | 0 | — |
| Great Horned Owl | 52 | 77 | 5.4 | 59 | 54 | 2.6 | 27 | 26 | 1.6 |
| Barred Owl | 10 | 33 | 1.0 | 0 | — | — | 0 | — | — |
| Long-eared Owl | 17 | 6 | 1.0 | 0 | — | — | 0 | — | — |

The persistence of adults in winter and spring suggests that pupae deposited during summer and early fall emerge before cold weather sets in; those deposited in late fall and winter remain dormant through the winter, emerging after a suitable period of warmer weather in spring and early summer. During late winter and spring the population decreases due to gradual mortality of adults, and a lower level of infestation is maintained until metamorphosis of pupae is completed or until sufficient numbers of infested migrants have returned. The coincidence of numbers of "*L. fusca*" on Broad-winged Hawks in spring might indicate the "importation" by hawks of a population of *L. americana* that lives year-round on birds of a more southern distribution.

According to Bequaert (1955), *L. americana* may not occur north of 48° 10′ north latitude, which is approximately the Canadian border in the central and western United States. We suspect that the range of this fly extends as far north as that of its hosts, which in the case of the Goshawk and Red-tailed Hawk is well north of the U.S.–Canadian border. There are few records of this fly from Mexico and farther south, and in western and southern states it is less common than *L. nigra* (Bequaert, 1955). The birds on which we found *L. americana* were, in fact, those which winter north of the Mexican border, and the only records we have for *L. nigra* are from the spring and from hawks that winter farther south.

*Lynchia albipennis*, *L. angustifrons* and *L. nigra* are tropical species (cf. Bequaert, 1955) that are occasionally introduced on spring migrants and apparently do not overwinter in a northern climate. *Microlynchia pusilla* is essentially tropical and rare north of the southwestern United States (Bequaert, 1955). Our specimen, taken from a Catbird in May, undoubtedly "migrated" north from Central America with its host.

## Phoresy and Infestation by Mites

The attachment of chewing bird lice (Mallophaga) to Hippoboscidae is frequently cited as an example of phoresy, the wingless louse using the winged louse-fly as a means of transportation (references in MacArthur, 1948:385–387; Bequaert, 1952:163–174; Corbet, 1956a). This phenomenon is difficult to explain because each species of Mallophaga is believed to feed exclusively on feathers and epidermis of hosts of a given species. *Ornithomyia fringillina,* which is the most common carrier of the lice, is found on a variety of host species, and flies which have been experimentally marked for individual identification have been followed to individuals of several species of birds (Corbet, 1956b; Bennett, 1961). The lice would presumably not benefit from being transported to a host of a different species, and the louse-fly would not seem to be a good host for the lice to parasitize. Bequaert (1952:163) suggests that phoresy of Mallophaga by Hippoboscidae is "on the borderline of true parasitism".

The incidence of phoresy, at least by *O. fringillina,* is too high to be accidental. Bequaert (1952) reported phoresy by 6 per cent of some 500 *O. fringillina* and less frequently by a number of other species of Hippoboscidae, including *Ornithoica vicina, Ornithoctona erythrocephala, Lynchia americana,* and *Lynchia albipennis.* MacArthur (1948) found 14 cases, 4 per cent of the total flies examined, and Bennett (1961) reported phoresy by 22.8 per cent of *O. fringillina* collected in 1957, with the highest frequency in July and much less in late August and early September.

We found 30 cases (11.3 per cent) of phoresy by *O. fringillina* and one by our only specimen of *Microlynchia pusilla* (a female Brüelia on the fly taken from a Catbird on 4 May, 1965). Avian hosts for flies that carried lice were a Sharp-shinned Hawk, a Yellow-shafted Flicker and 11 species of Passeriformes. In view of the diversity of bird species, it is perhaps surprising that all lice were in the genus Brüelia and appeared to be of the same species; adult female lice predominated. All 30 cases of phoresy by *O. fringillina* in our collection occurred in summer and early autumn (2 in July, 1 in August, 23 in September, and 4 in October). The lice were firmly imbedded in the integument of the louse–flies by their mouth parts, and the lateral surfaces of the abdomen were preferred places of attachment; in only one case was a louse attached to the prothorax. All were facing in the same direction as the flies.

The infestation of Hippoboscidae by epidermoptid mites (Acarina) is considered true parasitism (cf. MacArthur, 1948:387; Bequaert, 1952:142–160). We found mite clusters on 52 *O. fringillina* (26.6 per cent) and on three *L. americana;* the latter is a species not previously recorded as parasitized by mites (cf. Bequaert, 1952). The mites were of the genera *Microlichus* and *Myialges.* Hosts for the *L. americana* which carried mites were two Broad-winged Hawks trapped in April and one unidentified hawk in October. The mite-infested *O. fringillina* were on 18 species of passerine birds and one Pigeon Hawk, all trapped during autumn migration (2 in August, 31 in September, 18 in October, and one sometime in fall). Mites preferred the underside of the wings in the vicinity of the large veins, and they were rarely found elsewhere on the flies, such as on the abdomen or the upper surface of the wings. Mites usually consisted of a cluster formed by a female and her eggs or young. Clusters were often present on the underside of both wings, and only the immature mites tended to stray to other parts of the fly's body.

## Summary

In the years 1955 through 1965 more than 5,000 hawks and owls and nearly 54,000 passerine birds were trapped alive in Wisconsin, and louse-flies were collected. Most birds were caught during autumn and spring migrations. A total of 1,281 individuals of eight species of Hippoboscidae was taken from 695 individuals of 60 species of birds. Only three species of louse-fly were common: *Ornithoica vicina, Ornihomyia fringillina,* and *Lynchia americana. O. vicina* was most frequently found in the ears of the Great Horned Owl. *O. fringillina* was found on a wide variety of passerines and on 6 raptorial species, with no obvious host preferences. *Lynchia americana* clearly preferred hawks and owls, especially those with large-feathered, loose plumage. Hawks returning from the south occasionally harbored other species of Hippoboscidae: *Lynchia nigra, L. albipennis, L. angustifrons* and *Ornithoctona erythrocephala.* One specimen of *Microlynchia pusilla* was found on a Catbird.

The winter climate is probably the most important factor affecting the occurrence of a given species of fly in Wisconsin. Those species which cannot tolerate cold during the pupal stage (e.g. *O. erythrocephala, L. albipennis, L. angustifrons, L. nigra,* and *M. pusilla*) occur in Wisconsin only as vagrants and have essentially no chance of becoming permanently established. The pupae of *O. vicina* and *L. americana* can tolerate cold with a temporary suspension in development, and *O. fringillina* has a true diapause that depends on a period of chilling in order for development to resume (cf. Bennett, 1961). Adults of *L. americana* may overwinter on resident hosts, even perhaps continuing to reproduce, but there is no supplementation of their numbers until spring migration brings in adults that have emerged in the south or until local temperatures become suitable for emergence of new flies. Adults of species infesting migratory birds travel south on their hosts in autumn and die with or without reproducing in the south.

Lice of a species of Brüelia (Mallophaga) were found attached to 11.3 per cent of the *Ornithomyia fringillina.* Phoresy was also found in one specimen of *Microlynchia pusilla.* Parasitic mites of the genera *Microlichus* and *Myialges* were found on the wings of three *Lynchia americana* and 26.6 per cent of the *O. fringillina.*

## Acknowledgments

Most of the data for this study were obtained while the authors were engaged in a study of bird migration in Wisconsin. The following persons helped with the collection of louse–flies: F. and F. Hamerstrom, E. Bishop, C. Sindelar, D. Seal, J. Oar, J. Weaver, E. Schluter, and P. Drake. The Wisconsin State Experimental and Game Farm at Poynette gave us raptorial birds trapped on their premises Mites were identified by Professor G. W. Wharton, Ohio State University. Many of the collections were made during the course of a study of bird migration supported by a grant (GB-175) to Professor J. T. Emlen from the National Science Foundation.

## References Cited

Bennett, G. F. 1961. On three species of Hippoboscidae (Diptera) on birds in Ontario. Can. J. Zool., 39:379–406.

Bequaert, J. C. 1952–53. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part I. Structure, physiology and natural history. Entomol. Amer., 32–33 (N.S.):1–442.

Bequaert, J. C. 1954–56. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part II. Taxonomy, evolution and revision of American genera and species. Entomol. Amer., 34–36 (N.S.):1–611.

Corbet, G. B. 1956a. The phoresy of Mallophaga on a population of *Ornithomyia fringillina* Curtis (Dipt., Hippoboscidae). Ent. Mon. Mag. 92:207–211.

Corbet, G. B. 1956b. The life-history and host-relations of a Hippoboscid fly *Ornithomyia fringillina* Curtis. J. Anim. Ecol., 25:403–420.

Corbet, G. B. 1961. A comparison of the life-histories of two species of *Ornithomyia* (Diptera, Hippoboscidae). Entomol. Gaz., 12:24–31.

Hill, D. S. 1962a. Revision of the British species of *Ornithomyia* Latreille (Diptera: Hippoboscidae). Proc. Royal Ent. Soc. London, (B), 31:11–18.

Hill, D. S. 1962b. A study of the distribution and host preferences of three species of *Ornithomyia* (Diptera: Hippoboscidae) in the British Isles. Proc. Royal Ent. Soc. London, (A), 37:37–48.

Hill, D. S. 1963. The life history of the British species of *Ornithomyia* (Diptera: Hippoboscidae). Trans. Royal Ent. Soc. London, 115:391–407.

Hill, D. S., W. Hackman, and L. Lyneborg. 1964. The genus *Ornithomyia* (Diptera: Hippoboscidae) in Fennoscandia, Denmark and Iceland. Notulae Entomologicae, 44:33–52.

Maa, T. C. 1963. Genera and species of Hippoboscidae (Diptera): types, synonymy, habits and natural groupings. Pacific Insects Monog., 6:1–186.

MacArthur, K. 1948. The louse-flies of Wisconsin and adjacent states (Diptera: Hippoboscidae). Bull. Public Museum City Milwaukee, 8:367–440.

Mueller, H. C., and D. D. Berger. 1966. Analyses of weight and fat variations in transient Swainson's Thrushes. Bird-Banding, 37:83–112.

Mueller, H. C., and D. D. Berger. 1968. The relative abundance of species caught in mist-nets during fall migration at Cedar Grove. Passenger Pigeon, 29:107–115.

Woodman, W. J. 1954. Mallophaga of Wisconsin. (unpub.) PhD Thesis, Univ. of Wisconsin, Madison. 281 pp.

## APPENDIX

(Scientific names of birds* infested with Hippoboscidae)

| | |
|---|---|
| Goshawk | *Accipiter gentilis* |
| Sharp-shinned Hawk | *Accipiter striatus* |
| Cooper's Hawk | *Accipiter cooperii* |
| Red-tailed Hawk | *Buteo jamaicensis* |
| Red-shouldered Hawk | *Buteo lineatus* |
| Broad-winged Hawk | *Buteo platypterus* |
| Swainson's Hawk | *Buteo swainsoni* |
| Golden Eagle | *Aquila chrysaëtos* |
| Marsh Hawk | *Circus cyaneus* |
| Sparrow Hawk | *Falco sparverius* |
| Pigeon Hawk | *Falco columbarius* |
| Barn Owl | *Tyto alba* |
| Screech Owl | *Otus asio* |
| Great Horned Owl | *Bubo virginianus* |
| Barred Owl | *Strix varia* |
| Long-eared Owl | *Asio otus* |
| Saw-whet Owl | *Aegolius acadicus* |
| Yellow-shafted Flicker | *Colaptes auratus* |
| Yellow-bellied Sapsucker | *Sphyrapicus varius* |
| Eastern Kingbird | *Tyrannus tryannus* |
| Traill's Flycatcher | *Empidonax traillii* |
| Blue Jay | *Cyanocitta cristata* |
| Black-capped Chickadee | *Parus atricapillus* |
| Red-breasted Nuthatch | *Sitta canadensis* |
| Catbird | *Dumetella carolinensis* |
| Brown Thrasher | *Toxostoma rufum* |
| Robin | *Turdus migratorius* |
| Wood Thrush | *Hylocichla mustelina* |
| Veery | *Hylocichla fuscescens* |
| Hermit Thrush | *Hylocichla guttata* |
| Swainson's Thrush | *Hylocichla ustulata* |
| Gray-cheeked Thrush | *Hylocichla minima* |
| Ruby-crowned Kinglet | *Regulus calendula* |
| Cedar Waxwing | *Bombycilla cedrorum* |
| Solitary Vireo | *Vireo solitarius* |
| Red-eyed Vireo | *Vireo olivaceus* |
| Philadelphia Vireo | *Vireo philadelphicus* |
| Myrtle Warbler | *Dendroica coronata* |
| Bay-breasted Warbler | *Dendroica castanea* |
| Blackpoll Warbler | *Dendroica striata* |
| Ovenbird | *Seiurus aurocapillus* |
| Northern Waterthrush | *Seiurus novaboracensis* |
| Mourning Warbler | *Oporornis philadelphia* |
| Redstart | *Setophaga ruticilla* |
| Rusty Blackbird | *Euphagus carolinus* |
| Scarlet Tanager | *Piranga olivacea* |
| Cardinal | *Richmondena cardinalis* |
| Rose-breasted Grosbeak | *Pheuticus ludovicianus* |
| Evening Grosbeak | *Hesperiphona vespertina* |

* American Ornithologists' Union. 1957. Checklist of North American Birds. American Ornithologists' Union, Baltimore, Md.

| | |
|---|---|
| Purple Finch | *Carpodacus purpureus* |
| Pine Siskin | *Spinus pinus* |
| Rufous-sided Towhee | *Pipilo erythrophthalmus* |
| Slate-colored Junco | *Junco hyemalis* |
| Tree Sparrow | *Spizella arborea* |
| White-crowned Sparrow | *Zonotrichia leucophrys* |
| White-throated Sparrow | *Zonotrichia albicollis* |
| Fox Sparrow | *Passerella iliaca* |
| Lincoln's Sparrow | *Melospiza lincolnii* |
| Swamp Sparrow | *Melospiza georgiana* |
| Song Sparrow | *Melospiza melodia* |

Nancy S. Mueller is a native of Ohio. She received her B.A. from the College of Wooster and her M.S. and Ph.D. (Zoology) from the University of Wisconsin. She presently teaches embryology at North Carolina State University at Raleigh. Her husband, Helmut, is a native of Milwaukee and holds B.S., M.S. and Ph.D. degrees from the University of Wisconsin. He currently teaches animal behavior and vertebrate zoology at the University of North Carolina at Chapel Hill. Daniel D. Berger is also a native of Milwaukee, where he operates a small business and yet manages to spend about half of his time on his avocation, ornithology. He is a veteran of several ornithological expeditions to the arctic. All three have collaborated for some years in studies of bird migration at the Cedar Grove Ornithological Station in Sheboygan County.

## WISCONSIN ACADEMY OF SCIENCES, ARTS & LETTERS

Madison, Wisconsin

### OFFICERS 1968–69

*President*
Adolph A. Suppan
School of Fine Arts
The University of Wisconsin—Milwaukee

*Vice-President (Sciences)*
John A. Cummings
Department of Biology
Wisconsin State University—Whitewater

*Vice-President (Arts)*
Mary Ellen Pagel
1111 North Astor Street
Milwaukee

*Vice-President (Letters)*
Charles D. Goff
Department of Political Science
Wisconsin State University—Oshkosh

*President-Elect*
William B. Sarles
Department of Bacteriology
The University of Wisconsin—Madison

*Secretary*
Eunice R. Bonow
Department of Pharmacy
The University of Wisconsin—Milwaukee

*Treasurer*
Jack R. Arndt
University Extension
The University of Wisconsin—Madison

*Librarian*
Jack A. Clarke
Department of Library Science
The University of Wisconsin—Madison

### APPOINTED OFFICIALS

*Editor*—Transactions
Walter F. Peterson
Department of History
Lawrence University, Appleton

*Editor*—Wisconsin Academy Review
Ruth L. Hine
Wisconsin Conservation Division
Madison

*Chairman*—Junior Academy of Science
Jack R. Arndt
University Extension
The University of Wisconsin—Madison

### ACADEMY COUNCIL

The Academy Council includes the above named officers and the following past presidents of the Academy.

Paul W. Boutwell
A. W. Schorger
Henry A. Schuette
Lowell E. Noland
Otto L. Kowalke
Katherine G. Nelson
Ralph W. Buckstaff
Joseph G. Baier
Stephen F. Darling
Robert J. Dicke
Henry A. Meyer
Merritt Y. Hughes
Carl Welty
J. Martin Klotsche
Aaron J. Ihde
Walter E. Scott
Harry Hayden Clark
John W. Thomson

# WISCONSIN ACADEMY OF SCIENCES ARTS & LETTERS



## Transactions

Vol. LVIII—1970

THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

1870 - 1970

Cover Design by Arthur Thrall, Lawrence University

# TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

LVIII—1970



Editor
WALTER F. PETERSON

# TRANSACTIONS OF THE WISCONSIN ACADEMY

Established 1870

Volume LVIII


---

## EDITORIAL POLICY

The *Transactions* of the Wisconsin Academy of Sciences, Arts and Letters is an annual publication devoted to the original, scholarly investigations of Academy members. Sound manuscripts dealing with the state of Wisconsin or its people are especially welcome, although papers by Academy members on topics of general interest are occasionally published. Subject matter experts will review each manuscript submitted.

Contributors are asked to forward *two copies* of their manuscript to the Editor. The manuscript should be typed and double spaced on 8½ x 11" bond paper. The title of the paper should be centered at the top of the first page of the manuscript and should be *typed in capital letters throughout.* The author's name should appear in capital and lower case letters, and should be *underlined* and centered directly below the title. A note identifying the author by institution or background should be placed at the top of a fresh page, immediately after the text of the article. Upper right hand page notations from the second page on should read 2—Brown, 3—Brown, 4—Brown, etc.

The cost of publishing the *Transactions* is great. Therefore, articles in excess of twenty-five printed pages will not normally be accepted. In the rare instance in which a longer paper is approved, the contributor may be asked to help subsidize publication.

Documentary footnotes should appear at the end of the paper under the heading "References Cited." Supplementary or explanatory notes of material too specialized to appear in the text itself should be typed on a separate sheet entitled "Footnotes" and appended to the section entitled "References Cited." Contributors should avoid unnecessary documentation wherever possible. Other matters of style should be in harmony with current practice in the subject matter area.

Galley proofs and manuscript copy will be forwarded to the author for proofreading prior to publication; *both* should be returned to the Editor within *two weeks*. Papers received on or before *July 15* will be considered for publication in the current year. Papers received after that will be considered for publication the following year.

Contributors will be given five offprints of their article free of charge. Additional offprints in sets of 100, 200, etc. may be ordered at the time galleys and copy are returned to the Editor. Price will vary according to quantity desired and the length of the article.

Manuscripts should be sent to:

PROFESSOR WALTER F. PETERSON
Editor, *Transactions* of the Wisconsin Academy
Lawrence University
Appleton, Wisconsin 54911

**ADOLPH A. SUPPAN**

*48th President of the*
WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

# THE CREATIVE TEMPER IN A COMPUTERIZED SOCIETY*

*Adolph A. Suppan*

## I

I begin this talk with a short poem. I ask all of you to reserve your aesthetic judgment until I reveal the author.

Darling sweetheart
You are my avid fellow feeling
My affection curiously clings to your
passionate wish.
My liking yearns for your heart.
You are my wistful sympathy,
My tender liking.
Yours beautifully,
M.U.C.[1]

You will notice that the initials of the author are M.U.C. I am certain everyone realizes that the quality of the writing is somewhat below the standard of Shakespeare, Keats or T. S. Eliot; that is, of course, because M.U.C. is a beginner, and it may be some time before he rates a "B" in creative writing.

M.U.C. is the Manchester University Computer, and I let him introduce this talk to show that in an age of technology, in a society already dominated by the computer, its tentacles reach everywhere.

We are all personally aware of the prevalence of the computer; it is programmed for everything from manufacturing automobiles to finding ideal mates for single people. Hospitals employ computers to analyze a patient's ailment, count his blood cells, and compare his symptoms with the size of his bank account. Department stores use them not only in their business offices (for inventories, purchasing, billing) but to regulate escalators and revolving doors. Schools use data-processing systems to enroll their students, grade their examinations, and decide how much to sock (hit) them for in the alumni gift campaign.[2] An aircraft factory, wanting to know the equation concerning the distance a plane could fly on a given

* Address of the retiring President, delivered at the 99th annual meeting of the Academy, May 3, 1969.

[1] Quoted in A. J. Parisi, "The kinetic movement: technology paces the arts," *Product Engineering*, Dec. 2, 1968, p. 34.

[2] Corey Ford, "A Guide to Thinking," *Think*, Jan. 1961, p. 12.

amount of fuel, with a certain type of wing, had the answer in seven minutes. A man with an old-fashioned desk calculator would have taken seven years; pencil and paper calculation would have taken six generations. In what we call our ordinary lives, computers provide everything from bank balances to ticket reservations to personal horoscopes.[3]

The computer does have its flaws and its disadvantages. Recently, translating a Russian proverb, "Time flies like an arrow," a computer came out with "Time flies enjoys eating arrows."[4] More seriously, some authorities wonder if programmed learning might not affect man's reasoning process to the extent that he might accept ideas without studying or questioning them; some scientists also worry that constant graphic presentation might alter the ability to conceptualize.[5] Others fear that the computer will enable governments to exert almost continuous surveillance over every citizen.[6]

## II

These are some phases of the overall thrust of the computer in our lives; I come now to the main theme of my talk today—the influence of a technological age and the computer upon the creative artist in our society.

It is, of course, to be expected that artists react individually and differently to massive developments and events. It is also natural that the reaction can be both benevolent and malevolent. Certainly many painters, sculptors, composers, playwrights, and choreographers show by their works that they have been influenced by the technological thrust of our society. A reputable music critic, Frederic Grunfeld, has judged Europe's most successful piece of avant-garde music to be Rolf Liebermann's *Lés Echanges,* an automated symphony for business machines, which proved to be the major attraction of a trade exhibit at the Swiss National Exposition in Lausanne. Liebermann, known in the United States for his *Concerto for Jazz Band and Symphony Orchestra,* has scored this percussive composition:

> . . . for 156 office machines and mechanical devices, including typewriters, adding machines, cash registers, perforators, tape-moisteners, telephones and what-have-you, led by a computer with a mambo beat. The whole thing takes less than three minutes, but it points the way to a solution of all those problems with temperamental prima donnas and dictators of the baton.[7]

---

[3] John Lear, "Can a Mechanical Brain Replace *You?," Collier's,* Apr. 4, 1953, p. 62.
[4] Dr. Warren S. McCullock, quoted in *New York Times,* Apr. 24, 1966.
[5] "Obsolescence for the Printed Word," *Think,* Jan.-Feb., 1969, Vol. 34, No. 7, p. 19.
[6] Zbigniew Brzezinski, quoted in Arthur P. Mendel, "Robots and Rebels," *The New Republic,* Jan. 11, 1969, p. 16.
[7] Frederic Grunfeld, *Hi Fi/Stereo-Review,* Dec., 1964.

Two years ago in New York, more than forty artists and engineers produced nine evenings of kinetic art which they titled "Theatre and Engineering."[8] In Los Angeles recently, the County Museum of Art announced a project to "mate" art and industry, involving thirty-one companies and twelve artists at work in five plants.[9] Leading artists-in-residence will stay at the company plants for twelve weeks. Larry Bell, one of the artist-constructionists involved, is "group-thinking" with staff members of the Rand Corporation. He says:

> . . . we're discussing light, color perception, architecture, what art really is. We've found out that artists and corporations and technologies can co-exist and make each other's lives productive.[10]

A recent exhibition in New York's Whitney Museum of Modern Art was filled with objects that simply would not leave the viewer alone. According to a review in the *Milwaukee Journal,* all of them were electronic, all of them glowed, and some of them did even more than that: they growled, spun, flashed and hummed; they didn't just sit there, they performed. The review went on:

> The theatricality of the exhibition hits the viewer from the start. The show is called "Light: Object and Image," and it is installed entirely in the dark. The darkness sets the mood, as one steps into those darkened galleries, as the light goes dim and the catalog becomes unreadable, one waits with fascinated expectation for the performance to begin. Mysterious machinery bleeps and hums. Magical surprises have been promised. The intangible aura of show biz is in the air.[11]

The highly-respected American painter, Robert Rauschenberg, has created a "theatre piece" which begins with an authentic tennis game with rackets wired for transmission of sound. The sounds of balls hitting rackets control the lights. During the game, the sounds turn out the lights one by one. At the game's end, the hall is totally dark. But the darkness is illusory; the hall is actually flooded with infrared light invisible to the human eye. A modestly choreographed cast of from 300 to 500 persons enters to be observed and projected by infrared television onto the screens.[12] Another artist is producing computer drawings based on mathematical equations and using a light source or cathode-ray tube.[13]

One might suggest that the artists who are "collaborating" with the computer might have some reason to fear its ultimate victory

---

[8] "Single Channeled You Mustn't Be," *New York Times,* Feb. 5, 1967.

[9] Grace Glueck, "Coast Art—Industry Project Blossoms," *New York Times,* Apr. 17, 1969, p. 54.

[10] Larry Bell quoted in *Ibid.*

[11] Paul Richard of *Washington Post,* in "Light Show Flashes in New York," *Milwaukee Journal,* Aug. 25, 1968, Part 5, p. 6.

[12] Richard Kostelanetz, "The Artist as Playwright and Engineer," *New York Times Magazine,* Oct. 9, 1966, p. 22.

[13] A. J. Parisi, *op. cit.,* p. 36.

over them. A. M. Noll tells of an ingenious experiment which, to all intents and purposes, revealed that the computer could possibly out-create the creative artist. He (Noll) gave 100 people an original Mondrian drawing and a drawing made by a computer in Mondrian's style. He asked them to judge which drawing was artistically superior, and which was produced by a machine.

> Of all those asked, only 28 per cent correctly identified the computer picture and 59 per cent preferred it to the Mondrian . . . People who said they liked modern art preferred the computer-drawn picture, three to one.[14]

Noll comments: "I don't know whether this is overestimating the computer's artistic ability or underestimating Mondrian's."[15]

Some artists, however, are not too fearful. John R. Pierce says that:

> . . . it isn't too early for artists and programmers to study man and his arts on the one hand, and the computer and its potentialities on the other, hotly and realistically. We must decide whether men and machines should work gravely or wackily to produce works that are portentous or delicious. The choice is open, and I hope it won't be made too solemnly.[16]

The jarring question for the artist, however, remains: Can the computer itself produce art, thus by-passing the artist?[17] You will remember both the computer poem I used in the introduction and the episode of the fake Mondrian.

## III

As I have already shown, there is a trend of cooperation toward the computer and its possibilities, evidenced by numbers of artists in our society. This is countered by a mood of rebellion which is also evident in other directions taken by the arts. In saying this, I am, of course, fully aware that the artist, being the type of personality he is (more of that later), has often been a revolutionary in any age. I need only cite such a giant as Beethoven, whose works are now selected for the conservative portions of our symphony programs. His third symphony, considered by many to mark a tremendous advance in the entire history of music, outraged convention by its inclusion of a funeral march. His fifth symphony was condemned by a contemporary composer and critic as "an orgy of vulgar noise."[18]

---

[14] A. M. Noll in John R. Pierce, "Portrait of a Machine as a Young Artist," *Science, Art and Communications*, C. N. Potter, New York, 1968, p. 151.
[15] John R. Pierce, *Ibid.*, p. 151.
[16] John R. Pierce, *Ibid.*, p. 158.
[17] A. J. Parisi, *op. cit.*, p. 27.
[18] Wallace Brockway and Herbert Weinstock, *Men of Music*, New York, 1950, p. 190.

Some artists of our time, like Jean Tinguely, design machines that make their own commentary on the machine. In a recent work titled *Homage to New York,* he presented an assemblage of a piano, machine parts, bicycle parts, a weather balloon, and fireworks, which was programmed to be seen by an audience for a number of hours; after which the "machine" destroyed itself.[19] Nor is this tendency in the arts limited to sculpture. In theatre there is also a trend toward improvisation in the form of "happenings." The "aleatory" music of John Cage, dependent entirely upon contingency or chance, is drawing crowds (and some Brooklyn cheers) wherever he appears. One of his compositions, titled *4 minutes, 33 seconds,* consists of a pianist sitting at the piano without playing a note and then leaving. I understand that when asked "Where is the music?" Cage replied that it is in the sounds you hear in the audience while they are just sitting there.[20] The distinguished critic of the *New York Times,* Harold Schonberg, writes:

> Basically the entire avant-garde manifestation is revolt, unease, a profound dissatisfaction with current social, religious and cultural standards. At basis is the feeling that nothing *means* anything, certainly not when the Bomb has taken the place of God in so many minds as the ultimate disposer of the earth. The avant-garde in the arts, deriding the romantic concept of "beauty," has deliberately substituted an anti-ethical concept that is intended to demolish the great ethos upon which all art of the past was based.[21]

Joseph Wood Krutch testifies further to this rebellion. He suggests that artists have, "in their own way, signed off from their civilization almost as effectively as has the cultivated manufacturer of the shapeless dream."[22]

Another observer predicts that:

> If today's trend continues in theatre, we may all look forward to an influx of poorly-constructed plays covering up their inadequacy with a generous hunk of pornography, a liberal sprinkling of four-letter words and a sugar coating of poetry. This pretense at "free expression" is really no more avant-garde than a ready-mix cake.[23]

The jarring messages given by the rebellious artist to his society correspond with the free admission that he is disgusted with its dehumanization of human life as well as its despoilation of nature. This *is* a revolt, whether we relate it to our military-industrial complex or to our mass-society. Even the individual's name is on the

---

[19] Nathan Knobler, *The Visual Dialogue, New* York, (n.d.), p. 204.
[20] Summarized from *Look Magazine,* Jan. 9, 1968, p. 45.
[21] Harold C. Schonberg, "Art and Bunk, Matter and Anti-Matter," *New York Times,* Sept. 24, 1968.
[22] Joseph Wood Krutch, "The Creative Dilemma," *Saturday Review,* Feb. 8, 1964, p. 17.
[23] "To the Editor," *New York Times,* July 28, 1968.

way to becoming meaningless. He is identified merely as a group of numbers by his student admissions office, his insurance man, or his gas station attendant.

## IV

This evidence relating to the artist's confrontation with technology and the computer should be followed by the direct question: Why is the creative temper even more necessary to our technological society than to any past society?

A recent psychological study of creativity—The Creative Person—made by a group of psychologists on the University of California–Berkeley campus, is very informative here. It concludes (and I summarize) that the creative person is inclined to be interested and curious, more open and receptive than others; that he is strongly motivated to achieve in situations where independence of thought and action are called for;[24] that he has an openness to experience, a freedom from crippling restraints and impoverished inhibitions, and a delight in the challenging and unfinished.[25]

These characteristics marking the creative temper (and I must quickly point out that the creative scientist, as well as the creative artist, was considered) make me ask: In our society—shadowed by urbanization, mechanization, and over-population—where the person is in danger of becoming a non-person, is not the creative individual a last defense?

It is by now a truism to state that these qualities of character—independence, originality, open-mindedness—are more needed than ever by our society. These qualities are needed to challenge the forces a technological society has set in motion, forces that obliterate personality psychologically, not to speak of what can take place when computer-programmed missiles obliterate us *physically*.

Truly, as the arts of a civilization have often served to symbolize a nation's achievement or failure, the treatment of its artists has revealed the degree of freedom or oppression within its borders. One might therefore say that our age, more than any other, will be judged by future historians in relation to how it realizes the debt it owes to these free, independent spirits who might help prevent a society from melting its men into ciphers.

This implies, of course, the need for a greater recognition of the creative individual and his contribution to our culture. As Archibald MacLeish has said:

> What's wrong is not the great discoveries of science . . . What is wrong is the belief . . . that information alone will change the world. It won't.

---

[24] Donald W. MacKinnon, "What Makes a Person Creative?," *Saturday Review*, Feb. 10, 1962, p. 17.

[25] *Ibid.*, p. 69.

> Information without human understanding is like an answer without its question—meaningless. And human understanding is only possible through the arts.[26]

The arts and humanities provide meaning and purpose to our lives. The artist—in many different ways—probes, searches, and reinterprets reality so as to make our lives deeper, wider, and richer because of his efforts. When we need a jolt, he jolts us, with dissonances or happenings; when we need a shock, he shocks us, often to tell us that we're taking the wrong road.

I am fully aware of Plato's overt reason for excluding poets from his *Republic*—fear of the emotional influence of great art. But I've always had a sneaking suspicion that what Plato was really worried about was that the rebellious, independent, poets would upset the applecarts in his neat, controlled, structured, little state.

Certainly *our* nation is in danger of being computerized beyond belief, organized beyond belief, and benumbed beyond belief by the offerings of the mass media—so much so that the high prophet of the electronic revolution, Marshall McLuhan, has changed his gospel from "the medium is the message" to "the medium is the massage."

The creative temper, as I have emphasized in this talk, can remind, prod, and inspire us to sustain the value of the person in a non-personal world.

---

[26] Archibald MacLeish, "Thoughts on an Age that Gave us Hiroshima," *New York Times*, July 9, 1967, Section 2, p. 1.

# TOWARD DESIGN IN THE VERNACULAR

*William A. King*

There exists in this country a discontent, an almost voiceless potential, with little direction and few spokesmen. This discontent is the result of our lack of aesthetically satisfying visual and tactile experiences. It is a voiceless potential because it is the unspoken yearning for harmony and proportion that every man seeks consciously or unconsciously in his surroundings. There is little direction because few in positions of decision-making are concerned with the yearning. Little effort is directed toward giving a unity of expression.

Each one of us is part of this underground potential. Its basis is in the biological and psychological needs which should be reflected in the way we live and in the things we use. The way we live is expressed in a jumble of diversions. We are surrounded by cacophony, foul air to breathe and offensive visual experiences.

Phonographs look like antique chests, plastics imitate marble, kitchens imitate other factories and are merely as efficient. From the design of the development house (boxes within a box) to the form of the latest automobile, there is no effort at appealing to any one aesthetic sense. There is instead only a confusion of many directions. The recent epidemic of ludicrous tail fins on our automobiles is symptomatic of our plight. But if there is discontent, it may be asked, why is there no public protest? Perhaps because man, in his infinite capacity to adapt, shuts out what is intolerable. He no longer notices the unacceptable, just as the soldier in battle can ignore sights of death and mutilation.

In this paper I wish to trace the development of this phenomenon of life today.

In eighteenth-century America, before the industrial revolution had a strong grip, the objects of daily use expressed in a natural way the lives of the people of that time. There was a dialogue between the artisan and the user of his product. The consumer knew what he wanted and he got it; the craftsman was qualified by his sensitivity and his apprenticeship. Since there was this natural alliance between the artisan and the consumer, the results were generally satisfying. It was in the design of useful things that the American showed his creative genius. Creative impulses, untrammelled by tradition, were released. The character of early American design was summed up by James Fenimore Cooper, in *Notions of the Americans* (1828): "I have seen more beautiful, graceful and convenient ploughs in positive use here, than are probably to be found in the whole of Europe united. In this single fact may be traced the . . . character of the people, and the germ of their future greatness. Their axe is admirable for form, for neatness, and for precision of weight . . . the actual necessities of society supply an incentive to ingenuity and talent, that are wanted elsewhere . . . the vast multitude of their inventions ought to furnish food for grave reflection to every stranger."

Mass production was possible in the 1830's, and it gave almost everyone machine-made chairs, carpets and wallpaper. Designers tested the limits of the machine in their competition to come up with the most ornate product. Expediency took the place of art.

> Walter D. Teague writes of this industrialization: "While the Revolution had none of the grace and charm of childhood, it had the clumsiness, the ineptness, the unintentional cruelty and the pains of a gigantic, lumbering, grimy, immaturity. It had, too, the eagerness and vitality of youth . . . It accepted as a matter of course that the new industrial system on which the whole new scheme of life was based should proliferate in sinister black factories that blighted the lives of their workers . . . It received with uncritical acceptance the floods of crudely embryonic wares that poured from these factories to supply our needs ineptly, while they swamped our lives in ugliness."

The end result of the surfeit of badly designed products in this country was that no one was satisfied, as the craftsman and consumer were satisfied in a less complex age.

The disparity between man striving for beauty and the ugliness of the world is not new. In England Josiah Wedgewood endeavored to solve the problem in the mid-1700's by enhancing commercial pottery with applied decoration, which emphasized already existing beauty. William Morris a century later counseled, through modified medievalism, that man should ignore the machine entirely and return to the days of handicraft. "As a condition of life, production by machinery is altogether an evil . . . art must be produced by the people and for the people, as a happiness for the maker and the user." And he insisted on the importance of aesthetic considerations in the design of even insignificant objects, an idea which has had far ranging implications up until the present. Perhaps his most important contribution was the establishment of arts and crafts schools throughout England where young designers studied the possibilities for functional yet beautiful design.

Morris' ideas were followed in Europe by the movement called *Art Nouveau. Art Nouveau,* as its name suggests, attempted to create a new style. International in character, it was known as *Art Nouveau* in Belgium and France, *Sezession* in Austria, *Jugendstil* in Germany and *stile libertà* in Italy. The Belgian Henry van de Velde, one of its leaders, urged ". . . a logical structure of products, uncompromising logic in the use of materials, proud and frank exhibition of the working processes."

Significantly for industrial design, the German Hermann Muthesius advocated the study of "railway stations, exhibition halls, bridges and steamships . . . whose shapes are completely dictated by the purposes they are meant to serve." In 1907 Muthesius founded the Deutscher Werkbund, which was a step away from the arts and crafts *(kunstgewerbe)* toward a true industrial art. Its ideal was stated in Muthesius' inaugural address: "There is no fixed boundary between tool and machine. Work of a high standard can be created with tools or with machines, as soon as man has mastered the machine and made it a tool." Standardization was the goal, and it was only through it that reliable taste could be achieved.

The arts and crafts movement inspired by William Morris in England made its impact in the United States in the 1880's. Examples of this influence are the glassware of Louis Comfort Tiffany in New York and the Rookwood pottery of Maria Storer in Cincinnati. These were aesthetic protests against the poor quality of factory production.

In more modern times serial production, since its standard is that of indefinite repetition of objects, has changed the attitude of the consumer. Uniqueness or skill of craftsmanship is no longer a consideration; only the design is important. Novelty, however, has increasingly occupied the minds of merchandisers. Designers have borrowed criteria from cybernetics and feel that overfamilarity produces obsolescence. The greatest amount of pleasure is derived from newness, because of its ability to surprise us. These ideas have their roots in the writings of the English empiricist Burke, who formulated a functionalist attitude toward art.

Burke writes in *A. Philosophical Inquiry into the Sublime and Beautiful* (1756): "When we examine the structure of a watch, when we come to know thoroughly the use of every part of it, satisfied as we are with the fitness of the whole, we are far enough from perceiving anything like beauty in the watch work itself . . . the effect is previous to any knowledge of the use, but to judge of proportion, we must know the end for which any work is designed." He shows the distinction between beauty and proportion and fitness and knowledge of use. And in the same work he states: "Indeed beauty is so far from belonging to the idea of custom, that in reality what affects us is that manner is extremely rare and uncommon. The beautiful strikes us as much by its novelty as the deformed itself . . . For as use at last takes off the painful effect of many things, it reduces the pleasurable effect in others in the same manner."

Concepts such as those expressed by Burke underwent considerable change in the late 19th and early 20th centuries. Functionalism, which was originally understood in its materialistic meaning, now took on psychological implications. Beauty became synonymous with function. Louis Sullivan maintained that "form follows function." In the 1920's the Bauhaus set out to educate the industrial designer in the premise that beauty and utility meet in the well-designed object. Such men as Klee and Kandinsky, the architects Mies van der Rohe and Marcel Breuer, adapted the new principles of the arts to the unique requirements of serial production. It was hoped that the lowest possible cost would produce the best aesthetic result. Industry would be furnished with functional designs which were clearly made by machines.

With the rise of the Nazis in Germany the Bauhaus was closed. Many of its faculty came to America, and the works of Gropius at Harvard, Moholy-Nagy at the Chicago School of Design, Kepes at M.I.T. and Mies van der Rohe in the Chicago area have had their impact. America's own Frank Lloyd Wright had more influence on Europe than on his own country. Walter D. Teague, Henry Dreyfuss, Raymond Loewy, and Charles Eames have also made an impact with designs ranging from steamships and telephone receivers to bent plywood chairs.

In America the emphasis is on styling. The change is on the surface. Objects change form with what is thought to be the latest mood of the consumer. When aerodynamics occupies the primary concern all objects take on free flowing lines. The theory of entropy of communications hopes to produce the maximum amount of surprise by a deluge of new styled products. It is held that the greatest amount of information is supplied by a form which, because of its newness and unforeseeableness, gives the greatest amount of surprise. The amount of information is in direct proportion to its degree of surprise. When the form is repeated too often, there is a diminishing amount of information (the form is ignored by the consumer.) The idea that novelty produces aesthetic pleasure takes on cynical overtones and gives rise to planned obsolescence.

The benefits of the machine are obvious in our time, and there can be no turning back. The Bauhaus offered an answer to the problem of designing intelligently for the machine. It seems that much of the message has fallen on deaf ears. It would seem that the manufacturer has not discovered that additional dimension, and this keeps his product from being well designed. Much of the problem centers around the appropriateness of form and the function of decoration. Surely novelty is not the only thing which will appeal to the public.

Many business establishments are aware of the necessity of presenting an image in plant and administrative office appearance. The best architects are often engaged for this purpose. Why then is the consumer product shoddy in so many instances? An industrial designer, Richard S. Latham, says: "The quality of materials used and the characteristic details become more skimpy and inappropriate, until finally it appears that the worst design, the most inept craftsmanship and the least beautiful workmanship have been relegated to the individual consumer, with higher orders of skill and execution reserved for industrial products, and the highest order of concept and execution reserved for products that human beings will hardly ever see."

Industrial design is the only really popular art form. It has the influence to educate the public in the positive values of modern art. Our condition suggests that manufacturers are not seeking professional ideas in the solution of design problems. College and university departments of industrial design have been trying to educate students for more than a quarter of a century to solve these problems in an honest way. And yet their efforts are not very apparent. Imitation of handicraft is not an honest solution, and the machine does not do it willingly. Perhaps the market analysts are second guessing the public. Perhaps businessmen are afraid to disturb the situation which has arisen from the misuse of machines by misguided men.

Susanne K. Langer addressed herself to the problem in *Feeling and Form:* "The artisan-craftsman has been superseded by the industrial designer; and industrial design is next to architecture in shaping the visual scene. So it is in our things—our countless things, multiplied fantastically *praeter necessitatem*—that we must find some significance: a look of simple honesty in ordinary utensils, of dignity in silverware, and of technological elegance in our machines."

The time is long overdue for industry to bring its products into line with the limitations and the advantages provided by machine production. Forceful leadership by designers and businessmen is called for. Design in the vernacular can be achieved. It can bring a grace to our lives which has been absent.

# MUSIC AS VIBRATIONS AND AS FLYSPECKS

*Observations of a Music Bibliographer on the Unifamiliar Effects and Inherent Perniciousness of His Chosen Objects of Research.*

*Donald W. Krummel*

It is one of the curiosities of our language that "live" music should be that which will not survive. Like fruit, music keeps in cans or when frozen.

Like so many other human achievements, music has been preserved in written records. We know the past not through our memory of events but through documentary evidence, most of it preserved on paper. Axiomatically, that music which predates our written records is pre-historic; so then also is any music which we may hear which has not been notated or recorded. Paper enables the musician to benefit from the past. As we shall see, it also commits him to the past, developing his art into one of understanding, interpreting, learning from, and building on the basis of the past.

This study undertakes to survey the relationship between music and its documents, in terms briefly of (1) basic reasons; (2) history; (3) effects; and (4) future prospects. The subject itself inevitably evokes a wide range of responses, from precarious speculations to the most painful of truisms ("tear up his scores, and where is Beethoven?"). While I shall hope to develop the speculations out of some of the more significant of the truisms, quite clearly my conclusions are contemporary and highly personal rather than the product of any timeless reasoning. The activity of handling musical documents, I believe, could not have found the meaning which I am here proposing without the benefit of rather basic and widespread changes in our general intellectual attitudes during the past few years.

To be sure, we have always had misgivings about our musical heritage being preserved on paper. We concede that, until recordings came along, we were completely dependent on notation for saving our great musical masterworks. But we still feel the need to be both skeptical and demeaning of the paper. The notes we laughingly pass off as flyspecks, of which there are two varieties: the dead dots which our tiresome scholars study and analyze, and the silly dots which our mad composers trace in order to make the great idiotic compositions of today. The flyspecks are a mere reflection of the action, the harmonious vibrations in which is embodied music itself. The fact remains that, without notation and its painstaking formulation and study, our music itself would be an achievement far less significant than what we know and enjoy today—considerably less well developed, clearly an anachronism in our age, truly pre-historic.

What has led Western Man to go to the trouble of committing music to paper? First and most obvious is our belief that a musical entity is suitable for and deserves re-performance, which can best be accomplished through preservation—that its sounds, or at least their component relationships, ought to be heard again. This belief may be based on two attitudes. One is a moral, even a religious responsibility ("we must save this"), the other a volition which comes from enjoyment ("we want to save this"). We believe—and quite correctly—that oral tradition is fallible, that the passing of a message by word of mouth is not trustworthy, especially when the message is complicated.

Apart from preservation, we wish or need to accommodate a middle man. Divisions of labor usually result as our civilization becomes more sophisticated; in this instance the creator becomes separated from the re-creator, that is, the composer from the performer. Sound itself is transmitted by performer to audience; the notation enables the composer to communicate with the performer. Behind both, apart from but governing both, as something of a Platonic ideal, is the abstract concept of the work of music itself.

Third, we seek a wider circulation of a work. The music becomes part of the repertoire, not of one performer exclusively, but of many. Thanks to notation, the performer no longer needs to commit the work to memory. We are thus involved in the act of publishing, which requires promotion and publicity.

Implicit is the attitude that music should be shared by performers—an admirable sentiment at any time, and probably the exception in the larger course of music history. Such generosity departs from the practice of the artist's repertoire being a closely guarded secret. In eras of great virtuosity, to be sure, the notation may become the merest of outlines, in which case the publication is no act of generosity at all. The masterful performer shares the text with his colleagues, and then in comparison to them shows his superiority of skill and taste.

Finally, somewhat opposite to altruistic sharing is sharing for profit. Music becomes a commodity, a means of making money, a basis for commercial gain. Subject to copyright—a "literary" or "intellectual property," of all things—it provides the musician with a means of survival. He can flout the gods who had prescribed his lot as one of starvation, and, with exceptional luck, get rich and lose his musical soul entirely.

Out of such considerations, notation on paper—for all intents and purposes a permanent medium—has joined forces with an art form which is essentially fleeting and impermanent, made up of vibrations which are produced, resonate for an instant, and are gone—which live and die in the tragedy of immediacy. (The word "evanescent" was a favorite in describing it in the Romantic era.) In their essence sound waves, and therefore musical compositions, are momentary, and this we should not forget: such is their limitation, also their virtue, and their significance today.

The commitment of music to paper thus results in an alliance between two media, one visual and the other aural, one directed to the ear and the other to the eye. When the occasional and inevitable family conflicts arise between the two, the notation always loses. This is as it should be, since music was originally, and is essentially, sound and not paper.

We can see the way notation loses out as we follow the current fashion of pondering our everyday idioms. We adapt an old military expression and speak of a performer "facing the music," meaning that he has chosen to do his own thing which is not J. S. Bach's own thing. The printed page then brings him rudely back to orthodoxy. (Thus, in current colloquialism, have our flyspecks functioned as the fall guys in the Great Creative Cop-out of Western civilization.)

We also use the German term *Augenmusik*—music of the eyes—in speaking of a composition which is more rewarding in study than in listening. The term is not precisely appropriate: a better term might be *Kopfmusik*—"head" music, or at least "heady" music. If the fact be known, there has been very little true *Augenmusik* in the sense of music pleasing to the eye. As a graphic art, musical notation through history has fared very badly indeed. There have been very few great masterpieces of music book production. The thrilling prints of Petrucci, the first great music printer, and the handsome early engraving of Domenico Scarlatti's sonatas come to mind; but beyond this even the most experienced music bibliographer will have trouble finding examples of which he can be proud. The early twentieth century saw several attempts to make music beautiful on the page through specially prepared music type faces, fine paper, elegant design, and tasteful decoration. The results were hardly successful. Music which is visually attractive almost inevitably, and most unfortunately, becomes affected in its appearance. The performer wants his instructions stated in as clear and unornamented a version as possible—and in view of the speed and exactitude with which he must grasp his instructions, his needs are indeed critical. In printing, better an ugly legible statement than a beautiful illegible one. Similarly in publication: better an ugly edition of good music than a handsome edition of bad music.

Through the course of Western history, at least up to the twentieth century, music has found permanence by imitating the printed book. Music has enjoyed a free ride in the vehicle of literary texts; and as a result music has had to go where the literary vehicle was willing and able to go. This influence has yet to be extensively studied or appreciated. At this point, then, a survey of the main events in this history is in order.

We find the earliest notation of Western music, as it is traced back to the Middle Ages, already involving either numbers or words. Pitch levels are based on mathematical relationships. The names of these levels are assigned with word syllables, as in solmisation, or later with the letters of the alphabet themselves. Musical rhythm is derived either from the natural rhythm of spoken words, or later from mathematical subdivisions of time duration.

With the invention of printing in the mid-fifteenth century, the development of music printing a few decades later, and the emergence of music publishing soon after 1500, music becomes all the more strongly committed to words. One admires and is fascinated by the achievement of the early craftsmen who conceived the first music type faces; one also respects their output, which provided the permanence for most music written during a span of two centuries. Musical notation by 1500 had already come to resemble what we know today, to the extent that it consisted of symbols arranged in a line, like the letters of a word. To be sure, the staff lines themselves caused the printer some difficulties which he never solved completely; but it is hard to doubt that movable type, as soon as it was invented in the days of Gutenberg, was destined to be applied to music. Early type could not directly designate instructions for musical color or harmony. These two elements, we might observe, are in themselves less significant in Renaissance and early Baroque music than they were to be later.

Someone someday will perhaps defend the hypothesis that printing contributed to the transition from polyphonic music to that of the continuo period. Would figured bass have been adopted if performers could have had printed chords to read (and, by having had more of them to read, would have learned to sight-read them)? Was there also in the late Renaissance, as part of some larger subconscious arch of civilization, a need and desire for "line," for simple linear construction in music? For the first time, man dealt extensively with books, where one thing happens at a time; and at this time his imagination and interests were first being stimulated by a knowledge of exploration and travel, involving a person going to only one place at a time: perhaps such factors helped to discourage polyphony, in which several lines are presented at one time.

The great sixteenth-century commercial empire of music publishing, based on movable type, finally collapsed and was replaced around 1700. As early as 1620, new music type faces were seldom being designed. This is only a detail in the story of this period, to be sure—the Thirty Years War and the various forms of puritanism had ravaged Europe, and in fact new type faces of any kind were rarely to be seen. In music, the old type was used in religious service books, in treatises—again reflecting a tie to the printed word—and in popular song anthologies. Progressive instrumental music suffered in particular. No notes were available for rapid passage-work, and chords could be constructed only by carefully chipping two or more pieces of type and fitting them together.

We can thus add the upheaval of 1700 to our list of those musical revolutions which have obligingly happened every century, on the century. In this instance, liberation was not from a tired and corrupt artistic tradition, but from a book trade best suited to doing other things. Music from this time forward was on its own course in the publishing world, using engraved plates rather than movable type. With independence came also the loss of the usual channels of distribution and registration control: the librarian today can seldom rely on the standard historical bibliographies for evidence on published music. The circulation of some music even went underground, although partly for reasons of control over performance: Italian opera, for instance, conquered Europe not through transmission in typeset editions or even engravings, but through a highly developed manuscript copying network.

We can also plot a two-hundred-year historical cycle: music printing around 1500, music engraving around 1700, and sound recording around 1900. The implications of the last development are perhaps the most staggering of all. The marvelous Siamese-twin conveniences—permanent storage of the sound itself, and mass-media distribution of sound—are obviously very great technological "breakthroughs." Typically, they have eliminated production workers (i.e., musicians) and require more service workers (i.e., managers and electronics repairmen). At the same time, the surviving production workers are infinitely more effective: they reach a wider audience, and incidentally get paid slightly better. But typically the inventions have also led to many of the ills which beset music today: the virtual elimination of regional non-conformity; audience apathy; the decline of "live performances," at least of the institution of formal concerts; and in time perhaps the elimination of the performer, the composer in the de-specialized world of tomorrow communicating directly with his audience by creating his own sounds. Even now, the craft of music engraving is dying. Nobody is really sure what music publishers themselves are up to, and while they claim to be happy, neither the composers nor Wall Street seems to care much for them. The era of music on paper may thus now be regarded as the proper domain of the historian. It has become part of the past from which we are expected to learn something. What then is our heritage of music on paper?

What characteristics of our music are the result of paper? We have considered what we want when we commit music to paper: more important is what we actually get. In what ways—*pace* McLuhan and the ambiguous verb which he has taught us to say together—"is" the medium the message? We speculate and surmise, but with no real certainty: there is of course no parallel civilization with music not committed to paper with which we could make a clinical comparison. Even so, we can develop several lines of reasoning which tell us what the marriage has done to one of the partners. From this we can anticipate the freedom and to a lesser degree the loneliness which will characterize the newly found single life.

Let us begin with McLuhan's concept of the linear—the idea of progression from one point to another, such as we experience in countless ways: reading a text from one word to the next, traveling from one place to another, reasoning logically step by step, growing from childhood to adulthood. Before printing we communicated in "auditory" rather than "physical" space. Our communication, being mostly oral, took place in time rather than through the two-dimensional visual surface of paper or other documents.

It is wrong to say that auditory space is not linear, as I sometimes think (but am really not quite sure) McLuhan would have us believe. In its various forms—primitive, pre-Renaissance, and that since the invention of printing—music is always committed to a temporal "line." Line as perhaps been emphasized, or more systematically conceived, since the invention of printing. The devices for notating the elements of music were fixed long before the Renaissance, and then accommodated in movable type. Rameau's formulation of the harmonic progressions in the eighteenth century, the monumental Western codification of its practices, is a complex system of rhetoric and logic rather than a grammar or spelling guide, the appropriate counterpart to the succession of words on a printed page. When confused by new music even today we say "I don't follow," as if we were lost in an argument or discussion.

Line, the term we use for the sequence of sounds in time, is an essential dimension to all music, the other dimension being the variety of the sounds occurring in a single moment—color, and in a static sense, harmony. Line has certainly been conspicuous in the art music which we most highly esteem. We admire and are moved by music which brings out the "long line," be it an *Urlinie* in Schenker's musical analysis or the delicate *spinto* affectations of a great lyric soprano. Italian and German music, one might speculate, are generally more linear than French. The frequent abandonment of line is regarded as a hallmark of the new music, foreshadowed by the Romantic color made possible by the technology which produced the modern symphony orchestra. Composers are supposed to delight now in bright bursts of sonority—perhaps for purposes of being non-linear, unconsciously or self-consciously, possibly also to wake us up and keep us awake, and perhaps because the two are one in the same. In many of the non-Western musics, I am told, the linear element is also less conspicuous. Even in the most advanced music of the future, line is inevitable, since time—like physical space—has dimensions. Music always has a line, although it is possible that because of printing the line is more conspicuous.

Second, the printed page of music offers escape—a refuge from the bright glare of musical sound. The metaphor of a "bright glare" of course, is logically inappropriate, and in the same way as musical "color" is. Coming from the world of light rather than sound, it is useful only by way of suggesting the peculiar way in which sound engulfs us. Sound varies in loudness, and usually the hearer can locate the source of the sound. But we can not avoid sound by turning our head as we can avoid looking at a visual object.

It is important for a listener to be able to get away from music. This was felt as early as the Renaissance, when the audience came to be placed further away from the performers, especially the large groups of performers. Thanks to opera, the proscenium arch tended to be used for music as soon as it was devised for the theatre. In more recent eras the classic escape at a concert has of course been sleep. Today earphones offer a further element of privacy. Having the music we want when we want it is an unprecedented and staggering blessing, the only limitation being our ability to absorb very much of it at one time. We will still want and need to get away from it at times. It may prove to be one of the typical ironies of history that, at the very moment when we have the totality of the musical repertoire available, we will least care about it or need it.

Third, paper makes possible analysis: the printed page helps us comprehend music by allowing us a limited and a different access to it, enabling one set of senses to be reinforced by another. Music on paper lends itself to a varied manner of comprehension, the laying out flat on a two-dimensional surface making possible an impression of the totality at a glance. The score becomes a map of the terrain; and while there is admittedly no way to know the countryside better than through a good walk, we can correct many of our errors if we take along the map.

Fourth, and most important in many ways, is the prospect of betterment made possible largely through analysis. The composer can study the past and learn from it. He learns to hear his music "in his mind's ear" as interpreted through his eyes; and from this he can discover his own errors and correct them, his weaknesses and strengthen them. In an abstract way, his work can evolve in its perfection. He can work as a Beethoven, re-examining his achievements and thereby building an organically conceived type of music—keeping in mind all the time, of course, that there are also Mozarts who are no less great for having comprehended intuitively so many of the relationships which are to him so thoroughly a rational process.

Fifth, paper offers tangibility. Sound, being impermanent, is also undependable. We ask the man we deal with to "put it in writing"; and we argue endlessly after a concert, always about what the performer accomplished, often even about what sounds actually were heard. Control becomes possible with the printed page—the performer's job becomes one of making music in terms of conditions spelled out, the degree of freedom depending on the music. Stravinsky would have the conductor of *Le Sacre* acting largely as a cuing metronome; the composer of Neapolitan opera, of a concerto arriving at a cadenza, or of a pop tune intended for a jazz combo, draws in only the rough sketch, asking the improvising performer to take off like a liberated bird, making sure only that the flight follows the suggested course or lands at the right airport. In all such situations, the written notes, being fixed, are the means of control. Through our copyright laws, they take on the characteristics of real estate and personal property. They get bought and sold, and have resulted in music industries as concerned with self-perpetuation as our great corporations. The notes engender their own laws and rules; and they get hauled into court because of those regulations.

Finally, they also get us into heaven, if they're good enough. Permanence, and the prospect for improvement, together lead to immortality—to timeless musical monuments, the concept of the heroic Romantic musical genius leaving footprints on the sands of time. Through paper, music, long assailed by puritanism as sinful and ungodly, achieves revenge, offering its favored practitioners its own brand of salvation apart from the rules and regulations of the church: in effect, "instead of getting to heaven by being good, live it up, write a great symphony, and you'll make it."

It is thus much in order here to recall a lovely old German canon with the following text:

Himmel und Erde mussen vergeh'n,
Aber die Musici, bleiben besteh'n.

Literally translated, "Heaven and earth must pass away, but the musicians will always remain." Really quite outrageous. Today the words would probably read instead,

Soon the Establishment ceases to swing,
Leaving musicians a-doing their thing.

Or, as our feelings may become more specific, "When our institutions collapse of their own cumbersomeness, our cultural centers go bankrupt, our paper turns to pulp—then we'll be left with music." The innocuous *Sängervereine* who perpetuated this ditty certainly never thought of doing any such thing, but they have indeed brought us face to face with the doom of the flyspecks, the fall of the gods, the movement of the tide which will smooth the sand, erasing the footprints of the 3 B's.

The Armageddon we are talking about is not in itself the great battle going on today for social change, the eradication of poverty, or the rise of the non-white races—although the two are connected: music is part of society, and there are obvious parallels between our social and our musical establishments. By way of a brief digression, we might observe that even if the parallels did not exist, music would almost surely play a conspicuous role in social conflict. Its well-known emotional appeal is only half of the picture. Existing as it does in time, music is the very essence of change, of creating beauty in a context of impermanence. In days of uncertainty, it is symptomatic that we should so often hear the expression, "Play it by ear." To the musician the phrase means memorizing the notes and then executing them. The world of commerce flatters him by defining it even more broadly, as going into a difficult situation with no fixed course of action at all in mind.

Music's message is less obvious than that of words and pictures; thus it becomes the medium for reflecting those pulses and rhythms, those subconscious feelings and sensations which other forms are unable or unwilling to express or reflect. Music may be harmless and lovely in its purity as an autonomous art form; but as a means to an end, it can much too easily also be highly potent, intellectually stultifying as only an emotional appeal can be. If musicians are less "involved" today than their music is, perhaps this is because they can see the whole process of reform as merely one more mind-blowing operation, at least at the stage where music gets into the act. They can be sympathetic with the cause of social justice; but they also have strong impressions of how democracy in America has preferred mayhem and inanities on television to live artistry—how popular education has produced technicians rather than humanists, and how the more abundant life resulting from the battle against poverty is conceived largely in terms of Gross National Product.

Musicians perhaps have a better pipeline than we give them credit for. Their music has frequently revealed some important things about ourselves which we were not ready to accept. But they have also been all too quickly ridiculed for the attitude "My kingdom is not of this world" or "after all the blue meanies get bumped off, we meek little rascals will inherit the earth—the Bible tells us so." Thus it is well to return to the little German canon to note that the word is "Musici," and not "Musica": what will remain is not the music itself, but the musicians. We really must be allowed to stretch the point here and say that music-making is what will remain. The musicians' bodies and talents, like their compositions, must be regarded as part of the *Himmel und Erde* which will pass away. The musical experience is fixed in the human condition, and beyond this in the vibrations of the stars.

Music on paper has obviously played a large role in the process by which music has become increasingly committed to the past. Fifty to a hundred years ago, concerts came to favor the "tried and true" at the expense of the present. Within the past fifty years, our musicologists have sought to fill in the gaps in the panorama of Western musical development. Today the musical experience is largely an archival experience, our values those of the historian. What we make of our musical past may bother our sense of honesty, and quite appropriately. Hitler loved and used his Wagner; and the modern administrator loves and uses his Machiavelli. But to deny that our most cherished musical experiences are important to us and in some way bettering is dangerously close to a denial of that vague but important link between the humanities and humanity.

We all piously insist on a need for musical vitality. The price may be expensive indeed. Probably we would need to abandon the institutions which encumber our music, not only the flyspecks and recordings in our libraries but also the stultifying etiquette of our concert life. Also vulnerable are the concert halls themselves—indeed they are probably the very proof of Parkinson's "law" about institutions deteriorating when they move into an edifice properly suited to their image of themselves. Along with all of these monuments, alas, must go the *Art of Fugue* and *Messiah,* the Mozart concertos and the Beethoven quartets, *Otello* and even *Wozzeck.* We will never excel them—such is one of the obvious assumptions today, and whether inherently true or false, it will be true as long as we believe it.

With this in mind, I must take exception to a well-intentioned but wrong-minded defense of the arts in our society today on the basis of their excellence. We do indeed need excellence; and the level of excellence in the arts is indeed high enough to be a model for other activities today. The experience of music, like that of her sister arts, is one of stimulation, accomplishment and pleasure; and such being the case, the already high level of excellence will be further heightened by competition in an inevitably overcrowded profession. In practical terms, the results are likely to be less happy. For economic reasons—supply and demand, together with the technological "breakthrough" in sound recording mentioned earlier—the *Gradus ad Parnassum* is missing some steps near the top. The boy who practices seldom gets to Carnegie Hall. The excellence toward which the vast army of our educators must work must be fitted into a context in which amateurism, rightly and understandably, equals amateurishness, in which local pride is often an emotionally charged but valid excuse for quality. The ascent from the great plains, vast if less arid than we imagine, to the Olympian heights, is sudden, steep, and with frightening odds against survival. "It's warm in here—yes, perhaps for violinists"; and therefore, "If you can't stand the heat, get out of the cotton patch." And as a result, the Global Village Philharmonic will soon be impeccably performing the *opera omnia* of Western music, giving us with pushbutton convenience all the listening pleasure we want. Rather than justify music on the practical grounds of its excellence, one should perhaps accept its total uselessness as its greatest virtue—it does less harm than politicians or scientists. Far better one should hope and work for the impractical, unpredictable, but now highly possible: an aesthetic right-headedness of some sort, comparable to the recent moral righteousness over Viet Nam in this country, serving to remind us that the musical experience is more rewarding in achievement than in gratification, being in essence a creative art rather than a consumer commodity.

Rather than justifying music in terms of an administrative value in our society today, it would be nice to think that we might seek to apply one of the administrator's favorite laws of positive thinking: when faced with two alternatives, come up with a third which, with instinct and effort going for it, will prove to be brilliantly appropriate. Can we keep the past without being its slave? The mind boggles at what the answer might involve: but experience leads to the hunch that somebody will be singing about it before the mind stops boggling.

A dispassionate and analytical glace at the popular music of today will perhaps help to renew our faith. Its texts usually tend to strengthen our respect for the social values of adolescents; and similarly, its musical content leads to a sanguine hope that a new creative era is at hand. In comparison with most of the popular (and much of the classical) music of the past, its content is indeed richly varied, imaginative, and frequently quite skillful in its construction.

As for the future of music on paper, this is altogether more predictable: the dictator is alive and well and living in central Siberia, available for academic appointment. As long as performers and scholars continue to work with the past, the examination of a composer's documents will be a necessary experience, not to mention a moving one. As for the composer today, the notion that he learns from the past appears to be temporarily out of fashion. The Romantic genius saw the past as irrelevant in the light of a divine blessing, and so the composer of today sees it as subverting his originality, no longer relevant. The fact of the matter of course is that composers of any age develop their craft, a skill in the handling of their materials. In the learning experience, musical documents will maintain their importance. They are the giants, in the medieval metaphor of Bernard of Chartres, from whose shoulders the dwarfs of succeeding generations will be able to see more, and more distant things.

It is more than a cunning trick of a parsimonious librarian to suggest that our repertoire be shifted, quietly and *en bloc*, to his watchful custody. The care and feeding, and to a degree even the protection of the giants (sensitive as they are, and susceptible to disease, despite their great strength) should belong to specialists, and not the general public. Rather than become infatuated with the giants, or throw stones at them, our society will be far happier helping our midget composers climb onto the giants' shoulders—perhaps watching a few of them become giants in their own right.

Musicians learn first to read music, then to recognize the danger of playing the notes and missing the musical experience. As historians we examine our notation and come to appreciate what it has enabled us to have in our music; we should then look to its larger function, as both a preserver of and a stimulant to music itself.

# VICTOR BERGER: SOCIALIST CONGRESSMAN

*Frederick I. Olson*

Between 1910 and 1929 Victor Berger had not one but three congressional careers.[1] A single term from 1911 to 1913 coincided with, indeed was a major element in, the high tide of the Socialist party movement, both in Milwaukee and in the nation. His second career included no service in the House of Representatives, simply two election victories without seating in 1918 and 1919, and it signified his constituents' distaste for the first World War and their defiance of the federal government and the Wilson administration. Berger's triumphal return to Congress after his election in 1922, and his reelection in 1924 and 1926, were personal victories, devoid of the Socialist party import of 1910 and the anti-Wilson political symbolism of the 1918 and 1919 triumphs.[2] His defeat for a fourth consecutive term in 1928 removed the greatest prop for his pride and the major recompense for his party's decline. Nearing 70 and deprived of the regular income from his congressional salary, he now prepared to sell his majority stock interest in the Milwaukee Socialist daily which he had dominated since its founding in 1911, as a further step in the reorientation of his personal life. His party and his movement shattered, his Congressional seat gone, his newspaper about to pass under the control of others, Berger may have lacked that will to live which could overcome the injuries he sustained in a streetcar accident in the summer of 1929. On August 7, 1929 he died.

Nonconformity in politics came early to Berger. Born and educated in the decaying Austro–Hungarian empire, he migrated with his family to America in his late teens. He settled down in Milwaukee in the 1880's, amidst social and political turbulence which exposed him to emerging labor politics and to single tax, anarchist, and socialist solutions to the social problem.[3] An omnivorous

---

[1] This paper was read at the annual meeting of the Organization of American Historians in Dallas, April 19, 1968.

[2] For a somewhat different analysis of Berger as congressman, see Sally M. Miller, "A Socialist Represents Milwaukee," *Historical Messenger* (Milwaukee County Historical Society), 22:132–138 (December 1966).

[3] Edward J. Muzik, Victor L. Berger, A Biography, unpublished Ph.D. dissertation, Northwestern University, 1960; and for shorter sketches of Berger: Max and Edna Albers Lerner, "Victor L. Berger," *Dictionary of American Biography*, XXI (N.Y., 1944), 72–75, and "Victor Louis Berger" in Dwight L. Agnew et al., eds., *Dictionary of Wisconsin Biography* (Madison, Wis., 1960), 33–34.

reader, he built a large personal library on social issues. He loved disputation and found in German Milwaukee of the 1880's and '90's, with its Turn societies and its beer saloons, congenial companions to argue with. Such reading and discussion convinced him that one could accept a comprehensive theory for the solution of social ills.[4]

Through the 1890's Berger evolved a workable social philosophy to account for the future in terms of the past. This was Marxian socialism with its major components of the class struggle, economic determinism, social revolution, and wage, profit, and capital concepts. Like so many other Americans of the age who embraced Marxian socialist doctrine, Berger acquired a point of view, a system of analysis, and stereotyped rhetoric which clung to him for life. But he was soon convinced by socialist revisionism, especially of the Bernstein variety, and he was sufficiently American to realize the inapplicability of pure scientific Socialism to conditions in the United States. Moreover, he seems to have been impressed by the openness of American political institutions, their availability to all, even the immigrant, through easy naturalization, universal manhood suffrage, liberal qualifications for public office holders, and, at least locally, a fluid party system. Berger became above all a conservative or reform socialist politician with a burning desire to win public office for himself and for his fellow socialists.[5]

Even while evolving their socialist theories in informal discussions during the 1890's, Berger and his Milwaukee colleagues had participated in local politics through the Populist party. But Berger also sought to convert Eugene V. Debs to socialism and his American Railway Union into a socialist political movement. The founding of the Social Democracy of America in July 1897, followed by the chartering of the first branch in Milwaukee, was to Berger a first step toward the very political action which the leadership of the new organization had prohibited. Thus, in order to nominate a candidate for mayor in Milwaukee's spring 1898 elections, Berger's branch was obliged to seek special permission from the Social Democracy's national executive committee.

The next decade was critical in the evolution of an effective socialist movement in the United States and of a powerful Socialist party in Milwaukee. Berger's approach to the propagation of socialism was strongly political from the start. He persuaded the

---

[4] Part of Berger's impressive personal library may be identified in the collections of the University of Wisconsin–Milwaukee Library. Among his less scholarly Socialist party associates and among Milwaukeeans generally Berger's library and his reading habits took on a legendary character.

[5] In addition to Muzik's dissertation, see Roderick Nash, "Victor L. Berger: Making Marx Respectable," *Wisconsin Magazine of History,* XLVII (Summer 1964), 301–308, and two convenient collections of Berger's own views: *Berger's Broadsides* (Milwaukee, 1912) and *Voice and Pen of Victor L. BergerT: Congressional Speeches and Editorials* (Milwaukee, 1929).

Milwaukee Socialists after 1898 to endorse candidates for almost all elective offices in metropolitan Milwaukee and many in Wisconsin, until they matched the Republican and Democratic slates in city, school board, county, state, and congressional elections. Socialist candidates won seats in the city council, the county board, and the state legislature as early as 1904; for the remaining quarter century of Berger's life his Milwaukee party always held a substantial number of elective public offices.

Under Berger's leadership the Socialists not only ran candidates for office—they ran them to win. Berger adjusted Marxian theory and party doctrine in order to gain votes, particularly when an election victory was in sight. For electoral expediency he accepted regulation of utilities as a practical, short term alternative to public ownership. And on many other occasions he shrewdly calculated the effect of platform planks and candidate selection on Socialist vote tallies, not excluding the tactical advantages to be gained by an occasional abstention from competing with the two old parties for an office. Indispensable to Berger's party was its alliance with local trade unions and union leaders, without incorporating such unions into the party structure.[6]

Berger carried his absorption in Socialist politics two steps further. He adapted to Milwaukee and Wisconsin an essentially European concept of party organization and party discipline, contrary to Republican and Democratic traditions. Berger's party imposed stringent requirements and procedures on access to membership. It organized ward and foreign language branches as its basic units and coordinated them through a strong county central committee. It eschewed the open direct primary in the very state which popularized that device. Instead it determined party nominees through its own machinery. Candidacies for public office were intended to be, and to a large degree were, party not personal affairs. In theory this meant that a faithful party member dutifully accepted any draft and as faithfully swallowed his personal ambition if someone else were preferred to him. In fact it obviously wasn't that simple. Reputations, brokerage, personal friendship, and personal popularity all played a role in party endorsements. Proven vote getters and popular party figures like Berger, Hoan, Seidel, Gaylord, Ameringer, Minkley, and Heath usually received the election opportunities they wanted. They were nonetheless expected to campaign as Socialist party agents. This meant endorsing the party

---

[6] Marvin Wachman, *History of the Social-Democratic Party of Milwaukee 1897–1910* (Urbana, Illinois, 1945); Frederick I. Olson, The Milwaukee Socialists, 1897–1941, unpublished Ph.D. dissertation, Harvard University, 1952; and Olson, "The Socialist Party and the Union in Milwaukee, 1900–1912," *Wisconsin Magazine of History,* 44 (Winter 1960–61), 110–116.

platform and guaranteeing, if elected, to carry it out, on penalty of expulsion from membership or even involuntary removal from office. Campaigning had to be ticketwide, but the party handled all campaign arrangements and expenses, financing the latter through monthly dues, a checkoff from the salaries of officeholders, party benefit functions, and levies on the treasuries of friendly labor bodies. Never in American history, perhaps, has a political organization woven so tight a web over so many members as that which enmeshed the Milwaukee Socialists. It is not surprising that some opportunists joined the party to gain the support of so formidable an organization. And there were always some members who rebelled at the required pledges of loyalty and of money, at the expulsions and the purges, at the irritating limitations on their political independence, and their number grew when party fortunes waned and party decay appeared. As the genius who conceived and organized this tight structure, Berger was charged with being a boss, at first by his anti-Socialist political opponents, but soon by his enemies within the party.[7]

Berger's masterplan for pragmatic political action also included influence in national party affairs in order to protect Milwaukee autonomy from national interference. For years his nearly impregnable spot on the party's national executive committee provided Berger the necessary oversight. His vigilance extended to the national party's constitution, its election platforms, even the party name. Berger understood the need for a strong national movement to parallel Milwaukee's, but especially after the high tide of party ballots in 1912, he preferred to preserve the party's showplace in Milwaukee at almost any cost.[8]

Socialist political strength in New York, Chicago, and Los Angeles was always overshadowed by its major party opponents, however large their vote tallies by Socialist standards. Socialists were relatively more important in Berkeley, California, Haverhill, Massachusetts, Reading, Pennsylvania, Bridgeport, Connecticut, and elsewhere. But Berger's troops were the best organized and the most successful of all. Among the nation's large cities Milwaukee alone seemed to justify the "socialist" label.[9] The first Socialist victories in 1904 foreshadowed the landslide of 1910 when the party won city council and county board majorities and elected its candidate for mayor. Berger knew that as long as party labels prevailed in local elections, his Socialists could win pluralities in three way races. Beginning in 1912 Republican and Democratic fusion

---

[7] Olson, Milwaukee Socialists, 55–84.

[8] David A. Shannon, *The Socialist Party of America, A History* (N.Y., 1955), 17, 21–25, 62–63, 258–60.

[9] Shannon, *Socialist Party*, 8–42, 188–89.

and non-partisan election laws virtually eliminated such leverage, yet the Socialists continued to win selected elections.[10]

If Berger was a boss, he declined to play the traditional role entirely behind the scenes. He ran for public office regularly, a visible target for his intraparty opponents and his anti-Socialist enemies. In the 1910 landslide he finally won election as an alderman-at-large and for a year or so played the major role in Mayor Seidel's administration.

But Berger's ambition was to be Congressman. He ran as early as 1904 in Wisconsin's Fifth Congressional District, and beginning in 1910 he never missed a campaign for that seat. Berger emerged in the 1904 balloting as a possible threat to the incumbent Republican William H. Stafford by polling over 10,600 votes, or 33.8% of the total, for second place. His opponent, a colorless conservative, was a native Milwaukeean, 35 years old, a graduate of Harvard law school and a bachelor, who had won the seat for the first time in 1902. Between that date and Stafford's last victory in 1930, he or Berger won every Fifth District election. Over that period the seat was vacant for 2 years, Stafford served for 20 years, and Berger for eight. Curiously enough Berger and Stafford faced each other only 9 times in 14 Congressional contests between 1904 and 1928.[11]

What kind of district could alternate between a colorless conservative Republican and the first Socialist ever elected to Congress? A major clue is found in the changing relationships among three major parties. While Stafford and Berger remained constants, their Democratic opposition varied. Moreover, old party fusion succeeded against Berger three times. And once Stafford failed to win the Republican nomination. But the Fifth clearly bore the marks of a swing district, even after Berger and Stafford were gone. From Stafford's defeat in the Roosevelt landslide of 1932 to the election of Democrat Henry S. Reuss in 1954, three Democrats and two Republicans divided 22 years into seven segments, the longest consisting of three consecutive terms. Reuss had already made the seat safely Democratic before reapportionment reshaped it out of all resemblance to its 1904 character. Altogether, fickle Fifth District voters changed Congressman 14 times in 52 years. Only Stafford, at the very beginning of this period, won as many as four consecutive terms. He also shared with Berger and Stafford's immediate successor in New Deal days a run of three con-

---

[10] For contrasting views, see Myron L. Anderson, "Milwaukee Election Law That Boomeranged," *Milwaukee Journal,* December 20, 1959, and Erich C. Stern, "The Non-Partisan Election Law: Reform or Anti-Socialism?", *Historical Messenger* (Milwaukee County Historical Society), 16:8–11 (September 1960).

[11] For election statistics, see the biennial *Wisconsin Blue Books* (Madison, Wisconsin, odd years), and biennial reports of the Board of Election Commissioners of the City of Milwaukee (Milwaukee, various dates).

secutive terms. But seven times the incumbent failed to win even a second consecutive term.

Redistricting created a district in 1901 which joined the north half of the city of Milwaukee and the north and west suburban and rural-farm areas of Milwaukee County with villages and wealthy farm sections of Waukesha County to the West, the latter accounting for slightly more than a fifth of the District's voters. The combination of rural-farm-village with big city was a major cause of party alternations. Across the near north side of the city of Milwaukee stretched a band of German settlement which provided the core of the Socialist strength. The Germans as a whole were frugal, law-abiding members of the working class or lower middle class. Many were Socialist party members; others were sympathizers who often voted Socialist. In the suburbs, as well as in the rural and farm areas of Milwaukee and Waukesha Counties, lived business, professional, and farm folks, typically middle class and traditionally Republican. Scattered in both counties, but heavier in the city of Milwaukee, were traditional Democrats who were predominantly Roman Catholic and Irish or German. To win, the Socialists and the Republicans were obliged to woo not alone the independent voter, but the normally Democratic voter as well.

The redistricting of 1901 put two Congressional seats within the grasp of city of Milwaukee voters for the first time. Ten years later the detachment of Waukesha County made the Fifth District even more urban in character; and nearly half a century later, with all of Milwaukee County urban, the central city portion was divorced from the north suburban, and the latter was joined once again to the contiguous suburbanizing portions of Waukesha County.

Berger's election in 1910 gave the Socialist party its first House member, and Milwaukee its first labor-oriented congressman since 1886. The only other Socialist party member ever to win a House seat was Meyer London of New York; his three terms between 1915 and 1923 neatly complement Berger's subsequent victories to suggest a unique character for all Socialist congressional triumphs. One of Berger's successors in the Fifth after the second World War was ex-Socialist Andrew J. Biemiller, who had passed through LaFollette Progressivism into the Democratic party.[12]

The propaganda value of Berger's election for the Socialist party all over the nation can hardly be exaggerated. Electing Socialists to common councils and state legislatures was clearly not enough, for only Congress could legislate the major components of socialist doctrine. The Socialists had to demonstrate their capacity to capture Congressional seats if they were to move the nation

[12] Olson, Milwaukee Socialists, 197–99, 271–72; *Milwaukee Journal,* September 30 and October 23, 1955; Shannon, *Socialist Party,* 9, 11–12, 158.

towards socialism, and up to 1910 their propaganda about the relentless tide of Socialist votes notoriously lacked confirmation on this point. Berger thoroughly enjoyed the personal glory of becoming the first Socialist congressman, but he had to picture himself as a foretaste of growing numbers of Socialists, not as an effective instrument itself. Quips about caucusing in a telephone booth merely emphasized his ineffectiveness, for as a minority of one he could be readily tolerated. Patronage and his other perquisites as a Congressman appealed strongly to Berger, but Milwaukee Socialists had gained far more tangible party benefits from their other local victories.

In the House Berger was no social revolutionary. He claimed that he represented not alone—or not primarily—the Fifth District, but the working class and all the Socialist voters of the nation. He often acted prudently by doing errands for any of his constituents, even the anti-Socialist or non-Socialist as well as his known supporters. As the sole Socialist Representative he tried to be true to his apocalyptic role. For their propaganda value he sponsored futile Socialist measures such as old age pensions and national ownership of railroads and communications. His speeches and news handouts were designed not to win votes in Congress but to present Socialist positions and gain Socialist converts outside the halls of Congress. His occasional deviations from the party line to please his Milwaukee constituents brought prompt censure from the party faithful while failing to secure his reelection. His most effective action, in calling for an investigation of the textile workers strike at Lawrence, Massachusetts, depended, as he well knew, on support from and tolerance by colleagues in Congress whom he felt obliged to castigate at every opportunity. A gregarious person who had enjoyed social acceptance by his ideological enemies in Milwaukee, Berger could not now isolate himself from the fellowship of the House of Representatives. Most evident was the gratification of his desire for personal acceptance by fellow Congressmen. That he never recovered from the fascination of his first Congressional experience is witnessed by his biennial efforts to regain his seat for the rest of his life.

But the cruelest dilemma in Berger's congressional service arose not from compromise of his socialism but from diversion of his energies. His central role in the Milwaukee party organization made his absence in Washington and his attention to Congressional duties costly to the Milwaukee movement. The persistent financial strain of ordinary party activities now extended to building a labor temple and founding a daily newspaper, the latter a part of the publishing complex from which Berger drew a salary. The long planned Socialist daily *Milwaukee Leader* appeared December 7, 1911, coincidental with the opening of the 62nd Congress. While Berger espoused Socialist doctrine on the floor of the House in the Spring of 1912, the *Leader* limped along, powerless to prevent a Socialist administration wiped out by a fusion ticket, and the Milwaukee rout in the municipal elections. From afar Berger saw the Seidel Socialists rent by dissension in their leader's absence.[13]

Nor could Berger return for the fall campaign in time to develop a winning tactic against Stafford's coalition with the Democrats. Berger's plurality in 1910 had been a slim 350 or 1% of 35,224 ballots. The resulting anti-socialist fusion, although incomplete, reduced Berger's vote but slightly from 38% to 35 or 36%, yet provided Stafford with margins of 1,908 in 1912, 3,946 in 1914, and 3,649 in 1916. After his 1912 defeat Berger adopted the correct party stance, lamenting that the millions of Americans who had voted Socialist were deprived of a voice in Congress.

Between Berger's defeat in 1912 and his khaki election victory of 1918 the Milwaukee Socialists entered a new era. The momentum of local and national election gains and party membership growth was lost between 1910 and 1912. Within Milwaukee and Wisconsin politics the Socialists settled down to a respected but limited role. When Dan Hoan was reelected city attorney in 1914 and recaptured the mayor's office for the Socialists two years later, no one could foresee how long he would hold it or how remotely Socialist his administration would become before his defeat in 1940.[14]

Some Socialists including Berger did foresee the catastrophic potential of the first World War as early as 1914. But America's Socialists were obliged to reconcile their doctrinaire war beliefs to the votes of their European brethren on the war credits. Initially Berger maintained in his *Milwaukee Leader* a peace posture which was distinguishable from pro-Germanism. Stafford rather than Berger embraced an opportunistic pro-German position in 1914 which helped him win easy reelection. Gradually, however, Berger's reaction to the war took on a more pro-German, anti-French and anti-British tone, not surprising in one who was born and educated in Central Europe. It became more difficult for Berger to apply simple Socialist tests to the events preceding the entry of the United States into the war, and he seems to have convinced himself that the defeat of Germany must be avoided because it would destroy the most promising socialist party in Europe and thus in turn weaken the American movement. Fortuitously, Berger's cultural preference for Germany coincided with the prejudices of his Mil-

---

[13] Miller, *loc. cit.;* Olson, Milwaukee Socialists, 247–54; Olson, "Milwaukee's First Socialist Administration, 1910–1912: A Political Evaluation," *Mid-America,* 43 (July 1961), 197–207.

[14] Olson, Milwaukee Socialists, 271–72, 310–11.

waukee constituents and reinforced his concern for the fate of German socialism.

Stafford could outbid Berger for the critical German votes in the Fifth District as long as President Wilson did not invoke federal power against Berger. But when Wilson's Postmaster General revoked the *Leader's* second class mailing privilege on October 3, 1917, and his federal attorney brought indictments against Berger and four alleged Socialist co-conspirators under the Espionage Act on March 9, 1918, Berger was cast as a martyr to an all-powerful government which could not tolerate dissent. Berger, who had concurred in his party's condemnation of the American declaration of war, in his newspaper and by other acts and utterances had criticized many government policies and practices in prosecution of the war. But he had every reason to believe that he had remained within the letter of the law. That his opposition to the Wilson administration, or rather the latter's prolonged persecution of him for his beliefs, had election appeal was demonstrated in April 1918 when he polled 110,478 votes, or over 25%, in a senatorial election against a pro-war Republican and a Wilson Democrat. Most significant, concentration of Berger's votes gave him a plurality in the Socialist stronghold of Milwaukee.

In the November 1918 congressional race Berger won handily despite the pending federal indictment. The Democrats, hoping to convert Wilson's call for a Democratic Congress into their first victory in the Fifth District, defected from their fusion agreement to make their first serious challenge since 1908. But they merely gained second place while Berger drew enough traditional Republican and presumably German votes from Stafford to produce the largest plurality of his six victories, 5,470 votes.[15]

What Berger had regained at the polls, his erstwhile colleagues in the House now withheld. Between his election and the convening of Congress his indictment was converted in federal district court in Chicago into a conviction, with a sentence of 20 years from Judge Kenesaw Mountain Landis. While out on bail Berger fought to be seated, but the House refused him on November 10, 1919, by a 311 to 1 vote. Congressional reasoning was that Berger had given aid and comfort to the nation's enemies and thus invoked the third section of the Fourteenth Amendment, which required denial of his seat. Berger promptly stood for the Socialists in the December 1919 bye-election resulting from the vacancy, and as promptly was reelected by nearly 5,000 votes over his fusion opponent with the attractively Teutonic name of Bodenstab. Again Congress applied the Fourteenth Amendment to keep Berger from serving.

[15] *Ibid.*, 339–40, 355–56, 374–84.

By 1920 Berger could not so readily capitalize on anti-Wilson sentiment. For once fusion was so thorough it not merely weakened the Democratic effort as it had in 1912, 1914, and 1916, but it actually eliminated all non-Socialist candidacies but Stafford's. Even Berger was not safe from Republican exploitation of anti-war and anti-Wilson sentiment, and Stafford won by a 6,773 majority, the largest margin of any of their nine contests.[16]

Yet in defeat Berger was preparing for ultimate vindication. First of all, he appealed his conviction to the United States Supreme Court, which set aside Landis' sentence on January 31, 1921, and the Harding administration dropped the case without further effort. Next, in the favorable Wisconsin election climate of 1922, wherein a sympathetic Senator LaFollette also won triumphant reelection, Berger defeated Stafford by a 3,771 majority, or 6.7%, in another two way race, a most dramatic reversal of 1920. Without dissent he was now seated. And in the next two elections he survived the Coolidge landslide and the almost total eclipse of his own party everywhere, including serious setbacks in Milwaukee. But a presidential contest between Hoover and Smith in 1928 was too formidable for him to deal with. Hoover's candidacy capitalized on the fragile prosperity of the era, Smith's on Milwaukee's resentment over Prohibition. For the first time in 10 years the Democratic nominee for Congress polled over 20% of the vote, and Berger lost to Stafford by 709. It was his last race.[17]

As the first Socialist Congressman in 1911, Berger had symbolized his party's potential, and both his sense of party responsibility and his vision of the future had dictated the ideological role he must play. But by 1923 he had survived the terrible buffetings of the war period—persecution of his newspaper, prosecution of himself as a subversive, and double denial of a House seat—while his party, swollen by the transient growth of the war era, split wide open nationally over the Russian revolution and then declined sharply. What Berger salvaged of Milwaukee Socialism drew no nourishment from a national movement that struggled simply to maintain its name and headquarters. The hopefulness of its 1910 victories had given way to despair in the 1920's. The Berger brand of gradualist socialism, which had seemed so promising under Mayor Seidel, had deteriorated into a housekeeping version called sewer socialism under Mayor Hoan. It took great faith in a socialist

---

[16] *Ibid.,* 384–88; Edward J. Muzik, "Victor L. Berger and the Red Scare," *Wisconsin Magazine of History,* XLVII (Summer 1964), 309–18; *Hearings Before the Special Committee Appointed under the Authority of House Resolution No. 6 Concerning the Right of Victor L. Berger to be Sworn in as a Member of the Sixty-Sixth Congress* (2 v., Washington, 1919); Zechariah Chafee, Jr., *Freedom of Speech* (N.Y., 1920), 310–33.

[17] Olson, Milwaukee Socialists, 388–90, 441–42, 448–50.

future even to maintain a party organization from election to election. Ideological disputation, long the stock in trade of Socialists, gave way to factionalism, personality differences, and a scramble for personal preferment.

Thus Congressman Berger no longer claimed a socialist, only a Milwaukee, constituency. No one seriously expected a Socialist revival, even in Milwaukee. All one hoped for was to sustain the present officeholders and quiet the dissidents who wondered aloud what had happened to the fiery zeal of 1900. The respect Berger had once sought for his party and his movement he now craved for himself. He was not so much a lone Socialist in Congress; London had been that too, for three terms. He was rather the vindicated victim of a war time hysteria. The U. S. Supreme Court, Fifth District voters, and the House itself had in turn confirmed this. While he retained his love for the stereotypes of non-revolutionary socialist programs and socialist rhetoric, he spoke in Congress most commonly about international affairs and the issues and consequences of the war. Set apart from most Congressmen by his Central European upbringing and his informed interest in the larger movements of Europe and the world, he addressed himself to the deepening American disillusion with the war and the war settlement and to relations among the great powers of Europe. Here and there an underlying socialist analysis shone through, but generally the viewpoint was more personal and his major concern over civil liberties and Prohibition reflected election needs. Today his remarks reflect the shallowness of contemporary comment; then they drew attention to his education, his reading, and his essentially foreign cast of mind.[18]

If Berger continued to stand apart from his House colleagues as in 1911, it was due less to his Socialist label than to his personal independence. Yet he enjoyed far more than in 1911 friendships with other House members. The respect of some who differed from him most like John Nance Garner is reflected in their farewell remarks, while the friendly Fiorello LaGuardia saw Berger as "a pioneer, popularizing ideas of political and social reform long before they are accepted by the many, and while they are still frowned upon by the majority and denounced by political leaders."[19]

Berger's election as the first Socialist in Congress had been a natural by-product of his obsession with local Socialist political activity. He had fashioned in Milwaukee the most thoroughgoing and durable political organization the American Socialists ever saw, and thus won for himself not only a Congressional seat but

[18] *Ibid.*, 442–48. Berger, *Voice and Pen*, *passim*.
[19] *Congressional Record*, 70 Cong., 2 sess. LXX (Mar. 4, 1929), 5275.

a place in the Socialist pantheon along with Debs, Hillquit, London, Hoan, and Thomas. But before his death in 1929, the socialist conviction and optimism which had sustained his early party activity had given way to personal advancement and despair. "The Socialist party of Milwaukee," he had told his closest friends, "will not survive my death by six months." He was wrong. He had already outlived it.[20]

[20] Olson, Milwaukee Socialists, 451–52, 573–74.

# WHEN SEDITION LAWS WERE ENFORCED: WISCONSIN IN WORLD WAR I

*John D. Stevens*

Today, with television and Broadway shows satirizing public officials, with militants calling for armed rebellion, with young men chanting, "Hell no, we won't go," it is important to remember that it was not always so.

Certainly it was not so during World War I, when men went to prison for chance remarks in bars, rooming houses and on street corners, when the Post Office hounded foreign language papers out of business, when wearing an Industrial Workers of the World pin made you, automatically, a disloyalist.[1] Such "crimes" were prosecuted under local ordinances, state sedition laws, and primarily under federal statutes. This paper attempts to examine the enforcement of these federal laws in Wisconsin, which had the nation's highest proportion of German descendants and one of the nation's most active and successful socialist parties.[2]

Although President Wilson had been urging an internal security law since December, 1915, Congress could not agree on one, so the United States entered the war with only the Conspiracies Act of 1861[3] and the Treason Act of 1862.[4] Neither reached individual utterances.

The federal security package included five major laws which curtailed expression: Threats Against the President Act,[5] Selective Service Act,[6] Espionage Act,[7] Trading-with-the-Enemy Act,[8] and Sabotage Act.[9] These were supplemented by many presidential

[1] See e.g. Chafee, Zechariah Jr., *Free Speech in the United States* (1941) ; Johnson, Donald, *The Challenge to American Freedoms* (1963) ; Scheiber, Harry N., *The Wilson Administration and Civil Liberties* (1960).

[2] See Peterson and Fite, *Opponents of War 1917–1918* (1957) ; Preston, William Jr., *Aliens and Dissenters* (1963), and Maxwell, Robert S., *Emanuel L. Philipp, Wisconsin Stalwart* (1959), discuss Wisconsin's reputation for disloyalty.

[3] 12 *U.S. Statutes* 284

[4] 12 *U. S. Statutes* 589. This law was used to convict some anarchists; cf., *Goldman v. U.S.*, 245 U.S. 474 (1918)

[5] 39 *U.S. Statutes* 919.

[6] 40 *U.S. Statutes* 76.

[7] 40 *U. S. Statutes* 217, with amendment, 40 *U.S. Statutes* 553. The 1918 amendment sometimes is referred to as the Sedition Law.

[8] 40 *U.S. Statutes* 425.

[9] 40 *U.S. Statutes* 533.

orders and directives.[10] These five laws will be discussed in chronological order, with particular emphasis on their enforcement and effects in Wisconsin.[11]

## Threats Act

Spurred by the growing menace of war, the House of Representatives passed the act in June, 1916; the Senate concurred in February, and the President signed it on Valentine's Day, 1917. There had been suggestions for such a law since the 1901 assassination of President McKinley.

The brief law provided up to five years and $1,000 fine for mailing any "threat to take the life or to inflict bodily harm upon the President of the United States." Federal courts interpreted "threats" quite broadly, to mean something akin to the fifteenth-century English high treason law which made it a crime to imagine the death of the sovereign. By June 1918, 35 persons had been convicted under the law, and in Wisconsin nearly twice that many had been indicted.[12] Two men were convicted and five others pleaded guilty during the war. Penalties ranged from $100 to 18 months in prison. Without a broad interpretation of "threats," it seems unlikely any of them would have been convicted.[13]

A Racine policeman was the first person indicted under the law in Wisconsin. Allegedly he told another man that Wilson would be shot within 30 days and that if no one else did it, he would do it himself. During his trial in May, 1918, he denied making the last part of the statement and said the first was based on astrology. He said he was discussing astrology with another man when a third person overheard the conversation and reported it to federal officials. The jury was not impressed, and he was sentenced to 18 months in Leavenworth Prison.

Both indictments brought in the Eastern District were against Shawano County men, and both were joint actions under the Threats and Espionage Acts. One man had allegedly said, "If I was drafted I would take a straight shot for President Wilson's house and would do away with him if I got the chance." His case was dismissed in March, 1919, without coming to trial. The other was indicted and tried for saying in a private home in the presence of

---

[10] E.G., Alien Enemies Proclamation (April 6, 1917); Federal Employees Loyalty Order (April 7, 1917); Order Creating Committee on Public Information (April 14, 1917); Cable and Telegraph Order (April 28, 1917); Order Establishing Board of Censorship (October 12, 1917).

[11] Unless otherwise specified, information on Wisconsin cases was taken from federal court records in the Federal Records Depository at Chicago; in some cases, details were added by contemporary newspapers.

[12] *Report of the Attorney General* (1918), p. 56.

[13] Among decisions holding that the threat need not be communicated to the President were *U.S. v. Strickrath*, 242 F. 151 (1917); *U.S. v. Jasick*, 252 F. 931 (1918); *U.S. v. Metzdorf*, 252 F. 933 (1918); *U.S. v. Stobo*, 251 F. 689 (1918).

three other persons, "The President is the one that caused this war. He ought to be killed and if I had the chance I would kill him in a minute." The jury refused to convict him, perhaps because the trial came a month after the Armistice. It should be noted that the only Threats Act indictment which resulted in a conviction in the Eastern District was also the first one brought there.

On the other hand, in the Western District the first man indicted entered a plea of guilty and got off with the lightest penalty of all, a $100 fine. In October, 1917, he allegedly said:

> We ought to clean out the White House. Wilson wants to be shot before they shoot the Kaiser. If Wilson is not shot before he gets out of office, he will be after he gets out of office if he doesn't get out of the country.

Indictments were returned in March, 1918, against three men and one woman. The case against an Ashland man who was also indicted under the Espionage Act for saying "I'd kill the President like a dog" never came to trial. A German-American from Marathon County was sentenced to six months in the Milwaukee County House of Correction for saying, "I am a socialist. President Wilson is a son of a bitch and I would hang him if I had my way."

A young Eau Claire County farmer was indicted for saying that if he had an airplane he would "get that damned Wilson" and that if he were drafted he "would like to kill that goddamned Wilson." He pleaded guilty but told the judge he had been drunk. Unmoved, Judge Sanborn sent him to Leavenworth for a year and a day. The wife of a butcher at Milladore in Wood County, after hearing of the sinking of the *Tuscania* troop ship, which was carrying a large contingent of Wisconsin troops, allegedly threatened to put a bullet in the head of President Wilson. She was convicted in a one-day trial in August, 1918, and sentenced to six months in the Eau Claire County Jail or a fine of $500. She chose the latter.

A Dunn County man pleaded guilty in March, 1918, to saying, "The President ought to have been killed long ago, and if somebody does not do it, I will." He served 30 days in the Eau Claire County Jail for his indiscretion.

The final case was not related to the war at all and indicates how broadly the statute was being interpreted by federal judges. A Prairie du Chien man, three weeks after the Armistice, allegedly said, "I will shoot Wilson, the son of a bitch, if the country goes dry July 1." He was indicted May 12, 1919, and two weeks later entered a guilty plea. He was sentenced to 30 days in the Dane County Jail.

By most standards, none of these 10 persons posed much of a threat to President Wilson. For that reason, it might be instructive to review the only statement recorded about the purpose of the law by the author himself. During the congressional debate, Representative Webb said, "The man who makes the threat is not himself very dangerous, but he is liable to put devilment in the mind of some poor fellow who does try to harm him (the President)."[14]

Although no one can tell how much "devilment" the quoted remarks put in the minds of hearers—especially since the indictments did not indicate the context of most of the remarks—it seems unlikely that the hearers in Wisconsin posed much threat to the President. The same could be said about other persons reported in the newspapers as arrested under the Threats Act but who were not actually indicted.

From 1921 until World War II, the law was a virtual dead letter. Three cases under the Threats Act were appealed during the war and two have been appealed since. The Threats Act remains on the statute books, in peace as well as war time, and in 1962 was broadened to protect the Vice-President or other person next in line for the presidency, as well as the President-elect and the Vice-President-elect. It was 1965, in the aftermath of the Kennedy assassination, before Congress passed a law which protected the life of a President.[15]

## Selective Service Act

The conscription law of 1917 made it a crime to discourage men from registering or serving in the military services. There were widespread fears of draft riots such as those of the Civil War, but they were not realized.

In spite of Governor Philipp's later recollection that there was no opposition in the state to the draft "save now and then an individual," the dockets of the two federal courts in the state contain the names of hundreds of men indicted for draft violations, most of which were quietly dropped when the men "volunteered" for immediate army duty. Attorney General Gregory assured a congressman in July, 1918, that this was the usual procedure for men failing to register. He said that through June 8, there had been 8,802 actions under the draft laws through the nation; of these, 4,064 dealt with failure to register.[16]

From among the many indictments under the draft act, five Wisconsin cases have been singled out which resemble closely in-

---

[14] *Congressional Record,* 65 Cong., 2d Session, 9377.

[15] The Threats Act now is 18 *U.S. Code Annotated,* Section 871.

[16] Philipp, "Wisconsin's War Activities," *Wisconsin Blue Book,* (1919), pp. 301–303; *Congressional Record,* 65 Cong., 2d Session, 528.

dictments brought under the Espionage Act for expression. One, in fact, was a joint draft-espionage action.

This involved nine members of a "Holy Roller" fundamentalist religious colony in Barron County who were indicted in March, 1918. When they appeared in court June 3, they refused to plead, but instead made anti-war religious speeches. The judge ordered a not guilty plea entered in their behalf and placed them in jail when they refused to post bond. The men were indicted on 13 counts based on 16 separate speeches, personal letters, personal advice, and articles in their paper. After a three-day trial which ended July 20, all were found guilty. The leader was sentenced to 15 months at Leavenworth, and three other members were sent there for a year and a day. The other six were given terms of three to six months in county workhouses, although four of the six were permitted the option of paying fines of $250 to $500.

In another case, in June, 1918, three men were indicted jointly under the draft and espionage measure, but the indictment has been lost. A newspaper reported that their arrest at Ashland was for saying Wilson was responsible for the war and for the sinking of the *Lusitania.*

A wealthy Grant County farmer was convicted by a jury in 1918 and sentenced to a year and a day at Leavenworth plus a fine of $1,000. He was indicted on five counts and convicted on two, including the following statement made to draft-age men:

> This is a rich man's war and we would not have this war if it had not been for the rich girls in the United States marrying English lords. We had no business to start this war. The issue that Wilson was elected on was not to start war. They loaded supplies for the Allies on boats and hired a few Americans and put them on those boats and they were killed and this started the war. We had no cause to be in this war. The Germans killed no Belgian citizens and there are no orphans in Belgium or France that were caused by the war. The Germans have done no worse than Americans have done to Germans. We have no business in this war. We went into it to protect the money that was loaned to the Allies. The money interests hired a few Americans to ride on those ships so that if they were killed we could get into the war.

The jury, according to a newspaper, was out for only a half hour in convicting the 58-year-old father of seven.

This was the only case in which the judge's charge to the jury was preserved in the archives. It was given by special judge Evan A. Evans. In his charge, Evans denied the defense attorney's contention that such words had to be spoken to a person already in the service or who was about to be called; it was enough that they be spoken and there be some reasonable chance that they might somehow be conveyed to a soldier or potential soldier.

The fourth draft case involving expression was that of a Wood County man whose remarks were made in Polish in the summer of 1918 to some prospective draftees. After a one-day trial he was sentenced to six months in the county workhouse and fined $500 for saying:

> The kaiser will fare along better than ever because he has made peace terms with Ukrania, but the kaiser will pay no attention to the papers that were signed. It is coming to it that President Wilson will have to crawl on his knees to kiss the kaiser's boots. The submarines will work havoc with American boats. They have sunk nine boats and of a total of 1,000 persons on those boats, only 40 were saved.

It is difficult to imagine where the Wood County man got his "facts," but the jury decided that his remarks could frighten some rural Wisconsin lads enough that they might not fulfill their military duties.

The most celebrated draft case in the state had nothing to do with free expression directly but much to do with it indirectly. This was the action against Congressman John M. Nelson of Madison and his draft-age son, Byron.

To understand the free expression implications of the case, one needs to bear in mind that Nelson had voted against most war measures, including the declaration of war. He had been in Congress since 1906 and was clearly identified with the La Follette wing of the Republican Party. (In 1924, he managed La Follette's presidential campaign.) He had alienated many Republican "regulars" in Congress by his role in the 1908–1910 fight to prune the powers of Speaker Joe Cannon.

When, in August, 1917, the federal district attorney announced that he would seek indictment of the congressman's son for not registering for the draft, Nelson realized that he was the real target. Nelson knew his way around Capitol Hill and had many friends. On September 4, he sent a long letter to Attorney General Gregory refuting one by one the charges against his son. Byron was charged with not registering on "Duty Day"; however, those residing in foreign countries were specifically excluded from the registration requirement, and Byron had been managing a family farm in Alberta since May 5. This was 15 days before the draft act was enacted, 28 days before the President's proclamation establishing the registration date, and a month and two days before the registration day itself. Nelson said that at the time he had asked his son to go north he had no way of knowing what the terms of the act would be. His son had worked on the farm during summers while attending the University of Wisconsin. Nelson even sent Gregory a published "Roll of Honor" which showed that his son ranked fourth among students in donating their time during the spring to work on the university farm. Nelson further assured Gregory that in May he had received assurances from the Provost Marshal General that persons living abroad did not have to register for the draft. He had reaffirmed this in person with the Provost Marshal on September 1 after reading of the district attorney's intention to prosecute. Nelson cashed in some of his other political debts. For example, he convinced Speaker Champ Clark to write a confidential note to the Postmaster General on his behalf.[17]

In October, Byron pleaded not guilty to the draft evasion charge in the federal court in Madison. In late November, the Congressman was indicted for conspiracy to avoid the draft and his son for failure to register. Both entered pleas of not guilty and were released on bond. One month later, on January 3, the federal judge quashed both indictments. Although the irate district attorney told the press that he would appeal the judge's decision, he did not. That was the end of the case, at least in the courts.

Although the Nelson case was over in the courts, it was "retried" at the polls in the spring primary, and Nelson lost; however, he won back his seat in 1920 and held it until defeated by a gerrymander in 1932.

## Espionage Act

If, as John Roche suggested, World War I was a "black mass celebrated by the elected leaders of the American nation,"[18] then surely the Espionage Act must be considered its litany.

Only two provisions of the lengthy law affected free expression. Section 3 of Title I made it a crime to interfere with the military or recruiting services, while Title XII made it illegal to mail matter which violated other sections of the law. Strictly construed, these would have had little effect on expression.

That they were not so construed was shown by the number of prosecutions. Chafee wrote that 877 persons were convicted under Section 3 and more than 100 publications banned from the mails under Title XII. Chafee based his figure on annual reports of the Attorney General, which for the two federal courts in Wisconsin

---

[17] Nelson to Gregory, May 4, 1917, and Clark to Nelson, December 14, 1917 in John M. Nelson Papers, State Historical Society of Wisconsin, Madison, Box 1.

[18] Roche, John P., *Quest for the Dream* 49 (1963).

were too low. Other estimates ran higher, but it seems likely that there were at least 2,000 actions and 1,000 convictions under Section 3. Virtually all were for expression.[19]

Punishments under the law were harsh. At least 35 persons went to prison for the maximum 20 years and another 58 for 10 to 15 years; others received shorter sentences and fines. Still, the man who directed the law's enforcement admitted that there was not a single proven case of sabotage in the nation after the declaration of war, and Charles and Mary Beard concluded the law did not catch one bonafide spy or saboteur.[20]

Twelve days after the United States declared war, Senator Lee Overman of North Carolina introduced an omnibus measure which covered such diverse security matters as the embargo, conveying secrets to foreign agents, passports, impounding enemy vessels and counterfeiting the government seal. He described it as substantially the same measure which the Senate passed during the previous session but which died in the House.

Both in the press and on the floor, most of the controversy centered on a section which provided five years in prison and a $10,000 fine for publishing information declared by the President to be useful or even possibly useful to an enemy. There was much less attention to Section 3 of Title I which, as enacted in 1917, provided 20 years in prison and $10,000 fines for anyone who while the United States was at war should willfully make or convey false reports or false statements with intent to interfere with the operation or success of the military or naval forces of the United States or to promote the success of its enemies: and whoever, when the United States is at war, shall willfully cause or attempt to cause insubordination, disloyalty, mutiny, or refusal of duty in the military or naval forces of the United States, or shall willfully obstruct the recruitment or enlistment service of the United States.

Title XII allowed the Postmaster General to refuse to convey any letter or printed matter "advocating or urging treason, insurrection, or forcible resistance to any law of the United States." Maximum penalties were set at $5,000 and five years in prison.

In introducing the measure, Senator Overman assured his colleagues the measure in no way limited freedom of the press or of individuals to comment on governmental policies. He assured them that the courts could be trusted to interpret the law in a reasonable manner.[21]

For three days, the Senate debated the press censorship section, but in the end rejected it. The House accepted the mail section with

---

[19] Chafee, *op. cit., supra* note 1, at p. 52.

[20] O'Brian, John L., *National Security and Individual Freedom*, 49–50 (1955); Beard, Charles and Mary, *The Rise of American Civilization*, Volume II, 644 (1927).

[21] *Congressional Record*, 65 Cong., 1st Session, 778–781.

a few minor wording changes over the warnings of its only socialist member that Title XII would be the death knell for minority opinion press in this country. The bill passed, 260–106. The Senate then debated the bill for two days in executive session and for three more in public. On May 12, the Senate defeated the censorship section and later at attempt to reinstate it. The upper chamber prohibited postal inspectors from opening sealed letter and adopted the bill, 77–6. Wilson signed it June 15. Once shorn of its press censorship section, the Espionage Act was greeted by newspapers either with praise or with indifference.[22]

Early in 1918 the Attorney General requested an amendment to Section 3 to protect government bonds from criticism. The Senate Judiciary Committee broadened the amendment to cover disparaging remarks about the flag, the military forces, the Constitution or form of government. The amendment, sometimes called the Sedition Act of 1918, provided 20-year prison terms for remarks which interfered, even remotely, with the war effort or aided the enemy. The sponsoring committee admitted the amendment was quite superfluous since most district judges had interpreted the 1917 law to cover such offenses. During the seven days of debate, at least five senators said that such an amendment would help quell the mob spirit in the land. Gregory used the same argument in his 1918 report.[23]

The Senate strengthened Title XII, permitting the Postmaster General to refuse even to pick up or deliver mail during the war at addresses using the mails in violation of the act, thus crimping socialist and radical defense committee collections. On April 9, the Senate refused to incorporate even the protections of the 1798 sedition law, excluding truthful remarks made with good motives.[24]

Of the 92 indictments in Wisconsin under the Espionage Act—several in conjunction with the Threats, Draft or Trading acts—all but two involved expression. Since most judges and juries used ill tendency as their standard from the beginning, the 1918 amendment made little difference.

Analysis of the preserved indictments shows that the offensive remarks fell into certain logical categories, shown in Table 1. A few representative Wisconsin cases will be discussed for each category.

Thirty-six indictments included remarks praising Germany or the Kaiser or expressing the belief or hope that Germany would

[22] *Congressional Record,* 65 Cong., 1st Session, 847, 871–887, 1590–1596, 1698–1701, 1717–1720, 1750–1780, 1807–1841, 2055–2072, 2087–2113, 2166–2196, 2241–2270.

[23] *Congressional Record,* 65 Cong., 1st Session, 3002–3004, 4559, 4562, 4633, 4637, 4645–4646, 4710, 4764–4771, 4824.

[24] *Congressional Record,* 65 Cong., 1st Session, 4562–4563, 4637, 4784, 4826, 4835–4839, 4895–4898, 5541. Procedural safeguards did little to protect defendants under the 1798 law, according to Smith, James M., *Freedom's Fetters* 421–424 (1952).

TABLE 1. TYPES OF REMARKS INDICTED UNDER ESPIONATE ACT 1917–1918 IN WISCONSIN

| | |
|---|---|
| Praising Germany | 36 |
| Criticizing U. S. | 35 |
| "Rich man's war" | 32 |
| Criticizing Allies | 17 |
| Insulting flag, uniform | 9 |
| Criticizing bonds | 19 |
| Criticizing food laws | 9 |
| Criticizing charities | 15 |
| Obstructing recruiting | 17 |
| Praising ship sinkings | 3 |

(Total exceeds 90 because some indictments were for multiple remarks)

win the war. Such remarks seem more likely to produce a brawl than a breach of national security. While society has an interest in preserving peace and tranquility, punishing a man for remarks on this ground alone is like punishing a rich man for keeping money around to tempt thieves. A similar breach of peace rationale has all but disappeared from American criminal libel law.[25]

Two Wood County men were convicted for remarks favoring Germany in July, 1917. One, a 44-year-old native of Prussia, was sentenced to two years in prison for saying, "I wish the war would end and the Kaiser would win. Yes, God damn it. We will never have good times until the Kaiser wins." Although he had lived in the United States for seven years, his record showed that in 1914 he had been denied citizenship papers because he was not a "law abiding and peaceful" man. The jury was sworn in one morning, heard five government witnesses plus the defendant in the afternoon, and convicted him before nightfall.

The other man was a Pole employed at a Grand Rapids paper mill. Three fellow workers, through an interpreter, told the court the man had said the Kaiser was sure to win the war and to sink all the American troop ships. The defendant told the court that 25 years before he had fled Europe after killing a German officer who disciplined him. His court-appointed attorney told the jury that surely it could not find this man disloyal or pro-German. "He is the only man in this courtroom who bears on his body a scar inflicted by the brutality of Teutonic autocracy." After hearing the prosecutor tell them that their only duty was to decide if the words had been spoken, not to judge their criminality, the jury proved it certainly could find the Pole guilty. It took them only 90 minutes to convict him, and the judge imposed a six-month term in the county workhouse and a $500 fine. A Madison druggist who long

[25] Anon. "Constitutionality of the Law of Criminal Libel," 52 *Columbia Law Rev.* 521 (1952).

had been prominent in German-American societies pleaded guilty to similar remarks and was fined $2,000.

Even doubting the worst about the enemy could get a man in trouble, as it did a prosperous 68-year-old Grant County farmer who, among other statements, expressed disbelief about reports of German atrocities. (After the war, investigations showed that nearly all such tales were untrue.) The principal prosecution witness was a neighbor who had a long-standing grudge with the defendant over a land transaction. This hostile witness testified he heard the farmer say, "The Germans killed no Belgian citizens and there are no orphans in Belgium or France that were caused by the war. The Germans have done no worse than Americans have done to Germans. . ."

The farmer, the father of seven including a soldier in France, denied making such statements, but the judge ruled the neighbor's testimony admissable as he did that of two representatives of the Council of Defense who said there had been rumors about the farmer's disloyal remarks on other occasions. The jury took 35 minutes to convict. The sentence: a year and a day at Leavenworth prison plus a $1,000 fine.

Thirty-three indictments quoted criticisms, often quite pointed, of the American conduct of the war. Some of the offensive remarks said the Administration was too zealous, others that it was lethargic. Such opinions would seem to pose small danger to the success of a war; at least the United States managed to win World War II without prosecuting such criticisms.

One of the heaviest punishments—15 months in prison—was meted out to a 37-year-old Russellite evangelist from Milwaukee who was arrested at Plover in Portage County. He was convicted on four counts in a one-day trial at Eau Claire in July, 1918. His remarks, delivered in Polish, were translated thus in the indictment:

> The Constitution of the United States says that the government of the United States cannot compel a person to go to another country to fight, but Wilson has spoiled the Constitution, and is compelling men to go to other countries to fight. President Wilson started the war and he is now going to run away.

A socialist attorney at Milwaukee was indicted in October, 1918, for telling two men (including a judge) that the United States had no business in the war and that its army should not be in Europe. On another date, he allegedly told a woman at Whitefish Bay, "You are upholding the cruelest and most abominable form of government in existence."

A traveling salesman from Minneapolis was indicted in the Western District of Wisconsin for a remark he allegedly made in 1918 in a Portage store. He was accused of saying, "This Government was not ready for war. If Mexico were to rise up we could not protect our own country. The President and the Administration are to blame." He was indicted three weeks after the Armistice but his case was dismissed six weeks later.

A Milwaukee machinist was indicted for questioning the constitutionality of the draft law, and a former postmaster at Fall Creek got into trouble for questioning the constitutionality of the Espionage Act. Both cases were dropped without coming to trial, but the circumstances surrounding the Eau Claire County case are worth considering.

Six men called on the former postmaster to see why he had not taken his assigned "quota" of $500 in Liberty Bonds. Allegedly he told them, "The Government of the United States is dishonest. Freedom of speech has been abridged by the espionage law. Freedom of the press has been denied by the espionage law." The solicitors told the commissioner who heard the complaint that they had been chased off with a shotgun, but the ex-postmaster said he did not threaten them. He said he was carrying the gun because they were waiting for him when he came in from hunting. As to the remarks, he admitted criticizing the espionage legislation but denied saying the nation was dishonest. Although he never was penalized under the law, he was under indictment until July, 1920.

The most frequent words quoted in indictments were "rich man's war." The term had been part of the vocabulary of socialists, Wobblies and other anti-capitalist radicals for many years. In the case of the socialists, at least, they were saying the same things in Germany about the capitalist Junkers. Some of the remarks included under this heading were close equivalents, but all indicated a belief that it was a money war.

Since it is impossible to prove the cause of any war—historians have suggested more than 100 causes for the American Civil War, and a century after the shooting seem no closer to an agreement than they were at the time—a statement about its being a "rich man's war" can be considered no more and no less than an opinion. Certainly it is not a false report.[26]

A socialist who ran for the assembly from Sauk County in 1916 was indicated in 1918 for telling two neighbors it was a rich man's war. He pleaded guilty and was fined $500, the same fine imposed on a Medford physician who ran for sheriff as a socialist and made similar remarks during his campaign. A Wood County man was

[26] Anon., "The Espionage Cases," 32 *Harvard Law Rev.* 417 (1919).

sent to the workhouse for three months after pleading guilty to calling the war a "millionaire's graft."

Criticizing Great Britain or France was apparently as serious an offense as criticizing the United States' war effort. The first indictment under the war statutes brought in the Western District was for such remarks. The owner of a Madison hotel allegedly told some draft-eligible Italian-Americans that since the war was being fought for England's benefit they ought to head back to Italy to avoid the draft. At the time of his arrest in August, 1917, the federal district attorney was quoted in the press as saying, "This thing of saying we are fighting for England must stop. I am going to have all such persons tried if I can obtain indictments for them. Any other remarks tending to honeycomb our solid front and to give comfort to the enemy and cause disloyalty among our soldiers will be summarily dealt with if I have my way." The hotel owner pleaded not guilty and was released on bond. Two years later the case was dropped without coming to trial.

The 1918 amendment was a new wrinkle in American law, protecting symbols from offensive words. Nine Wisconsin indictments referred to verbal attacks on the flag or military uniforms.

On August 17, 1918, there was great excitement in the little Racine County town of Corliss. Men and women were scurrying about, stringing up bunting and flags for a Red Cross parade. The town marshal was just stepping back to admire the decorations when he saw a threshing rig heading straight for the biggest American flag, draped from a wire across the main street. Apparently the rig operator did not hear the warnings. Suddenly the top of his stream machine caught the flag, yanked it down, and devoured it.

Three or four men raced out and waved down the operator, who pulled over to the side of the road. Over the terrible roar of the machine, they carried on an animated conversation about how he had ruined the flag.

"Keep the damned flag out of the road," the operator shouted back. "It's a public highway."

Three months later, the operator was indicted for insulting the flag, not as one might expect for tearing it down, but rather for calling it a "damned flag." He pleaded guilty and was fined $200.

As was pointed out earlier, the original excuse for requesting the 1918 amendment was to protect government securities from disparaging remarks. Attacks on Liberty Bonds and Thrift Stamps were quoted in 19 Wisconsin indictments.

For telling three other men that the government "makes men buy bonds so that they can get their wages away from them," and that the bonds would be worthless after the war, a Richland Center socialist was sent to Leavenworth for a year and a day. It cost a man from near Wausau $500 to say that the bonds would not be worth 40 cents on the dollar after the war. Unfortunately for him, he made the remark in the presence of the vice-president of the local Loyalty Legion. A Washburn man told a Liberty Bond salesman that the bonds were no good for the poor man. Tried and convicted nearly a year after the Armistice, he was fined $200.

Truth certainly was no defense, since a Taylor County man was fined $1,250 for saying the money from bonds was being used to help England defeat Germany. A Grant County farmer who said "they can't make us buy any bonds" was fined $600.

Although there was no rationing, a federal Food Commissioner in each state enforced rules against hoarding and profiteering. Eight Wisconsin indictments mentioned criticisms of the food controls; however, of these cases, one stands out because it was one of only two to be reversed on appeal and one of the few to involve a prominent state politician, John M. Becker, circuit court judge at Monroe for 21 years.

Becker was a lifelong Democrat who supported La Follette's stand against the war; in fact, Becker promoted a referendum on whether the nation should enter the war. The election was April 3, 1917, the very day Wilson went before Congress to ask a declaration of war. The vote was 954 to 95 against entering the war.[27]

Two days later, Becker addressed a patriotic rally, urging all citizens to be loyal to the nation once war was declared. He threatened criminal libel actions against those circulating rumors he had been charged with "aiding the enemy." In August, Becker hinted and in January confirmed that he would run for governor on an anti-war platform. His candidacy, however, was short-lived, because the Attorney General announced that Wisconsin law prohibited anyone from holding a judicial post and running for another office.[28]

Becker's troubles were only beginning. In May he was indicted under the Espionage Act for saying on February 5:

> The idea of having an administrator of fuel and food is ridiculous. There is no shortage of food. The idea of a shortage of food is being preached by agents employed by corporations for their own gain, and going about the country on high paid salaries. This is a rich man's war. We won't have peace as long as these high-salaried fellows have jobs to protect. There is no labor shortage. There is no seed shortage. Farmers, beware of taxes, war taxes, which must be paid in July.

---

[27] *Monroe Evening Times,* March 23–April 4, 1917.

[28] *Monroe Evening Times,* April 5–6, May 10 and November 19, 1917, and January 8, 1918.

(His jury refused to convict on a second count based on testimony from a German woman bitter at Becker over settlement of her husband's estate.)

The Circuit Court of Appeals detailed the circumstances surrounding the meeting at which Becker's food remarks were made. Because Green County had failed to meet its quota in the first two Liberty Loans, the state Council of Defense insisted the county council be reorganized. The county board called a meeting for this purpose, but because of a storm, only six of the 27 elected board members showed up. These six got into an informal discussion with 50 or 60 spectators, and in the ensuing session Becker spoke for 15 to 20 minutes. Two witnesses swore that the thrust of his remarks were patriotic and that the statements quoted in the indictment were taken out of context. Other witnesses admitted they were talking among themselves and could not hear what Becker was saying. The appellate court reversed the conviction on the grounds that the words were not unpatriotic. The court also objected to testimony introduced during the trial about how many Liberty Bonds the defendant had purchased and to the fact that one witness gave a Sunday dinner to the other witnesses.[29]

The trial was conducted at Eau Claire in August, 1917. One witness collapsed from the heat. Almost none of Becker's questions were about the food remarks but dealt with personal attitudes and his gubernatorial platform. At one point the special deputy district attorney called the platform "bunk." Two friends helped Becker down from the stand after the long afternoon. The jury consisted of 10 farmers, one miller and one mechanic. After a week of testimony, it took them six hours to convict Becker. Wolfe told reporters he considered the conviction an important one since it might "deter" lesser individuals who might be inclined toward disloyalty.

On August 16, Becker was sentenced to one year in federal penitentiary on each of three counts, the sentences to run consecutively. He was released on $20,000 bond, pending the appeal which was decided October 5, 1920.

Upon his conviction, the state Attorney General ordered Becker to vacate his office. A successor was appointed and sworn in. After the reversal, Becker sued to recover his lost salary, but the Attorney General ruled against him on the ground that state law required resignation only for conviction of an infamous crime and the Espionage Act did not so qualify. The Attorney General told Becker the earlier order had been only "advisory" and that he complied of his own volition.[30]

---

[29] *Becker v. U.S.*, 268 F. 195 (1920).
[30] *Opinions of the Attorney General* (1920), pp. 529–534.

By April, 1917, there were 159 voluntary war relief agencies in the United States, all conducting fund drives. The Red Cross alone collected more than $400 million during the war.[31] Fifteen Wisconsin indictments quoted criticisms of the war agencies. It was in the conviction of Louis B. Nagler of Madison[32] that the legal principle was established that such criticism could be prosecuted under the Espionage Act.

Nagler, like Becker, was a prominent supporter of La Follette. While assistant secretary of state, he published a letter in the Madison paper defending the senator's anti-war stand. His indictment resulted from remarks in November, 1917, to solicitors for the Red Cross. He told them he was through "contributing to your private grafts." He named the YMCA, the YWCA and the Red Cross and said "not over 10 to 14 per cent of the money collected goes to the soldiers or is used for the purpose for which it is collected." His indictment reasoned that since the Red Cross was chartered by Congress, it was a "government agency" within the meaning of the Espionage Act. Although the YMCA and YWCA were not chartered, they were engaged in similar morale work and logically should be covered, too.

Nagler's trial was scheduled immediately before Becker's, and the district attorney made it clear they were to be showcase trials. His jury of 10 farmers, a miller and a railroad employee (five of whom had relatives in the army) wasted little time in convicting.

The Circuit Court of Appeals upheld the conviction, and to the defense contention that such a decision would encompass even the Jewish Relief Agency, the Knights of Columbus and the Salvation Army, the court wrote, "With this position I agree." In July, 1921, the United States Supreme Court remanded the case for a new trial, at which point it was quietly dropped. Nagler certainly was not cowed during the appeal. He even wrote a congratulatory letter to Victor Berger on his fine showing in the 1918 senatorial election.[33]

Among the other 14 Wisconsin indictments which included comments about voluntary agencies, all but one were based on replies to solicitors. The exception was a Milwaukee woman who said it was foolish to sew for the Red Cross since the rich people took all the garments and they never reached the soldiers. Her case was dropped without coming to trial.

The tragedy which brought the war home to many Wisconsin citizens was the sinking of the troop ship *Tuscania* in the spring of

[31] Cutlip, Scott M., *Fund Raising in the United States* 110–139 (1965).
[32] *U.S. v. Nagler,* 252 F. 217 (1918). See Nagler, "A Fragment of War-Time History," 121 *The Nation* 568 (1925).
[33] Nagler to Becker, Nov. 8, 1918, in Socialist Party Papers, Milwaukee County Historical Society, Milwaukee, Box 23.

1918. Soldiers from many Wisconsin communities went down with the ship. Those who lost friends or relatives were not in the mood for snide remarks about the incident.

For example, a Port Huron man went to jail for six months for remarks about the effectiveness of German submarines. One man was fined $300 for saying he hoped the Germans sank every ship that we sent across the sea, while another pleaded guilty to a federal charge arising out of his remark that "All those who go across ought to be at the bottom of the ocean."

Section 3 seemed to be aimed at persons who tried to keep others from fulfilling their duties, either by not registering or enlisting or by disobeying superior officers; still, few prosecutions had anything to do with recruiting.[34]

Fifteen Wisconsin cases did involve some actual counseling. The most prominent man convicted for such an offense was a former state legislator and president of the Marathon County Telephone Company. During his eight-day trial in September, 1918, the prosecution called 27 witnesses, including the secretary of the Cassel town draft board who testified that Schilling had dissuaded more than 70 men from enlisting. The trial judge permitted testimony about his niggardly contributions to war charities and about his alleged hoarding of food, although neither was mentioned in the indictment. The jury was out only three hours before convicting. The next day the judge sentenced him to 18 months in prison plus a $3,500 fine.

A Lithuanian who had lived in this country for 16 years went to prison for a year and a day for saying he would not register and for telling others they were fools for doing so. A Racine man allegedly advised some Armenians not to report for the army if called, and he too was sentenced to a year and a day.

Four other indictments cited remarks questioning the legality, not of the draft but of sending drafted men overseas; however, none of these cases came to trial.

## Trading Act

During the summer of 1917, the House devoted three days and the Senate two to enacting this omnibus measure, whose primary purpose was to establish guidelines for seizing and holding property owned by alien enemies, particularly German corporations. Not until the final 15 minutes of debate was there any mention of a provision affecting expression, and then there were two. One was virtually a carbon copy of the new Section 3 later added to the

---

[34] Apparently no prosecutor even attempted to prove injury to military procurement or allow a jury to consider possible effects of utterances. Nelles "In the Wake of the Espionage Act," 111 *The Nation* 684, (1920).

Espionage Act. After its defeat (because the sponsoring Commerce Committee did not want such an unrelated section in the act), Senator William H. King then proposed a requirement that all German-language publications print a parallel English translation. Penalties were to be $500 or a year in prison. King explained that he earlier had proposed a total ban on foreign-language publications, but that this measure was bottled in committee. The Utah Democrat asserted that his regulation "certainly works no great hardships" on any publisher while at the same time providing a good check on sedition for the postal officials and for neighbors. A spokesman for the Commerce Committee said he thought the Postmaster General already had sufficient censorship powers under the Espionage Act and expressed the hope that this irrelevant section would not be tacked on to the Trading Act. It was anyway, and the bill went to conference committee. The committee greatly expanded the mail section to cover publications in any foreign language. Instead of publishing English translations in adjoining columns, publishers now had to file such translations in advance of publication with local postmasters. Only material which dealt in some way with the war was covered by the requirement. The Speaker overruled objections that the conferees had exceeded their authority by adding new classes of crimes to the mail section, and the House adopted the report by voice vote.[35]

Most of the newspapers affected by the new regulations were one- or two-man operations, working on a tiny financial margin. Because filing translations cost both time and money, many foreign-language newspapers closed down. Others began publishing in English or tried to make their contents totally bland. That the latter tactic was not always successful for avoiding trouble with the federal officials is illustrated by the Auer case, described below. Auer's was one of seven actions brought under the Trading Act in Wisconsin. Three of the actions involved possession of explosives and had no expression connotations and are not considered here. Four actions did involve expression under the mail section of the Trading Act. One of these was a joint action with the Espionage Act.

Jacob J. Auer, a crotchety old man, was the editor and publisher of a little German-language weekly, the Eau Claire *Herold*. Most of his readers apparently were about his age. The younger generation had learned English in the schools and read "American" publications instead. Even his closest friends and relatives testified that old Jacob was senile and that sometimes he "acted strangely." He had been in this country more than 30 years and had been bitterly

---

[35] *Congressional Record,* 65 Cong., 1st Session, 4840–4879, 4907–4930, 4968–4989, 6949–6958, 7007–7025.

disappointed a few years before the war when he was not appointed postmaster of Eau Claire.

In his edition of December 6, 1917, Auer published an editorial entitled, "Uncle Sam's Army Threatened by Slow Destruction." The menace he was describing was not the German army, but the United States Army's policy of giving all its recruits smallpox vaccinations. The article was long, rambling and none too coherent. Auer did not file a translation of it with the postmaster for advance clearance, nor did he submit the next week's issue, which quoted Hindenberg as charging the United States had used the submarine as an issue to enter the war on the side of the Allies. His December 27 edition carried an editorial which suggested Germany's enemies were on the verge of collapse. In subsequent weeks, he attacked those citizens who were persecuting everything which was German, praised the German-Russion peace treaty and cautioned his readers not to believe everything they read in the press about how many German ships the Allies were sinking. He did not file translations of any of these articles, the local postmaster told a citizens' protest committee meeting which met on March 15. The postmaster said Auer had filed translations of some other articles and editorials, however. The public meeting, which was sponsored by the county Council of Defense passed a resolution "to personally notify J. J. Auer that his attitude on the war, as expressed by said articles is seditious and disloyal, and warn him against publishing like articles in the future."

Auer hardly had the opportunity, since he was arrested by the federal marshal eight days after the meeting. The marshal waited until after Auer had put out that week's issue before taking him to Madison for arraignment. He was formally indicted in June, 1918, under both the Espionage and the Trading Acts.

He first entered a plea of not guilty and then tried to change it to *nolo contendere*. The special assistant federal district attorney objected because such a plea carried with it only a fine, not imprisonment. The judge refused the plea and Auer pleaded guilty.

Before sentencing, a Civil War veteran and long-time friend of Auer spoke on his behalf. He said there had been a noticeable decline in Auer's mental capacity during the last two years, a fact confirmed by both Auer's wife and his son. His relatives testified that the old man had purchased Liberty Bonds and had contributed to the Red Cross and other fund drives. The son told the judge that he did not think that his father really understood the translation regulation.

The prosecution charged the judge to show no mercy in assigning sentence. The judge said he was unmoved by the claims of mental incompetence since the articles seemed clearly written to him; however, he would be merciful because of Auer's advanced age. His version of mercy was a year and a day at Leavenworth.

If Auer's case seemed somewhat pitiful, consider the fate of poor Jacob Mueller, who edited the German-language *Dodge County Pioneer* at Mayville. In his edition of August 16, 1918, he ran a front-page story about Auer's conviction, adding at the end:

> Since October 6, 1917, the German newspapers have been under the knout and have not been permitted to print any war news unless a true translation is filed with the postmaster. Since we have no desires to pester police with translations we print absolutely no war news. We are not going to be caught.

Mueller was wrong about that. The district attorney thought Auer's conviction was "war news." With some earlier articles, this one formed the basis for his indictment in March, 1919. Mueller pleaded guilty and got off with a $50 fine. After all, the war had been over for four months.

Until March 4, 1918, there had been two German weeklies in Mayville, but on that date the *Dodge County Banner* had switched to English. Ever since, it had been attacking Mueller for supporting Victor Berger and for having no principles. When Auer was convicted the opposition paper wondered editorially if Mueller would relay that information to his readers. He did, much to his later regret.

On October 24, 1918, about two weeks before a special Senate election in Wisconsin in which he was a candidate, Victor Berger and four other officials of the Milwaukee *Leader* were indicted under both the Trading and Espionage acts. Among other charges, they allegedly had failed to file translations of some letters to the editor which had been written and published in German. The five were released on bond and the case finally was dropped in 1922.

## Sabotage Act

That there were few prosecutions under this broad statute, which punished "malicious destruction or injury to property, no matter how essential the property might be to the conduct of the war," probably can be attributed to the fact that it was enforced by the Justice rather than the Post Office Department and that it was not signed until less than seven months before the Armistice. It is ironic that the federal government waited so long to prohibit overt acts of sabotage when it was so prompt to prohibit speech which might incite such overt acts.

There were three actions under the Sabotage Act in Wisconsin, two of them against employees of the E. I. du Pont Demours Company powder plant at Barksdale in Bayfield County. Plant guards were deputized by the sheriff and they kept a wary eye on "agitators." They were also stringent in their enforcement of the rule against having matches within the plant gates. One employee was arrested in July, 1918, and charged under the Sabotage Act for carrying four concealed matches in his socks. Two weeks later another employee was arrested for carrying 12 matches in his socks.

In the only Sabotage Act case tried in Wisconsin, a Milwaukee man was convicted by a jury for throwing ice tongs into plant machinery; however, the trial judge ordered the case dismissed for reasons not made clear in the preserved record.

There was a marked difference in enforcement in the two districts of Wisconsin. Not only were half as many persons indicted under the Espionage Act in the more populous, more socialist, more German Eastern District, but a far higher proportion of cases were dismissed without coming to trial. Table II compares the activity in the two districts.

Apparently the major variable was the vigor of the enforcers. Certainly the laws were interpreted quite differently by different federal judges.[36] Chafee pointed out that although Massachusetts

[36] The Department of Justice issued 204 "Interpretation of War Statutes" bulletins in an effort to increase consistency.

TABLE 2. ACTIONS UNDER FEDERAL WAR STATUTES IN WISCONSIN

| | No. | Pled Guilty | Convicted | Acquitted | Dismissed |
|---|---|---|---|---|---|
| Espionage | | | | | |
| East | 30 | 2 | 1 | 2 | 25 |
| West | 60 | 30 | 17 | 3 | 8 |
| Threats | | | | | |
| East | 3 | 0 | 1 | 1 | 1 |
| West | 7 | 5 | 1 | 0 | 1 |
| Trading | | | | | |
| East | 3 | 1 | 0 | 0 | 2 |
| West | 1 | 0 | 1 | 0 | 0 |
| Sabotage | | | | | |
| East | 1 | 0 | 1 | 0 | 0 |
| West | 2 | 0 | 0 | 0 | 2 |
| Total | | | | | |
| East | 37 | 3 | 3 | 3 | 28 |
| West | 70 | 35 | 19 | 3 | 11 |
| GRAND TOTAL | 107 | 38 | 22 | 6 | 39 |

had large military posts, a major port of embarkation, many war plants, and a large alien enemy population (to say nothing of the anti-English population of Irish), there was not a single Espionage Act indictment in the Bay State. The District Attorney simply refused to bring any, and Chafee said there was no rash of sabotage there as a result.[37]

Even more striking was the contrast in punishments in the two districts. In the East, the three defendants who pleaded guilty were fined a total of $900, and none of them went to prison. The three convicted in the Eastern District each went to Leavenworth for a year.

By contrast, the 35 defendants who pleaded guilty in the West were fined $600 but sentenced to 28 years and 2 months in prison. The 19 convicted were fined $13,100 and sentenced to prison and workhouses for a total of 26 years and 3 months.

The only prison sentences of more than a year and a day came in the Western District, where one man (Becker) was sentenced to three years, two others to two years, one to 18 months and another to 15 months. All were for violations of the Espionage Act. Thirteen men (10 of them in the West) received the year-and-a-day sentences. Eleven others were sentenced to terms of 30 days to six months in various county workhouses.

The two heaviest fines were both in the Eastern District and both were for violations of the Espionage Act. One man was fined $2,000 and another $1,250. No other fine exceeded $500.

In total, the 96 men convicted or entering guilty pleas to war statute violations of the Espionage Act in the two Wisconsin courts were sentenced to 57 years and 5 months in prison or workhouses[38] and fined $14,600.

During World War II, there were almost no actions against "disloyal" expression under any of these five laws, although all were on the books in slightly altered form. There were no such actions in Wisconsin. The civil liberty picture of World War II was a much brighter one in spite of the blot of the Japanese evacuation. Perhaps it was because the Administration was more enlightened, or the society was less naive, or there were fewer internal threats. Or perhaps it was because the nation profited from the black mass of World War I.

---

[37] Chafee *op. cit., supra* note 1, at pp. 59–60.

[38] If Berger had not been convicted of Espionage Act violations and sentenced to 20 years in the Northern District of Illinois, *Berger v. U.S.*, 255 U.S. 22 (1921), it is likely he would have been tried on one of the three cases pending in the two Wisconsin federal courts; in such case, Wisconsin's penalty total might have been 20 years higher.

# POLICE IN A LARGE SOUTHEASTERN WISCONSIN COMMUNITY

*John C. H. Oh*

ABSTRACT

This is a study of the local law enforcement personnel, who not only possess but often exercise a great deal of discretionary power in the course of administering the laws and ordinances in their local communities. Their general attitudes and the manner of contacting with the public have very important consequences upon the society. Yet, we know very little about these people.

The present study is based on the analysis of the survey questionnaires returned by police officers of a large southeastern Wisconsin community. It was designed to answer the following three questions:

1. How the police officers felt about the role of the Supreme Court in the criminal justice system in American society, particularly in regard to some of the recent Court decisions dealing with the constitutional rights of the suspect—in the area of criminal law and procedures;
2. How they felt about the law and order—their general attitudes toward violence, civil rights, and social order;
3. And, how they felt about themselves—their general attitudes toward their work and status in the community.

The study shows that police officers generally have a very low regard toward the U. S. Supreme Court, that the majority of police officers tend to develop an inferiority complex in their work (because they believe that the public does not extend due recognition to the police officers), and that they are excessively protective of their own work and quite unreceptive to any kind of criticism toward the police officers everywhere. It must be cautioned that these findings are only preliminary and suggestive; however, any concerned reader cannot help but to conclude that it is an urgent national task to intensify our efforts to train the police officers with the ideals of democracy and constitutionalism either through in-service or out-service training, or both.

## INTRODUCTION

In recent years social scientists have made some significant contributions to the understanding of two related questions concerning the community power structure—"where power lies" and "who makes decisions" in the political communities. Consequently, we probably know more about the "men at the top" at both governmental and non-governmental levels in various political communities than ever before.[1] On the other hand, we know very little about the middle and/or lower level of the governmental personnel, because the same social scientists have generally shunned conducting any systematic studies on them. One such area of neglect is the local law enforcement personnel. These people—whether they are called constables or sheriffs or police officers—not only possess but often exercise a great deal of discretionary power in the course of administering the laws and ordinances in their local communities. Their general attitudes and their manner of contact with the public have very important consequences for the society.

The present study is based on the analysis of the survey questionnaires returned by 55 of 73 police officers of the Waukesha Police Department during the period of October 14–21, 1968. A brief description of the community being surveyed is in order. Waukesha has experienced one of the most rapid population increases among Wisconsin's cities and is a city of 36,339 people according to a special census of 1966, as compared to 30,004 in 1960 and 21,233 in 1951. (Waukesha County, which is seated in the city, had an increase of 326.5% during the period 1910–60, which was the fastest population growth rate among the state's 70 counties.) The city was the fourth largest in the Greater Milwaukee Standard Metropolitan Statistical Area,[2] which in 1968 contained an estimated population of 1,458,100, of which only 83,931 (or 5.8%) were Negro. The city itself had only a dozen or so Negro families, since the bulk of the Negro population in the area resided in the central city (Milwaukee). It must be noted, however, that the city is not a suburb of the central city in the strictest sense, because it is a booming industrial community on its own with a number of nationally-known manufacturing firms (i.e. It had some 23 banking and savings and loan associations with total assets of over $150 million at the end of 1966).[3]

---

[1] See Floyd Hunter, *Community Power Structure* (1953), Robert Presthus, *Men at the Top* (1964), Robert A. Dahl, *Who Governs?* (1961), and Arnold M. Rose, *The Power Structure* (1967), among others.

[2] The area covers at least 38 separate governmental units which include four counties, 15 cities, 15 villages, and four towns.

[3] *U.S. Census of Governments, 1962;* State of Wisconsin, *Blue Book, 1968;* Milwaukee Sentinel, *1969 Wisconsin Almanac* (January 7, 1969).

Politically, Waukesha residents have generally voted for Republican candidates. In the latest election they again voted heavily Republican for the presidency, the state-wide ticket (for the governor and four other constitutional officers), the state assemblyman, the state senator, and for the U. S. congressman. The only Democrat who received the plurality of votes in the city was an independent-minded, popular U. S. senator.

As far as the incidence of crime is concerned, it was reported that Waukesha had a total crime index of only 295 in 1967, which was not only far below the national average of similar size cities but also lower than the state average of 1,121.1 and that of the Milwaukee SMSA's 1,613.2. This lower crime incidence may be partially due to the fact that Waukesha's full-time police employee rate of 1.8 was far in excess of an average number of officers per 1,000 inhabitants for the same size communities in the state and the nation as a whole.[4]

The present study was designed to answer the following three questions:

1. how the police officers felt about the role of the Supreme Court in the criminal justice system in American society, particularly in regard to some of the recent Court decisions dealing with the constitutional rights of the suspect in the area of criminal law and procedures;
2. how they felt about law and order—their general attitudes toward violence, civil rights, and social order;
3. and, how they felt about themselves—their general attitudes toward their work and status in the community.

We felt that October, 1968, was the most opportune time for this type of study because many of the questions used in the survey were the same kind of issues raised by the various candidates in their election campaigns. Our actual subjects included 37 uniformed patrolmen and 18 detectives and police executives. The data in *Table 1* show that there were some marked differences between these two groups of officers, in that patrolmen were in general younger (51% under age 30 compared to only one of 18 detectives in that age group), better educated (38% to 17% for some college work), and less experienced in police work (an average of six years service for the former as compared to 13 years for the latter) than detectives and executives.

---

[4] Federal Bureau of Investigation, *Uniform Crime Reports, 1967* (August 27, 1968).

TABLE 1. AGE AND EDUCATION OF POLICE OFFICERS

| AGE | ALL POLICE OFFICERS* (NUMBER: 55) | UNIFORMED PATROLMEN (NUMBER: 37) EDUCATIONAL BACKGROUND | | | | DETECTIVES AND EXECUTIVES (NUMBER: 18) EDUCATIONAL BACKGROUND | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Some H. S. | H. S. | Some College | Total | Some H. S. | H. S. | Some College | Total |
| Between 21–30 | 36% | — | 7 | 12 | 51% | — | 1 | — | 6% |
| Between 31–40 | 40% | — | 12 | 2 | 38% | — | 7 | 1 | 44% |
| Between 41–50 | 18% | 1 | 1 | — | 5% | 2 | 4 | 2 | 44% |
| Over 51 | 6% | — | 2 | — | 6% | — | 1 | — | 6% |
| | 100% | (1) 3% | (22) 59% | (14) 38% | 100% | (2) 11% | (13) 72% | (3) 17% | 100% |

*All officers educational backgrounds: Some H. S. (3) 5%; H. S. (35) 64%; Some College (17) 31%

## On the Supreme Court and the Criminal Justice

Our study shows that police officers generally have a very low regard for the U. S. Supreme Court, to such an extent that the very legitimacy of the highest court is being questioned. Almost unanimously (93%), they felt that the Court in its recent decisions dealing with criminal law and procedures has reduced sharply the effectiveness of the police. However, it was found that such general negative attitudes toward the Court did not prevail consistently when we asked them a series of questions concerning their particular attitudes toward several selected court decisions which dealt with the constitutional rights of the suspect. They were specifically asked about these five decisions of the Court: *Miranda vs. Arizona* (1966); *Mapp vs. Ohio* (1961); *Mallory vs. U. S.* (1957); *Gideon vs. Wainwright* (1963); and *Escobedo vs. Illinois* (1964). (In asking their reactions to these cases, we described the essence of the decisions and elicited their reactions, instead of by the official legal citations.)

First, as to their reactions to the *Miranda* decision, we asked the police officers whether the Court ruling that requires them to inform a suspect of his constitutional rights before questioning him interfered with their performance of duties. The data[5] show that a great majority of detectives and executives (72%) who must question the suspect in the course of their investigatory work felt that it interfered with their work, while only 22% felt it did not. The uniformed patrolmen were almost divided evenly. This change of attitude (from their general negative attitude toward the Court) is very significant in view of the fact that the *Miranda* decision was the most comprehensive requirement laid down by the Court to protect the constitutional rights of the suspect from being infringed upon by the law enforcement officials.

Surprisingly, in the next three cases we find that there were more police officers agreeing with Court opinions than disagreeing. In the *Mapp* decision, 49% agreed with the Court that evidence obtained by illegal searches and seizures cannot be introduced into a state court, while 47% opposed it. In the case of the *Mallory* decision, only 71% felt that the Court decision (requiring a prompt arraignment of the suspect) is a reasonable one, but 80% stated that it did not interfere with their work in any way. The overwhelming majority (82%) also said that they agreed with the *Gideon* decision (which requires a state to provide free counsel for defendants who cannot afford a lawyer).

---

[5] Additional statistical supporting data are deleted throughout the paper. They are, however, available from the author upon request.

The police officers in general find the *Escobedo* decision most objectionable. The Court in 1964 ruled in this case that a defendant has a right to have his lawyer with him when he is being questioned by police officers. Seventy-one per cent of the respondents (83% of the detectives and executives and 65% of the uniformed patrolmen) indicated that this decision interfered with their investigative work. Altogether 56% of the officers felt that it was a bad decision. It must be emphasized that what they objected to most was not that the defendants should be given free counsel to defend themselves but the Court ruling that permits the presence of a lawyer at the time of their questioning of the suspects. In this sense, the *Escobedo* case is the main cause of the Supreme Court's unpopularity among the police officers.

## On Social Order, Violence and Civil Rights

Our study shows that police officers are generally conservative toward issues such as social order, violence and civil rights. We first asked them the following open-ended question: "There is much discussion over the police action that took place during the 1968 Democratic National Convention in Chicago. Please indicate how you feel about the incident, including whether or not you feel that the Chicago police over-reacted in the situation." Almost all the respondents (95%) felt not only that the Chicago police did not over-react in the controversial incident but also that what they did was proper because, as one officer indicated, "the demonstrators were forewarned and if they didn't want to get hurt they should not have been there." Not one officer said that the Chicago police should have handled the situation differently—in direct contrast to the findings of the Walker Report. Even with Chicago Mayor Daley's very controversial order "to shoot to kill the looters" (as reported by the mass media during the disturbances), only 11% indicate that they did not agree with the mayor.

When asked "How do you feel about alleged police brutality?" 83% of the officers claimed that not only does it not exist but such a charge is part of a conspiracy to undermine the police throughout the country. In reply to another question on civil disorders in our cities and college campuses, 96% of the officers stated that maximum (rather than minimum) force should be used in quelling such disorders. A substantial majority (69%) also felt that there is too much violence on T.V. and in the movies.

It is significant to note that police officers in general felt that in order to stem the rising crime rate the criminal offenders must be given much stiffer penalties than they receive now. Fifty-one per cent of the officers (61% of the detectives and executives and

46% of the uniformed patrolmen) favor capital punishment for persons convicted of crimes such as first degree murder, kidnapping, sabotage or treason, in spite of the fact that the state of Wisconsin does not allow capital punishment. When asked "whether they felt we needed stiffer penalties in cases involving misdemeanors and/or felonies," 64% indicated that there should be stiffer penalties for misdemeanors, and almost all the officers (97%) felt the same way toward felonies (the major crimes). In a near unanimous opinion, they opposed the parole system as now being practiced in the United States, because they strongly feel that when a criminal is given a specific sentence—whether it is life imprisonment or a specified number of years of confinement—he should be forced to serve it without being released on parole.

Politically, too, police officers generally leaned toward the conservative side. They have a higher voting turnout than the general population, for 78% of them voted in 1964 (it would have been much higher if 12% were not under the voting age). In that election year, of those who revealed their actual vote (69%), they voted almost two to one in favor of Johnson (45%) to Goldwater (24%). However, when asked "Which of the candidates (Nixon, Humphrey, Wallace) have you decided to vote for in 1968?" 35% favored Wallace, 33% Nixon, 5% Humphrey, while 27% were either undecided or gave no response. What surprised us most was that this particular community had not experienced any civil disorder *per se* in recent years, and yet in view of their general attitude toward law and order, a substantial majority of officers (68%) were attracted to either Wallace or Nixon.

## On the Role and Status Perceptions of Police Officers

Generally, police officers possessed a strong sense of community service, dedication, and altruism. Sixty per cent of all police people and at the same time serving the community best through law enforcement work. Another 29% felt that the profession gave them a sense of job security. Only 4% felt that police work gave them excitement and adventure not to be found in other lines of work, while 2% chose it because of family tradition.

However, they also agreed that the general public does not extend due recognition to the police officers. The data show that although higher ideals motivated them to choose the law enforcement profession, a majority of police officers (58%) tend to develop an inferiority complex in their work, for they believe that the public generally tends to look down on them socially. Eighty per cent of the officers also felt that they are not being rewarded in terms of salaries and fringe benefits as they think they deserve. (This salary schedules of this police department ranged from about $580 to $900 per month depending upon rank and seniority of the officers). One surprising finding was that when asked whether they would advise young people to go into police work, 74% answered affirmatively. It suggests that their lower reputational perception is largely due to the general public's apathy toward police work, because most police officers believe that they are contributing something positive to the general well-being of the community.

Finally, it must be pointed out that police officers are not only conscious of their own status but quite defensive about their work and the police everywhere. We have already shown how sensitive and defensive they were to the charges of police brutality and the Chicago convention incident. To further check on this feeling we asked them the following question: "What educational requirements do you feel police officers should have?" The data show that 51% of all the respondents felt that education beyond high school is needed, but only 4% felt they should have a college degree. There is, however, marked difference between the relatively younger uniformed patrolmen and the somewhat older detectives and executives, since 60% of the former stated that police officers should have more than a high school education as compared to only 34% of the latter. These attitudes tend to reflect their own educational background, for within this department not only is there no single college graduate but the formal education of the detectives and executives is comparatively lower than that of the uniformed patrolmen. (In this connection, it is interesting to not that the governor of Wisconsin early this year proposed the establishment of a state-run police academy to train all police officers within the state.)

## Conclusion

These findings are not entirely unknown, for both the Kerner Report and the National Crime Commission Report made it clear that police officers in general have one of the lowest formal educational attainments among all the professional groups in the country. Some of the disturbing findings are that:

1. The majority of police officers tend to develop an inferiority complex in their work, in spite of the higher ideals that motivated them to choose the police profession (because they believe that the public does not extend due recognition to the police officers).
2. They are excessively protective toward their own work and quite unreceptive to any kind of criticism toward police officers anywhere (e.g. their reactions to the Chicago violence).

3. They generally believe that social order can best be maintained by the maximum use of force by law enforcement officers and by imposing much stiffer penalties upon the criminals than they are given today.
4. They apparently have very little faith in the Supreme Court of the United States—the highest court deciding questions of law and the official body for interpreting the U.S. Constitution.

It must be cautioned that these findings are only preliminary and suggestive; however, any concerned reader cannot help but conclude that it is an urgent national task to intensify our efforts to train police officers with the ideals of democracy and constitutionalism either through in-service or out-service training, or both. It may well be that eventually education beyond high school (either college education or relevant police education through police academies or special institutes) must become the mandatory requirement for all those who seek a police career.

# TRENDS IN WISCONSIN'S TOURIST–LODGING INDUSTRY

*L. G. Monthey*


### Highlights

This research study included all of Wisconsin's lodging establishments that were inspected by the State Board of Health during the years 1961 to 1968, inclusive. It reports significant changes in the number, distribution, seasonality, size, and type of tourist-lodging establishments in that period.

Wisconsin lost 1,019 establishments between 1958 and 1968; approximately two-thirds of these were seasonal businesses, primarily resorts. However, the State's total capacity in bedroom units (B.U.) has remained near 80,000 for 11 years or longer.

Since 1961 the total number of hotels dropped 21%; resort-type businesses declined 14%; motel establishments increased 16%.

Small establishments with less than 10 B.U. decreased 16%, while the number of large enterprises (30 B.U. or more) increased 17%.

Motels were the only type of T–L establishment that increased in all size classes, seasonal and year-round, during the 8 years.

Among the seasonal establishments (open 9 months or less) only the motel-type business showed a gain in both firms and B.U. capacity. Likewise, motels were the only type to show a large increase in average size, going from 13.8 to 18.5 B.U. in 8 years.

The number of year-round establishments also declined, but their total B.U. capacity went up about 5,000 during the period. The number of year-round resorts dropped 14% between 1961 and 1968.

The biggest losses in both number of establishments and total B.U. capacity occurred in the northeast and northwest regions of Wisconsin.


Tourist accommodations, and the housing enterprises which provide them, are an important part of Wisconsin's $900 million travel–recreation industry. However, significant changes have taken place within this business since 1960. This study is an attempt to determine and measure some of these changes over a period of years, also to identify and quantify the important trends that are taking place in the tourist-lodging industry (hereinafter referred to as the "T–L industry"), which is in a state of rapid transition.

The methods used are similar to those employed in an earlier study entitled "The Resort Industry of Wisconsin." (Wis. Acad. Transactions, Vol. 53/Part A/ 79–94, 1964.)

In order to obtain comprehensive inventories of Wisconsin's T–L business, State Board of Health inspection records and mailing lists for the years 1961 through 1968 were used. The appropriate data were coded for each establishment, transferred to IBM cards, and the results compiled by data-processing techniques. Four major categories were used in classifying T–L businesses: (1) Hotel type; (2) Motel type; (3) Resort type; (4) Other. The establishment's name was used to categorize each business, and each category was then studied in detail as to the distribution, number, size, and seasonality of the establishments it contained.

## An Eleven-Year Look

Thanks to an earlier study of the tourist-overnight accommodations in Wisconsin,* we can go back to the year 1958 for some limited data on the total number of establishments, their seasonality and bedroom unit (B.U.) capacity. This enables us to trace a few of the major trends over an 11-year period (1958–68).

The number of T–L establishments has declined markedly, but the total capacity for housing visitors has held its own. In 1958 there were 7,842 firms offering about 79,000 B.U. to the traveling public. By 1968, the number of businesses had dropped to 6,823—a decline of 1,019 establishments—but the total B.U. capacity remained near 80,000 units. (Note Tables 1-a and 1-b.)

A seasonal establishment is one which operates less than 9 months during a given year. Of the one thousand T–L establishments that have disappeared since 1958, over two-thirds were seasonal in nature and predominantly resort-type businesses, as we shall see later. It is noteworthy that the greater part of this decline, both in total establishments and in seasonal businesses, has occurred since 1965. This suggests that certain trends, at least, have accelerated during the past few years.

Tables 1-a and 1-b show not only the big losses in T–L establishments—673 seasonal and 346 year-round—over the 11 years, but also a substantial drop of almost 5,000 in seasonal B.U.

* By Fine and Tuttle, School of Business, University of Wisconsin.

Table 1-a. Overall Summary: Changes in the total number and seasonality of Wisconsin Tourist-Lodging Establishments during the period 1958–1968.

| Year Studied | Seasonal Establishments | Year-round Establishments | Total No. Establishments | % Seasonal Businesses |
|---|---|---|---|---|
| 1958 | 5,668 | 2,174 | 7,842 | 72.3 |
| 1961 | 5,733 | 1,983 | 7,716 | 74.3 |
| 1965 | 5,638 | 1,827 | 7,465 | 75.5 |
| 1968 | 4,995 | 1,828 | 6,823 | 73.2 |
| Change (1958–68) | (−673) | (−346) | (−1,019) | |

TABLE 1-b. OVERALL SUMMARY: CHANGES IN THE TOTAL NUMBER AND SEASONALITY OF BEDROOM UNITS (B.U.) AVAILABLE AT WISCONSIN TOURIST-LODGING ESTABLISHMENTS DURING THE PERIOD 1958–1968.

| YEAR STUDIED | SEASONAL B.U. | YEAR-ROUND B.U. | TOTAL NO. B.U. | SEASONAL B.U. (AS % OF TOTAL) |
|---|---|---|---|---|
| 1958 | 47,577 | 31,533 | 79,110 | 60.1 |
| 1961 | 47,608 | 32,690 | 80,298 | 59.3 |
| 1965 | 47,085 | 34,719 | 81,804 | 57.6 |
| 1968 | 42,611 | 37,087 | 79,698 | 53.5 |
| Change (1958–68) | (−4,966) | +5,554 | +588 | |

## AN EIGHT-YEAR STUDY

We now depart from an 11-year comparison and concentrate on a more detailed 8-year analysis of T–L establishments. Except for the above-mentioned tables, all of the remaining statistical material—including figures and discussion—relates to the period 1961–68 inclusive. Generally speaking, data for the years between 1961 and 1968 are not included herein, since most of the changes and trends observed are quite consistent throughout the period studied. Thus, virtually all of the data used here relate only to the years 1961 and 1968.

Despite changes in the number, type and distribution of T–L establishments, the total visitor-housing capacity has remained near 80,000 B.U. and has not varied as much as 3% since 1958. However, the number of year-round B.U. has increased about 5,000 since 1961, reaching a high of 37,087 in 1968. A comparable decline in seasonal B.U., from 47,600 to 42,600, has tended to offset this gain. In other words, 60% of all B.U. were provided by seasonal establishments in 1961 as compared to only 53% in 1968. It is interesting to note, however, that about 73% of all establishments, statewide, were classed as seasonal in both years.

Table 2 involves the main categories of T–L establishments and includes the total B.U. capacities and number of firms under each category for the years 1961 and 1968. A few definitions may be in order at this point.

## SOME DEFINITIONS

A *hotel* is defined as a lodging house, usually more than two stories high, having five or more bedroom units and (usually) a public lounge or lobby plus food service. Most Wisconsin hotels were built prior to World War II.

TABLE 2. OVERALL SUMMARY: CHANGES IN THE TYPE AND B.U. CAPACITY OF WISCONSIN TOURIST-LODGING ESTABLISHMENTS BETWEEN 1961 AND 1968.

| Type of Establishment | 1961 | | 1968 | | 1961–68 Changes | |
|---|---|---|---|---|---|---|
| | No. | B.U. | No. | B.U. | No. | B.U. |
| Hotels | 583 | 19,567 | 457 | 15,971 | (−126) | (−3,596) |
| Motels | 915 | 12,600 | 1,056 | 19,505 | +141 | +6,905 |
| Resorts | 4,761 | 40,465 | 4,101 | 36,255 | (−660) | (−4,210) |
| Other | 1,457 | 7,666 | 1,209 | 7,967 | (−248) | +301 |
| Totals | 7,716 | 80,298 | 6,823 | 79,698 | (−893) | (−600) |

A *motel* is a T–L establishment, usually on one level and seldom with over two floors, having five or more bedroom units and a convenient auto-parking space on the premises at no extra charge to the guests. The distinction between hotels and motels is usually quite clear for the small establishments with fewer than 20 B.U. However, there is almost no definable difference between medium-sized and larger hotels and motels (usually called motor hotels), except for structural age. Virtually all of the latter are less than 20 years old, whereas very few hotels of the traditional type have been built since 1950. In any case, our motel category includes the newer motor hotels.

A *resort* is defined as a T–L business situated in or near a scenic and/or recreational environment. In Wisconsin a resort-type establishment is usually on or near the water, either a lake or river, but not always.

Our fourth category of establishments, designated as "Other", includes all types of T–L businesses that cannot be identified under the three classifications listed above.

As Table 2 shows, there have been some significant changes in the types of T–L establishments between 1961 and 1968. Hotels and resorts have diminished in number. The hotel total dropped from 583 to 457 during the 8 years, a decline of over 20%. Motels, on the other hand, increased by 15% and showed a gain in capacity of almost 7,000 B.U. The totals for resort-type establishments show a loss of 660 firms and a drop of about 4,200 B.U. since 1961. The "Other" (miscellaneous) category of T–L establishments had a significant loss in the number of businesses, but it gained about 300 B.U. during the 8 years. This group is predominately tourist homes and rooming houses, but youth camps, guest farms, dude ranches, and many other kinds of housing facilities are included among its 1,209 establishments.

In 1961 resort-type establishments comprised 61.7% of all T–L businesses in Wisconsin; in 1968 they still made up 60.1% of the total. Meanwhile, the motel category increased from 11.8% to 15.5% of the total in just 8 years, and the hotel group declined from 7.6% to only 6.7%.

## Size of Establishments

As Table 3 indicates, there were some noteworthy changes in the size of housing establishments during the 1961–68 period.

In 1961, for example, the average size of T–L establishments was about 10.4 B.U.—ranging from 8.3 B.U. for seasonal properties to 16.5 for year-round businesses. By 1968 the over-all average had increased to almost 12 B.U. per establishment, with the seasonal businesses showing only a slight increase to 8.5 B.U. and the year-round operations rising sharply to 20.3 B.U. in average size.

The number of small establishments has been dropping rapidly, especially since 1965. Those with less than 10 bedrooms comprised 64.7% of all lodging places in 1961, but they declined to 61.3% of the total by 1968. In 1961 there were 4,995 such businesses offering a total of 23,046 B.U. to the public. Eight years later there were 4,181 establishments and 19,229 B.U. in this 1-to-9 size class, which reflects a loss of 814 establishments and 3,800 B.U. between 1961 and 1968. This drop, the largest in any size group studied, was especially noticeable in the 5-to-9 B.U. range.

The intermediate group of establishments with 10 to 19 B.U. also declined in number, dropping from 1,937 to 1,806 properties and showing a loss of almost 1,500 B.U. during the 8 years. This group, however, still makes up a substantial segment of the industry. It included 25.1% of all Wisconsin T–L businesses in 1961 and 26.5% in 1968, providing about 30% of the State's 80,000 B.U. in the latter year.

Table 3. Overall Summary: Changes in the Size Classification of Wisconsin Tourist-Lodging Establishments between 1961 and 1968.

| Size Class of Establishment | 1961 | | 1968 | | 1961–68 Changes | |
|---|---|---|---|---|---|---|
| | No. | B.U. | No. | B.U. | No. | B.U. |
| 1-to- 4 B.U. | 2,682 | 7,353 | 2,325 | 6,467 | (−358) | ( −886) |
| 5-to- 9 B.U. | 2,313 | 15,693 | 1,857 | 12,762 | (−456) | (−2,931) |
| 10-to-19 B.U. | 1,937 | 25,366 | 1,806 | 23,888 | (−131) | (−1,478) |
| 20-to-29 B.U. | 458 | 10,610 | 461 | 10,662 | +3 | +52 |
| 30-to-99 B.U. | 277 | 12,643 | 308 | 14,352 | +31 | +1,709 |
| 100 and over | 49 | 8,633 | 66 | 11,567 | +17 | +2,934 |
| Totals | 7,716 | 80,298 | 6,823 | 79,698 | (−893) | ( −600) |

It is probably significant that all size categories under 20 B.U. per establishment showed substantial declines in capacity, with a total loss of 945 businesses and 5,295 bedroom units between 1961 and 1968.

Meanwhile, those properties with 20 or more B.U. increased from 10.2% of all T–L businesses in 1961 to 12.2% of the 1968 total. There were 784 such firms with a total of 31,886 B.U. in 1961; by 1968 this group included 835 businesses with 36,581 units. This 20-plus category provided 39.7% of the State's B.U. total in 1961 and 45.9% of it in 1968.

There was a most substantial gain of over 4,600 units in the group of larger establishments with 30 or more B.U. per business, which comprised 5.5% of the T–L firms in 1968. However, the one category showing the largest increases of all—both percentage-wise and in B.U. capacity—was the 100-plus group which gained nearly 3,000 units from 17 additional establishments. Here we observe a 34% increase in the number of businesses and a 35% gain in B.U. in only 8 years, 1961–68.

Table 4 shows the 1961–68 comparisons of Wisconsin T–L establishments as to type, seasonality, number, and bedroom (B.U.) capacity. It also indicates the average size of establishment under each classification, both seasonal and year-round, and under the combined totals for each year.

## Fewer but Larger

These data clearly illustrate the fact that, in general, Wisconsin's T–L establishments are getting fewer in number but larger in size. But they also reflect some significant variations among the major categories of establishments. For example, the impact of the newer motels and motor hotels on the traditional hotel-type operation is quite apparent from these figures.

The general decline in resort-type establishments is also evident in Table 4, where we note a loss of 660 businesses and 4,200 B.U. since 1961. Our data indicate that the greater portion of this resort loss has occurred since 1964, when the rate of decline for these establishments accelerated to about 4% per year.

The only group of T–L businesses which has increased steadily in both number of establishments and in B.U. capacity over the 8-year period is the motel category. This group has also shown the largest gain in average size of business (B.U. per establishment).

The remainder of this report will consider in more detail the major changes taking place, as well as apparent trends, within each of the four main categories of T–L businesses. The geographic nature of these changes, especially the regional trends and patterns involved, will also be presented and discussed.

TABLE 4. TYPE, SEASONALITY, AND AVERAGE SIZE OF WISCONSIN TOURIST-LODGING ESTABLISHMENTS, COMPARING 1961 AND 1968.

| Type of Establishment | 1968 Data | | | 1961 Data | | |
|---|---|---|---|---|---|---|
| | Seasonal Businesses | Year-round Businesses | Total Establishments | Seasonal Businesses | Year-round Businesses | Total Establishments |
| HOTELS | | | | | | |
| No. of Establishments | 72 | 385 | 457 | 112 | 471 | 583 |
| No. of Bedroom Units | 1,409 | 14,562 | 15,971 | 2,414 | 17,153 | 19,567 |
| Average Size (B.U.) | (19.6) | (37.8) | (34.9) | (21.6) | (36.4) | (33.6) |
| MOTELS | | | | | | |
| No. of Establishments | 283 | 773 | 1,056 | 261 | 654 | 915 |
| No. of Bedroom Units | 3,648 | 15,857 | 19,505 | 3,028 | 9,572 | 12,600 |
| Average Size (B.U.) | (12.9) | (20.5) | (18.5) | (11.6) | (14.6) | (13.8) |
| RESORTS | | | | | | |
| No. of Establishments | 3,824 | 277 | 4,101 | 4,439 | 322 | 4,761 |
| No. of Bedroom Units | 32,835 | 3,420 | 36,255 | 37,262 | 3,203 | 40,465 |
| Average Size (B.U.) | (8.6) | (12.3) | (8.8) | (8.4) | (9.9) | (8.5) |
| OTHER | | | | | | |
| No. of Establishments | 816 | 393 | 1,209 | 921 | 536 | 1,457 |
| No. of Bedroom Units | 4,719 | 3,248 | 7,967 | 4,904 | 2,762 | 7,666 |
| Average Size (B.U.) | (5.8) | (8.3) | (6.6) | (5.3) | (5.2) | (5.3) |
| TOTALS | | | | | | |
| No. Establishments | 4,995 | 1,828 | 6,823 | 5,733 | 1,983 | 7,716 |
| No. Bedroom Units | 42,611 | 37,087 | 79,698 | 47,608 | 32,690 | 80,298 |
| Average Size (B.U.) | (8.5) | (20.3) | (11.7) | (8.3) | (16.5) | (10.4) |

## Geographic Distribution

Thus far, we have concentrated on statewide totals, summaries, breakdowns, and changes in the T–L industry. It might be appropriate, at this point in the study, to examine the geographic distribution of T–L establishments in Wisconsin on a county-by-county basis. Figure 1 does this for the years 1961 and 1968 (upper figure is '68), including all types of lodging businesses.

It is noteworthy that only 12 of the 72 counties did not show a decline in the number of T–L establishments, and only 6 counties

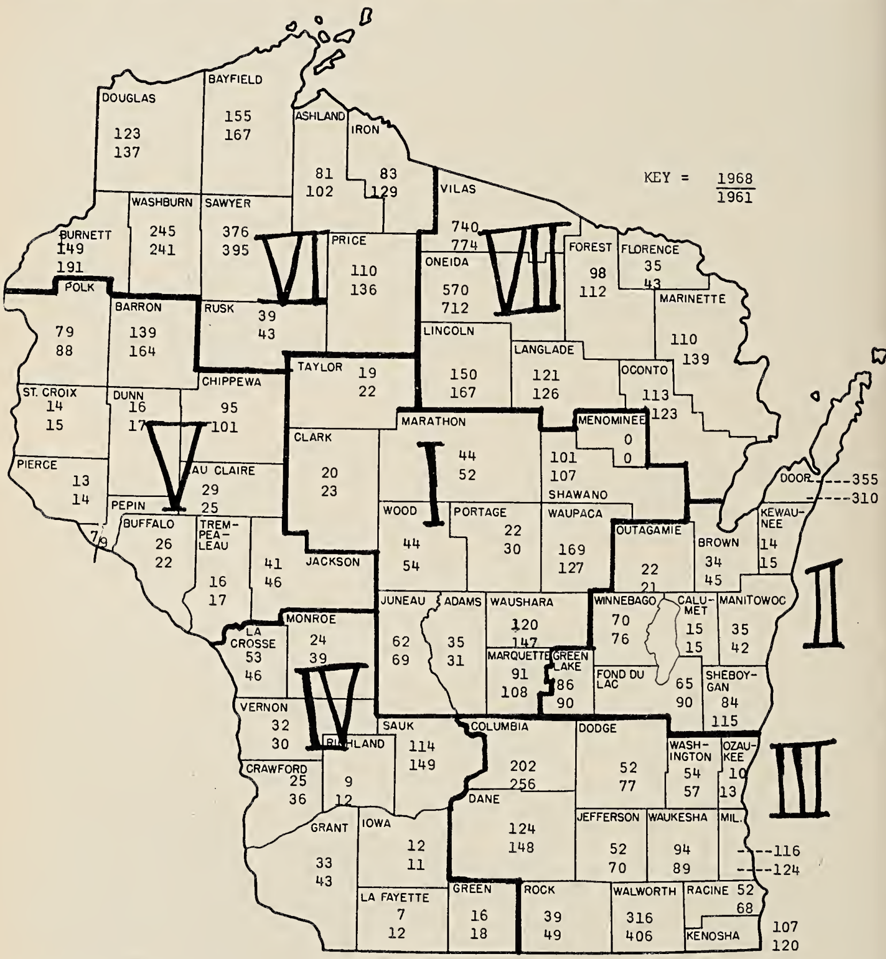



Figure 1. The Distribution of Wisconsin Tourist-Lodging Establishments in 1961 and 1968, showing the totals for each county. The upper figure is the 1968 count; the lower is for 1961. These totals include all types and sizes of lodging businesses.

had an increase of 10% or more. Numerically, however, only two counties could claim substantial gains in their total of T–L establishments: Door gained 45; Waupaca gained 42; and La Crosse ranked a poor third with a gain of 7 over the 8-year period. All of the northern counties except Washburn showed substantial declines since 1961, with Oneida's loss of 142 topping the entire state. Percentagewise, Iron County was the "leader" with a drop of 35.7% in its T–L businesses.

It is also interesting to note, on a comparative basis, some of the regional patterns involved in the significant changes and trends affecting the T–L industry since 1961. This will be done by a series of state maps, each showing selected data by geographic regions, comparing 1961 and 1968 figures.

The seven regions used in this analysis are the so-called "state planning regions", which group the 72 Wisconsin counties as follows:

| *I. Central* | *II. East Central* | *III. Southeast* | *IV. Southwest* |
|---|---|---|---|
| Adams | Brown | Columbia | Crawford |
| Clark | Calumet | Dane | Grant |
| Juneau | Door | Dodge | Green |
| Marathon | Fond du Lac | Jefferson | Iowa |
| Marquette | Green Lake | Kenosha | La Crosse |
| Menominee | Kewaunee | Milwaukee | Lafayette |
| Portage | Manitowoc | Ozaukee | Monroe |
| Shawano | Outagamie | Racine | Richland |
| Taylor | Sheboygan | Rock | Sauk |
| Waupaca | Winnebago | Walworth | Vernon |
| Waushara | | Washington | |
| Wood | | Waukesha | |

| *V. West Central* | *VI. Northwest* | *VII. Northeast* |
|---|---|---|
| Barron | Ashland | Florence |
| Buffalo | Bayfield | Forest |
| Chippewa | Burnett | Langlade |
| Dunn | Douglas | Lincoln |
| Eau Claire | Iron | Marinette |
| Jackson | Price | Oconto |
| Pepin | Rusk | Oneida |
| Pierce | Sawyer | Vilas |
| Polk | Washburn | |
| St. Croix | | |
| Trempealeau | | |

These county groupings, or regions, are delineated in Figure 1.

The regional totals of both T–L establishments and their bedroom units are shown in Figure 2 for the years 1961 and 1968. The average size of establishment (in B.U.) is also shown for each of the regions. Although all of the regions had an increase in size of business (B.U. per establishment), this gain varied from 0.2 B.U. for the Central Region to a high of 4.6 B.U. in the Southeast Region. All of the regions except for II (East Central) and III (Southeast) showed losses in B.U. capacity, with the largest drops recorded in Region VII (—1,746) and in Region VI (—826). Both of these regions are in northern Wisconsin. They had a combined loss of 439 T–L establishments during the 8 years, almost exactly half of the total loss (—893) registered by the entire state!

The other region showing a relatively large loss of T–L businesses since 1961 is the Southeast (Region III), which had 259 fewer firms in 1968. Altogether, these three regions (III, VI, VII) accounted for 78% (698 firms) of the statewide loss of T–L establishments during the period.

Figure 3 gives similar 1961–68 information, also on a regional basis, for the *seasonal* T–L establishments in Wisconsin. This group includes almost 75% of all T–L businesses. Again, we note that the two northern regions (VI and VII) had a combined loss of slightly over 400 establishments and almost 3,100 B.U.—mostly resort-type accommodations—over the 8-year period.

The average size of establishment (figures in parentheses) varies to only a small degree—from region to region—with these seasonal T–L businesses. It ranged from 6.2 B.U. to 8.9 B.U. in 1961, and from 5.6 B.U. to 9.9 B.U. to 1968, with a state-wide average of

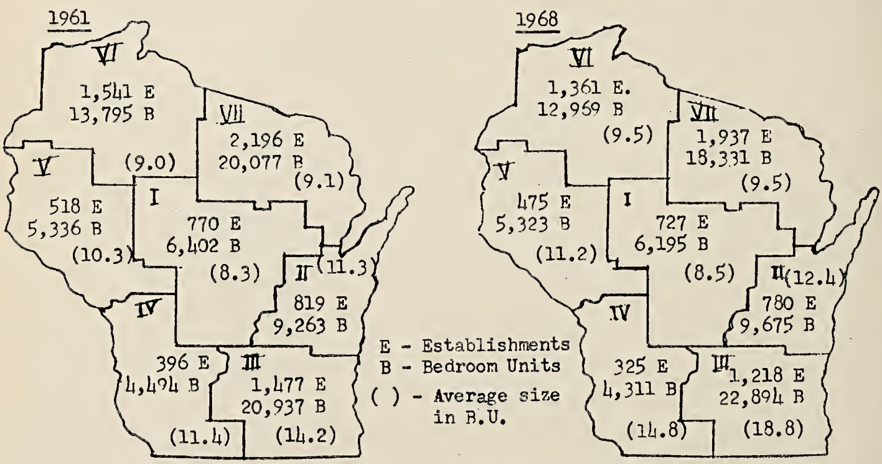



FIGURE 2. The Regional Distribution of Tourist-Lodging Establishments (all types) in Wisconsin for 1961 and 1968.

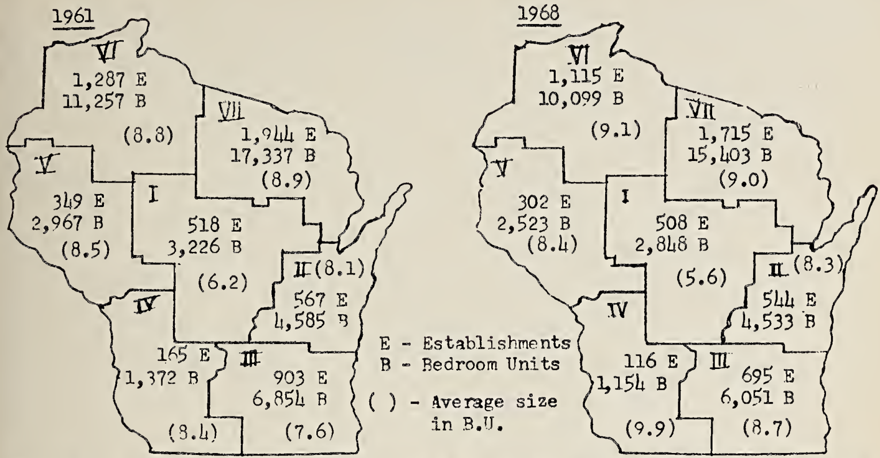



FIGURE 3. The Regional Distribution of Seasonal Tourist-Lodging Establishments (all types) in Wisconsin for 1961 and 1968.

about 8.5 B.U. There was a much greater fluctuation in the average size of year-round establishments, which ranged from 10.0 B.U. to 32.4 B.U. among the various regions during the years studied.

## HOTEL-MOTEL TRENDS

The analysis of hotel establishments as to number, size, seasonality, and B.U. capacity is shown in Table 5 for the years 1961 and 1968. The regional distribution and inventory of Wisconsin hotels (all types and sizes) for 1961–68 appears in Figure 4.

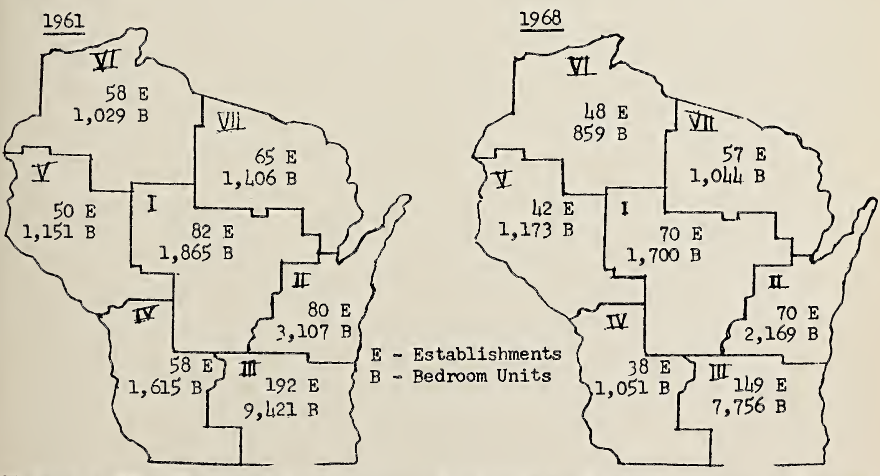



FIGURE 4. The Regional Distribution of Hotel-type Establishments (all sizes) in Wisconsin for 1961 and 1968.

TABLE 5. THE NUMBER, SIZE CLASSIFICATION, SEASONALITY, AND B.U. CAPACITY OF WISCONSIN HOTEL ESTABLISHMENTS IN 1961 AND 1968.

| SIZE CLASS IN BEDROOM UNITS | SEASONAL | | YEAR-ROUND | | TOTAL | |
|---|---|---|---|---|---|---|
| | No. Hotels | No. of B.U. | No. Hotels | No. of B.U. | No. Hotels | No. of B.U. |
| | | | Hotels—1968 Data | | | |
| Small—5 to 19 B.U. | 43 | 421 | 194 | 2,105 | 237 | 2,526 |
| Medium—20 to 99 B.U. | 28 | 888 | 158 | 6,218 | 186 | 7,106 |
| Large—100+ B.U. | 1 | 100 | 33 | 6,239 | 34 | 6,339 |
| 1968 Totals | 72 | 1,409 | 385 | 14,562 | 457 | 15,971 |
| | | | Hotels—1961 Data | | | |
| Small—5 to 19 B.U. | 66 | 689 | 245 | 2,465 | 311 | 3,146 |
| Medium—20 to 99 B.U. | 43 | 1,408 | 188 | 7,584 | 231 | 8,992 |
| Large—100+ B.U. | 3 | 317 | 38 | 7,104 | 41 | 7,421 |
| 1961 Totals | 112 | 2,414 | 471 | 17,153 | 583 | 19,567 |
| Changes (8 years) | (−40) | (−1,005) | (−86) | (−2,591) | (−126) | (−3,596) |

For the purposes of this study, both hotels and motels are classified into three size groups as follows:

| *Size Group* | *B.U. Range* | *1968 Hotels* | *1968 Motels* |
|---|---|---|---|
| Small | 5 to 19 B.U. | 237 | 805 |
| Medium | 20 to 99 B.U. | 186 | 232 |
| Large | 100 plus B.U. | 34 | 19 |

Approximately one-fourth of the small-size hotels and one-fifth of the medium-size group were lost during this 8-year period, according to Table 5, with heaviest losses in the seasonal ranks. These two size groups alone showed a net loss of 119 establishments and 2,500 B.U. Large hotels (100 B.U. or more) also dropped downward, from 41 to 34 establishments, causing the loss of another 1,100 B.U.—or 3,600 in all for the hotel universe.

Table 6 gives essentially the same kind of information for motels and motor inns as Table 5 provides for hotels.

Although the number of hotels dropped by 126, mostly in the small and medium-size classes, the number of motels increased by 141 establishments. Most of the additional motel enterprises were in the year-round category, and in the medium-size and large-size groups. It is interesting to note, however, that the motel-type businesses increased numerically in every size class, both in the seasonal and in the year-round categories. In fact, motels were the only type of seasonal T–L operation to show any significant increase in number during the 1961–68 period.

The 8-year increase in total motel capacity exceeded 6,900 B.U., and thus it has more than offset the total loss of hotels and hotel rooms since 1960. Hotels provided 24.4% of all B.U. in Wisconsin in 1961, but this percentage dropped to 20.0 by 1968. Meanwhile the motel-type enterprises, which increased from 11.8% to 15.5% of all T–L businesses, provided 15.7% of all B.U. during 1961 and 24.5% of the State's total in 1968.

Besides increasing in number, Wisconsin's motels have increased quite markedly in their average size. In 1961 only 16% of our motel establishments were 20 B.U. or larger in size; and this medium-to-large group provided a total of 4,650 B.U.—only about half of what the small (5-to-19 B.U.) group offered. By 1968 the "20-plus" group comprised 24% of all motels and was providing 10,950 B.U., exceeding the small-size group by 2,400 B.U. In 1961, 28.5% of the 915 motels were classed as seasonal establishments; this percentage dropped to 26.8% for the 1,056 motels in 1968, although the actual number of seasonal motels rose from 261 to 283.

Figure 5 shows the regional distribution of Wisconsin motel establishments in 1961 and 1968. The growth in number of motel

TABLE 6. THE NUMBER, SIZE CLASSIFICATION, SEASONALITY, AND B.U. CAPACITY OF WISCONSIN MOTEL ESTABLISHMENTS IN 1961 AND 1968.

| Size Class in Bedroom Units | Seasonal | | Year-round | | Total | |
|---|---|---|---|---|---|---|
| | No. Motels | No. of B.U. | No. Motels | No. of B.U. | No. Motels | No. of B.U. |
| | Motels—1968 Data | | | | | |
| Small—5 to 19 B.U. | 238 | 2,353 | 567 | 6,216 | 805 | 8,569 |
| Medium—20 to 99 B.U. | 45 | 1,295 | 187 | 6,596 | 232 | 7,891 |
| Large—100+ B.U. | — | — | 19 | 3,045 | 19 | 3,045 |
| 1968 Totals | 283 | 3,648 | 773 | 15,857 | 1,056 | 19,505 |
| | Motels—1961 Data | | | | | |
| Small—5 to 19 B.U. | 229 | 2,228 | 539 | 5,717 | 768 | 7,945 |
| Medium—20 to 99 B.U. | 32 | 800 | 113 | 3,525 | 145 | 4,325 |
| Large—100+ B.U. | — | — | 2 | 330 | 2 | 330 |
| 1961 Totals | 261 | 3,028 | 654 | 9,572 | 915 | 12,600 |
| Gains in 8 years | +22 | +620 | +119 | +6,285 | +141 | +6,905 |

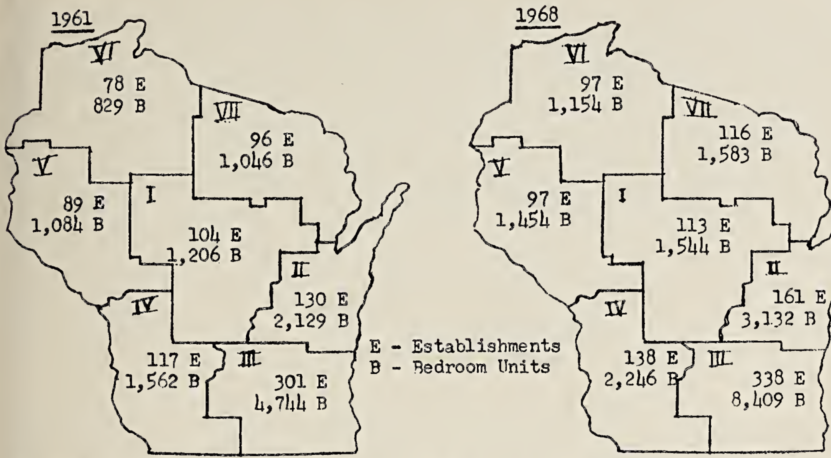



FIGURE 5. The Regional Distribution of Motel-type Establishments (all sizes) in Wisconsin for 1961 and 1968.

establishments has been fairly uniform among the seven regions. However, the increased motel capacities in 1968 (see regional B.U. totals) clearly indicate that the largest gains were in Regions II and III (East Central and Southeast), where over two-thirds of the 6,900 additional B.U. were located.

The three southernmost regions (II, III, and IV) contained well over half of the hotel and motel establishments in Wisconsin, and about two-thirds of the hotel-motel B.U. as well, in 1968. These same regions also showed the greatest gains in motels and the largest losses in hotels during the 8-year period.

## Resort-type Establishments

Resorts, despite a substantial decline in numbers, continued to make up 60.1% of all T–L establishments in 1968 compared to 61.7% 8 years earlier. In 1961, 83.0% of all *seasonal* T–L businesses were of the resort type; by 1968 this percentage was still 82.1%.

In 1961 resorts provided 50.4% of all B.U. in the State, compared to 45.5% eight years later. However, the great bulk of these were seasonal units—32,800 out of 36,200 B.U.—90.6% in 1968 compared to 92.1% in 1961.

Resort-type establishments continue to be highly seasonal in Wisconsin, despite many promotional efforts and overtures—largely by state and regional tourist organizations and agencies—to encourage and expand year-round housing for visitors. In 1961 seasonal resorts comprised 93.2% of all resort establishments, and the percentage was exactly the same in 1968. Thus, less than 7% of all resort-type businesses are open for 9 months or longer each year, and these are generally located at or near winter-sports facilities.

Because resort-type businesses are considerably smaller than hotel-motel establishments, on the average, a different size classification is used in this study to show what has taken place. This breakdown (together with the 1961 and 1968 totals) is as follows:

| *Size Class* | *B.U. Range* | *1961 Totals* | *1968 Totals* |
|---|---|---|---|
| Small | 1 to 9 B.U. | 3,202 | 2,708 |
| Medium | 10 to 29 B.U. | 1,468 | 1,301 |
| Large | 30 or more B.U. | 91 | 92 |

Although these categories show the general trend in resort-type establishments between 1961 and 1968, they may not give an adequate picture of what is taking place within the so-called "resort industry" in recent years. Thus, a more detailed size breakdown for resorts is given in Tables 7-a and 7-b.

## Small Resorts Are Declining

When we separate the "small" resort group into the 1-to-4 B.U. size—which we term non-commercial establishments—and the 5-to-9 B.U. size, some important differences are readily seen. They are depicted in Tables 7-a and 7-b, which classify the Wisconsin resort inventory by size and seasonality for 1961 and 1968, including a breakdown of the B.U. provided by these establishments and the appropriate totals. For the small-resort category as a whole, there was a loss of 2,473 bedrooms—a drop of 16.5% in capacity—during the 8-year period. However, whereas the 1-to-4 class lost only 10% or 455 B.U., the 5-to-9 group dropped nearly 20% or 2,017 B.U. Similarly, the non-commercial group declined only 11% in number of businesses, while the 5-to-9 class dropped slightly over 20%. In some areas the 1-to-4 class of establishment actually increased in numbers, and it is reasonable to assume that many of these "businesses" are actually recently-built, private cottages or summer houses that are rented out during the prime vacation months of July and August.

Of the 4,639 B.U. lost by small- and medium-size resorts—those with less than 30 B.U. per firm—3,886 or 83% were from establishments in the 5 to 19 B.U. range. Apparently the resorts in this size bracket are closing down more rapidly than those in either the 1-to-4 class or the 20-plus group, possibly because they have the least to offer in the way of economic returns. Yet the percentage of Wisconsin resort establishments in the 1-to-19 B.U. range has

TABLE 7-a. CLASSIFICATION OF WISCONSIN RESORT-TYPE ESTABLISHMENTS AS TO SIZE, SEASONALITY, AND B.U. CAPACITIES FOR 1968.

| SIZE CLASS | B.U. RANGE | SEASONAL | | YEAR-ROUND | | TOTALS | |
|---|---|---|---|---|---|---|---|
| | | No. Resorts | Total B.U. | No. Resorts | Total B.U. | No. Resorts | Total B.U. |
| Small | 1 to 4 | 1,408 | 3,875 | 78 | 224 | 1,486 | 4,099 |
| | 5 to 9 | 1,142 | 7,817 | 80 | 563 | 1,222 | 8,380 |
| Medium | 10 to 19 | 996 | 13,203 | 82 | 1,128 | 1,078 | 14,331 |
| | 20 to 29 | 202 | 4,613 | 21 | 476 | 223 | 5,089 |
| Large | 30 to 99 | 74 | 3,076 | 13 | 560 | 87 | 3,636 |
| | 100 and over | 2 | 251 | 3 | 469 | 5 | 720 |
| Totals | | 3,824 | 32,835 | 277 | 3,420 | 4,101 | 36,255 |

TABLE 7-b. CLASSIFICATION OF WISCONSIN RESORT-TYPE ESTABLISHMENTS AS TO SIZE, SEASONALITY, AND B.U. CAPACITIES FOR 1961.

| SIZE CLASS | B.U. RANGE | SEASONAL | | YEAR-ROUND | | TOTALS | |
|---|---|---|---|---|---|---|---|
| | | No. Resorts | Total B.U. | No. Resorts | Total B.U. | No. Resorts | Total B.U. |
| Small | 1 to 4 | 1,554 | 4,246 | 116 | 309 | 1,670 | 4,555 |
| | 5 to 9 | 1,423 | 9,660 | 109 | 737 | 1,532 | 10,397 |
| Medium | 10 to 19 | 1,169 | 15,385 | 63 | 815 | 1,232 | 16,200 |
| | 20 to 29 | 218 | 4,983 | 18 | 403 | 236 | 5,386 |
| Large | 30 to 99 | 74 | 2,862 | 14 | 674 | 88 | 3,536 |
| | 100 and over | 1 | 126 | 2 | 265 | 3 | 391 |
| Totals | | 4,439 | 37,262 | 322 | 3,203 | 4,761 | 40,465 |

declined but little—from 93.1% to 92.3%—since 1961. In terms of total B.U. at resorts, this group still provided nearly 74% of our resort capacity in 1968.

Unfortunately, there has been no significant increase in either the medium-size or the large-size categories of resort-type businesses to offset the decline in small establishments. Thus, the loss in small firms and their B.U. capacities tends to approximate the total loss for the resort industry as a whole.

## Resort Distribution

Figure 6 shows the regional distribution of all Wisconsin resort establishments in 1961 and 1968. In both years, over 60% of the resort enterprises and about two-thirds of the total resort B.U. were located in the two northern regions. In fact, Region VII (the Northeast) alone has long had well over one-third of Wisconsin's resorts and almost 40% of the total resort B.U. capacity in the entire state.

Figure 6-a shows the geographic distribution of all resort-type businesses which operate on a year-round basis (open 9 months or longer each year). The number of establishments in this group has not increased in recent years. In fact, the total of these "all year" resorts has dropped from 322 to 276 since 1961. However, the total B.U. capacity of these enterprises has increased about 6.0%—from 3,203 B.U. to 3,402 B.U. over the 8 years.

Figure 6-b depicts the 1961-68 regional distribution of small resorts with less than 10 B.U., which comprise about two-thirds of

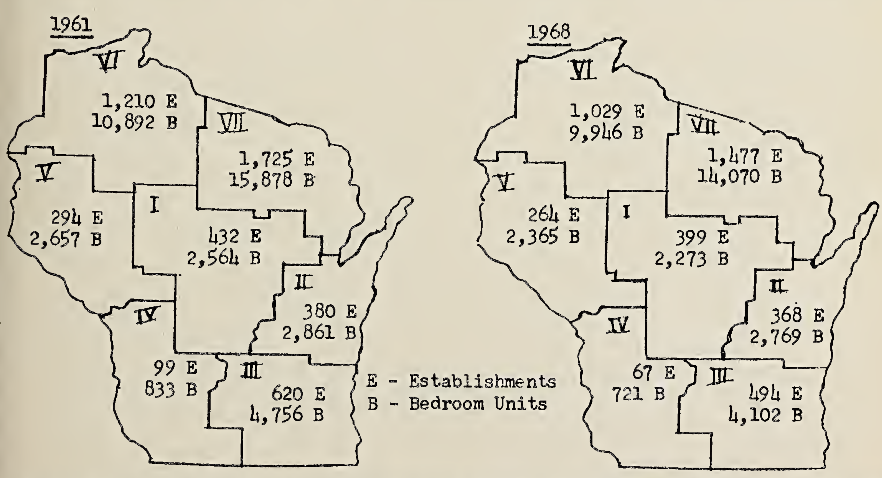



FIGURE 6. The Regional Distribution of Resort-type Establishments (all types and sizes) in Wisconsin for 1961 and 1968.

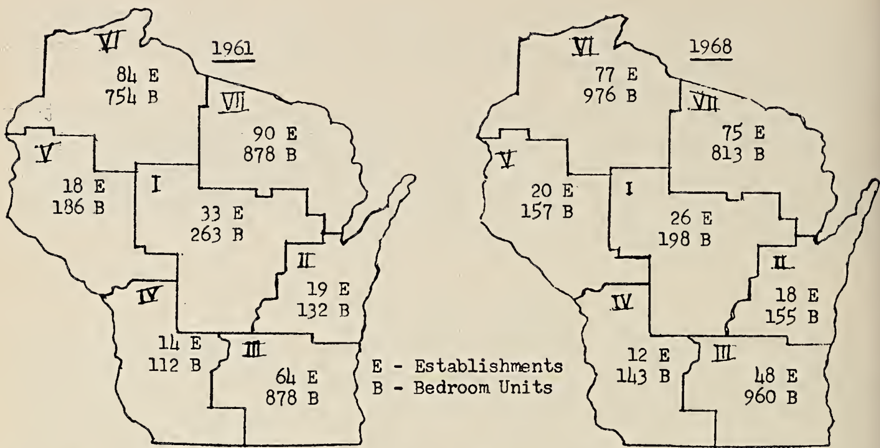



FIGURE 6-a. The Regional Distribution of Year-round, Resort-type Establishments (all sizes) in Wisconsin for 1961 and 1968.

all resort-type establishments in Wisconsin. Both the number of businesses and the total B.U. are shown for each of the seven regions. It is noteworthy that in both years, over 55% of the small resorts and over 60% of the units they provide are located in Regions VI and VII of Northern Wisconsin. These are also the regions in which the greatest losses of small resorts have occurred.

Figure 6-c details the regional distribution of medium-size (10 to 29 B.U. class) resorts in Wisconsin for the years 1961–68. Over 70% of these establishments were located in the two northern re-

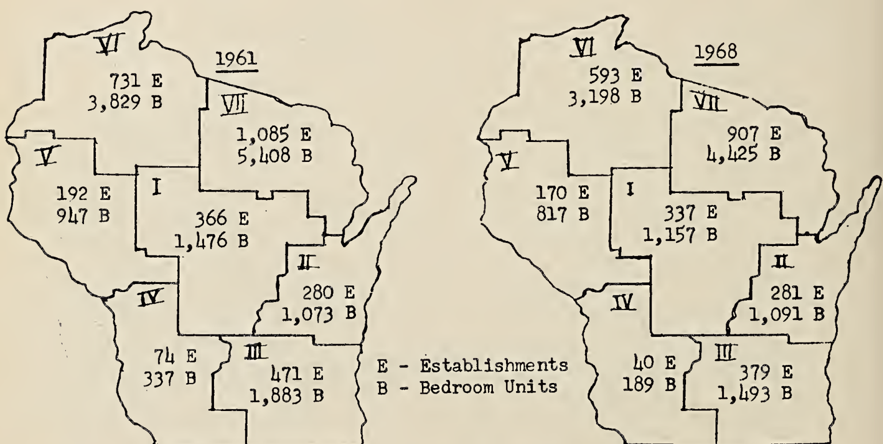



FIGURE 6-b. The Regional Distribution of Small Resort-type Establishments (less than 10 B.U.) in Wisconsin for 1961 and 1968.

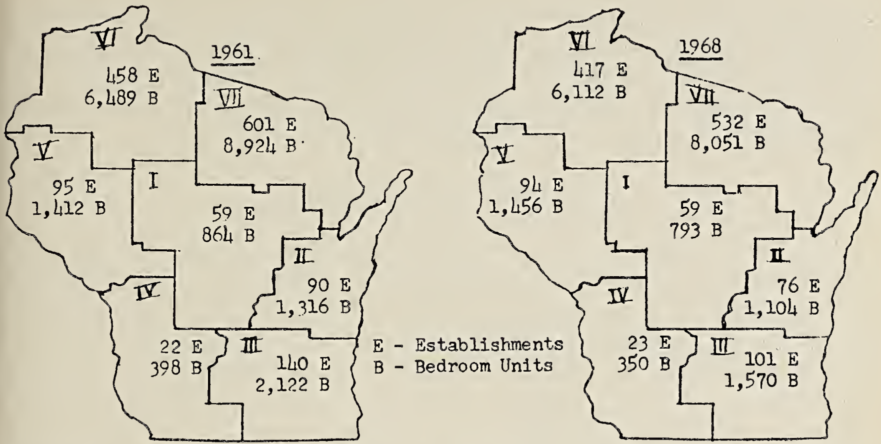



FIGURE 6-c. The Regional Distribution of Medium-size, Resort-type Establishments (10 B.U. to 29 B.U.) in Wisconsin for the years 1961 and 1968.

gions during both 1961 and 1968. The heaviest losses in medium-size resorts occurred in these two regions and in Region III (Southeast) during the 8-year period.

Figure 6-d reflects the distribution of Wisconsin's largest resorts (those with 30 or more B.U.) in 1961 and 1968. As can readily be noted, both the number of establishments and the B.U. capacities are relatively small. Except for some changes among the regions, there have been no major gains or losses during the 8 years studied. Perhaps the most significant change has been in the average size of

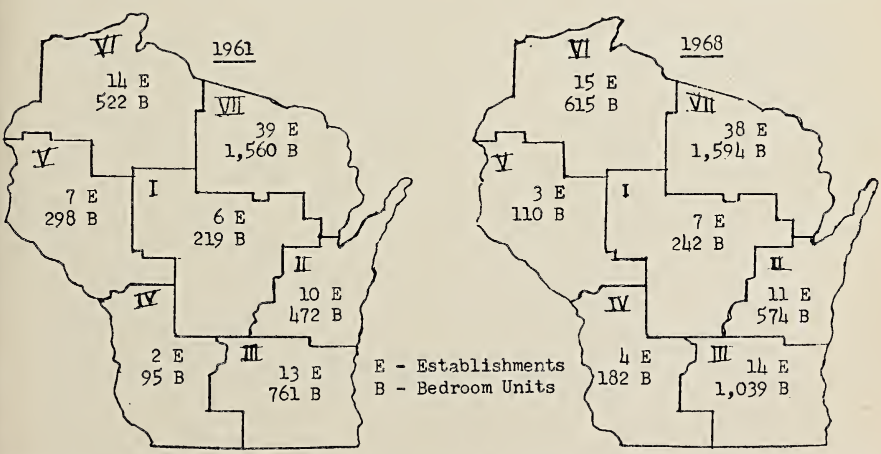



FIGURE 6-d. The Regional Distribution of Large Resort-type Establishments (30 B.U. and over) in Wisconsin for 1961 and 1968.

establishment, which has gone up about 4.5 B.U. per firm. Over one-half of these larger resort-type establishments and about 50% of the total B.U. capacity they provide are situated in the two northern regions. However, the major increase in room capacity since 1961 has occurred in Region III (SE).

## Other T–L Establishments

All other types of T–L establishments, particularly those not tallied as hotels, motels or resorts, are categorized and totalled in Table 8 for the years 1961 and 1968. This catch-all group is classified as to size, seasonality, and B.U. capacity. Since the average size of establishment is relatively small, the size classification used is identical with that used for resort-type establishments. This "Other" category includes such diverse types as tourist homes, rooming houses, seasonal dormitories (often called "camps"), dude ranches, vacation farms, clubs, taverns, truck stops, and a variety of other lodgings. Over two-thirds of them have less than 5 B.U., and the bulk of these very small ones are private homes with one or more rental bedrooms.

Table 8 shows a loss of 249 "other" T–L establishments between 1961 and 1968, and well over 90% of these were in the small (1 to 9 B.U.) category. Taken together, these businesses represented a loss of 888 B.U. However, this was more than offset by a gain of 1,189 B.U. from additional establishments in the large category.

Figure 7 shows the regional distribution of Other T–L establishments in Wisconsin for 1961 and 1968, including the number of

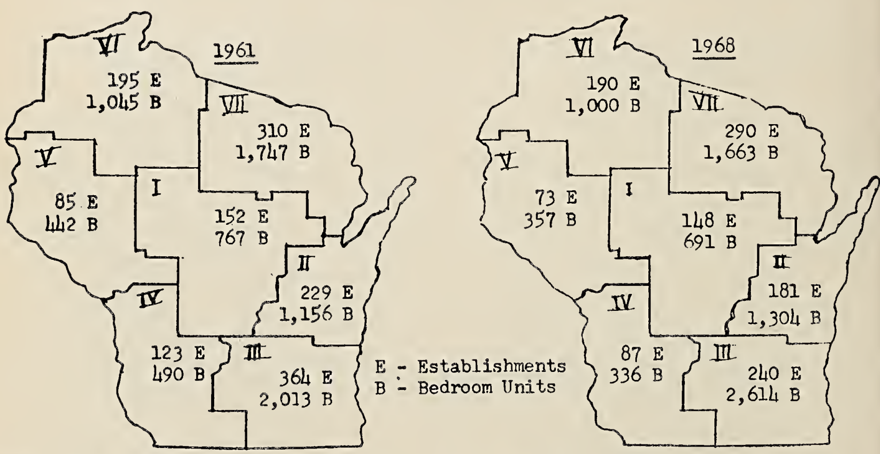



FIGURE 7. The Regional Distribution of Other Types of T–L Establishments (all sizes) in Wisconsin for 1961 and 1968.

TABLE 8. CLASSIFICATION OF OTHER TOURIST-LODGING ESTABLISHMENTS IN WISCONSIN AS TO SIZE, SEASONALITY AND B.U. CAPACITY IN 1961 AND 1968.

| SIZE CLASS | B.U. RANGE | SEASONAL | | YEAR-ROUND | | TOTALS | |
|---|---|---|---|---|---|---|---|
| | | No. Estab. | Total B.U. | No. Estab. | Total B.U. | No. Estab. | Total B.U. |
| | | 1968 Data—Other Establishments | | | | | |
| Small | 1 to 4 B.U. | 562 | 1,539 | 276 | 829 | 838 | 2,368 |
| | 5 to 9 B.U. | 154 | 1,015 | 56 | 377 | 210 | 1,392 |
| Medium | 10 to 29 B.U. | 91 | 1,416 | 46 | 645 | 137 | 2,061 |
| Large | 30 B.U. and over | 9 | 749 | 14 | 1,397 | 23 | 2,146 |
| 1968 Totals | | 816 | 4,719 | 392 | 3,248 | 1,208 | 7,967 |
| | | 1961 Data—Other Establishments | | | | | |
| Small | 1 to 4 B.U. | 603 | 1,606 | 409 | 1,192 | 1,012 | 2,798 |
| | 5 to 9 B.U. | 198 | 1,282 | 87 | 542 | 285 | 1,824 |
| Medium | 10 to 29 B.U. | 110 | 1,590 | 36 | 497 | 146 | 2,087 |
| Large | 30 B.U. and over | 10 | 426 | 4 | 531 | 14 | 957 |
| 1961 Totals | | 921 | 4,904 | 536 | 2,762 | 1,457 | 7,666 |
| Changes 1961–68 | | (−105) | (−185) | (−144) | +486 | (−249) | +301 |

businesses and the total B.U. capacities for each of the seven regions. Although this group represents about 17.7% of the State's T–L establishments—almost two out of every ten—it accounts for only 10% of the total B.U. capacity. This indicates the relatively small size of the average establishment in this category, which would be even further reduced if several of the large seasonal dormitories were excluded from it.

Because such a high percentage—over two-thirds in 1968—of the other establishments are in the seasonal category, it is likely that a substantial number of them are of the resort type, possibly 100 or more. However, since the firm name does not provide us with a positive identification, we will leave them where they now repose in the unclassified "other" group. In any case, it is unlikely that they would add more than 3 or 4 percent to the present resort inventory.

## Summary and Observations

Many questions have been raised concerning facts and trends in the travel-recreation industry of Wisconsin, mainly because there has been no regular compilation or analysis of year-to-year data concerning the various businesses involved. Such a "data bank" is essential if we are to identify and measure the changes or trends in this industry or any other field of economic activity.

This study was undertaken in an effort to shed some light on what has taken place in the tourist-lodging business over a period of years (1958–68). Special emphasis is given to changes in the number, size, type, distribution, and seasonality of lodging establishments between 1961 and 1968. However, an earlier study provides us with some data on T–L establishments in 1958, which enables us to observe a few 11-year trends.

In 1958 there were 7,842 T–L businesses in Wisconsin, which provided a total of 79,100 B.U. for the traveling public. By 1968 the number of establishments had dropped to 6,823—a decline of 1,019 firms—but the total capacity remained at 79,700, or essentially the same as it was 11 years earlier. About 70% of the drop in establishments involved seasonal-type businesses, including 660 resort operations.

How serious is this situation? Are we in danger of losing an important segment of our travel-recreation industry in Wisconsin? Some touristry-business leaders have said "yes" as they point to the drop in the number of enterprises. However despite the drop of 12% in the inventory of T–L businesses, the State's total capacity to house vacationers and other visitors has not decreased. It is true that we have lost many of the smaller seasonal establishments —especially cabin courts and cottage resorts—and that certain areas have lost more heavily than other parts of the State. But the number and size of other types of facilities have increased substantially, tending to offset these losses. Campgrounds, for example, are not considered in this report but have increased six-fold since 1958.

These and certain other trends, as noted in this report, do not necessarily spell hardship for the lodging industry or disaster for any group of operators within it. More than likely, these changes simply reflect the shifts and internal adjustments of an industry in transition. And there has apparently been no great economic loss in either business income or in the overall value of T–L facilities. However, certain geographic areas lost more heavily than others in terms of number of businesses and in their total capacity to house visitors. (The two northern regions, for example, dropped substantially in seasonal B.U. capacity.) In addition, some types of T–L businesses appear to be at more of a disadvantage than others in competing for the tourist's dollar.

The smallest establishments showed the largest decreases in number. Those with fewer than 10 B.U. showed a net loss of 814 businesses and over 3,800 B.U. since 1961—a drop of 16%. This category continues to be a fairly large one, however, since it still provided 19,300 B.U. in 1968 (almost 25% of the State's total). Meanwhile, the number of large T–L enterprises with 30 B.U. or more increased from 326 to 374—about 17%—with a gain of almost 5,000 B.U.

As mentioned previously, seasonal establishments have suffered the largest numerical losses since 1961. But contrary to a widely-held notion, the number of lodging businesses that are open to the traveling public on a year-round basis has not increased in recent years. The number of seasonal establishments declined by 13% (from 5,733 to 4,995) during the 1961–68 period, while the year-round firms dropped about 8% from 1,983 to 1,828. However, the total number of year-round bedrooms did increase, going up about 4,400 B.U. since 1961 and almost offsetting the loss of 5,000 seasonal B.U. during the same 8 years. While there is undoubtedly less demand for certain types of seasonal accommodations, the primary reasons for the sharp dip in summer-only establishments in Wisconsin since 1961 appear to be economic ones. First, they have not been able to generate sufficient income to cover the increased costs of operation during the 1960s. Also, the booming market and soaring prices for recreational real estate (especially good lake and river shoreline) have encouraged many unprofitable lodging businesses to sell their property at a handsome price over and above their total investment. A recent study of Northeast Wisconsin by Staniforth and others reported that resort sales in that area were bringing prices equal to about twice the owner's total investment, on the average. When they are sold, practically all of these properties pass out of the lodging business and go over to another use, usually residential.

As to type-of-establishment trends, the biggest declines were noted in the hotel-type and the resort-type businesses. Hotel numbers declined 21%, from 583 to 457, while the number of establishments classified as resorts dropped about 14%—from 4,761 in 1961 to 4,101 in 1968. Despite this substantial decline in resort numbers, the percentage of Wisconsin T–L businesses that can be identified as resort-type establishments dropped only a little (from 62% to 60%) during the 8-year period.

Motels, on the other hand, increased about 15% to a 1968 total of 1,031 establishments and 19,500 B.U., certainly a noteworthy gain in only 8 years. In general, Wisconsin's T–L establishments are getting fewer but larger, while the State's total capacity for housing guests—travelers of all types—has remained fairly constant at about 80,000 B.U. since 1958.

## Trend of the Times?

At first glance, the disappearance of over 1,000 T–L establishments in just a few short years seems almost a tragedy. But it is probably in keeping with the general trends of our fast-moving age. These include the trends toward: (1) bigger business places; (2) greater efficiency; (3) more one-stop services; (4) more full-time or round-the-clock operations. Farm businesses have been getting fewer but larger since before World War II. We have seen what has already happened to many small businesses, including neighborhood groceries and small gasoline stations. The same trend seems to be taking place in our Wisconsin T–L industry. The small, inefficient, part-time operations are gradually disappearing. Meanwhile the more-successful businesses are getting bigger, or more specialized, with a greater array of services and conveniences for their guests and other customers.

It has been said that time is the greatest innovator of all in our type of economy. Most of us tend to stall until the change is forced upon us. Time is particularly relentless when people and businesses are slow in adapting to new demands, changes, and opportunities. The obsolete facility, the inefficient business, and the apathetic operator usually drop out of the game. This is undoubtedly a major factor in the substantial decline of hotels and resort-type establishments in Wisconsin.

In most areas, the traditional hotel is fast becoming an antique, particularly the smaller ones in our smaller cities. Many of the older hotels were built on a downtown, railroad-oriented site that is no longer convenient to modern-day travelers. Today we find some of them being converted to apartments, offices, shops, and other uses. Still others have just "hung on", hoping for better days as they watch their business volume dwindle. In any case, these older hotels are gradually being replaced or superseded by modern motels and motor hotels, which provide better accommodations, more and better services, and greater convenience in location, parking, and highway access.

Not only are motel establishments displacing hotels in most communities, but they are also moving into new areas, attracting new business, and expanding their initial plants and facilities at a fairly rapid rate. They are the only type of T–L enterprise in Wisconsin to show a sizeable growth in both number of establishments and total bedroom units. They have increased in all size classes, both seasonal and year round.

An explanation for the large decline in resort-type establishments, most noticeable in the 5-to-19 B.U. range, is not so easy to develop. Despite a rising population, an affluent society, increased urbanization, and more leisure time, there appear to be fewer customers for the traditional type of cottage-resort facilities—particularly those with no food service and limited opportunities for family recreation. Even with longer vacations and greater travel expenditures, the clientele for most of the older resort establishments—those who depend on the long-term (full week or longer) vacationers' trade—has not increased. The reasons are not entirely clear, but there are several major trends in vacation-travel preferences and leisure-time pursuits that may have some bearing on this question.

One of these has been the great increase in the number of camping enthusiasts since 1961, when the Athletic Institute and the American Camping association reported 5,500,000 participants. By the year 1966 there were 37,000,000 participants—an amazing gain of 670% in only 6 years—according to these organizations.

A closely-related factor is the *cottage-on-wheels* movement, which includes the owners and users of all types of recreational vehicles —campers, travel trailers, pick-up coaches, motorized homes, and so on. This group numbers approximately 10 million at present, including almost 2 million American families who wish to transport their own housing while on vacation trips. These citizens have become "campers deluxe" who wish to travel first-class and visit a lot of country, seldom staying at a single site more than 2 or 3 days. For this reason, we might call them "recreational nomads."

We have witnessed an amazing increase in recreational vehicles since 1960. About 83,000 were manufactured in 1961, compared to

395,000 in 1968. The total number in use is expected to exceed two million by 1970, according to the Recreational Vehicle Institute, which is the industry's trade association. This new development has undoubtedly had a considerable impact already on the tourist-lodging business in most parts of the country.

There is another important factor that probably has affected the demand for resort accommodations in recent years. This is reflected in the great and growing demand for second homes and other types of recreational real estate here in Wisconsin.

More and more families want to have their own little "resort" in the form of a vacation cottage, a summer home, a farm, or a little retreat back in the woods. Some want solitude, but others want to be where the action is. In either case, and regardless of what they seek, these people want to nestle down on a private plot and have their own lodging in or near their favorite recreation center. They find it imperative to have a recreational territory that they can hold, either as owners or under long-term leasing. Their numbers are increasing every year in Wisconsin, as well as other states. Because of their habits and their importance to the economy of many communities, we identify this group of people as the "recreational nestlers"—or seasonal residents.

In 1960 there were approximately 55,000 seasonal dwellings in Wisconsin, compared to over 96,000 in 1966. They ranged from hunters' cabins to large, elaborate summer homes that cost well over $25,000 to build. Every family that buys or builds its own recreational nest in Wisconsin ceases to rent vacation accommodations from our T–L businesses. Furthermore, these private seasonal dwellings are also used frequently by relatives, friends and business associates of the owners. Quite a few of them are rented out regularly during the summer period and, since they are subject to inspection by the Board of Health, a considerable number of them are included in the 1-to-4 B.U. category of resorts and "other" establishments. This may explain why this size class of T–L businesses has maintained its total numbers better than the 5-to-9 and 10-to-19 B.U. classes, which have shown greater losses. Since there were fewer than 30,000 rental cottages throughout the state in 1968, including some obsolete units, the importance of private-cottage rentals (and complimentary usage) cannot be ignored as a market factor that affects both the demand for rental cottages and their prices.

With the tremendous increase in the number of both *nomads* and *nestlers* in our recreational landscape, especially during the past 2 years, we can expect even greater changes in our tourist-lodging industry of the future. These are not the only two groups affecting the picture, of course. But, they are of prime importance in determining what happens to our 5,000 seasonal establishments, which still represent about three-fourths of all lodging businesses in Wisconsin.

## Bibliography

COOPER, ROLLIN; R. A. CHRISTIANSEN, S. D. STANIFORTH, and A. JOHNSON. (1968) *Cabin Resort Income in the 'Near North'*. Research Report 35, College of Agricultural & Life Sciences, The University of Wisconsin, Madison.

FINE, I. V. (1966) *Wisconsin and The Vacationer*. Wis. Dept. of Resource Development, Madison.

FINE, I. V. and R. E. TUTTLE. (1966) *Private Seasonal Housing in Wisconsin*. Wis. Dept. of Resource Development, Madison.

FINE, I. V. and R. E. TUTTLE. (1963) *The Tourist Overnight Accommodations Industry in Wisconsin*. Wis. Dept. of Resource Development and The University of Wisconsin, Madison.

FINE, I. V. and E. E. WERNER. (1961) *The Tourist-Vacation Industry in Wisconsin*. Wis. Dept. of Resource Development and The University of Wisconsin, Madison.

MONTHEY, L. G. (1963) *Classification and Inventory of Tourist-Lodging Businesses in Wisconsin*. Recreation & Touristry Notes RT–011, University Extension, The University of Wisconsin, Madison.

MONTHEY, L. G. (1964) *The Resort Industry of Wisconsin*. Wisconsin Academy of Sciences, Arts and Letters Transactions, Vol. 53 (Part A), pp. 79–94.

SIELAFF, R. O. (1963) *The Economics of Outdoor Recreation in the Upper Midwest*. The University of Minnesota, Duluth.

STANIFORTH, S. D., R. A. CHRISTIANSEN, and R. WOLTER. (1965) *Cabin Resort Income in Northern Wisconsin*. Wis. Agr. Experiment Station Bulletin No. 576, The University of Wisconsin, Madison.

Trends in American Living and Outdoor Recreation. (1962) Study Report No. 22, Outdoor Recreation Resources Review Commission, Washington.

# TOPOGRAPHIC INFLUENCE ON TORNADO TRACKS AND FREQUENCIES IN WISCONSIN AND ARKANSAS[1]

*Robert G. Gallimore, Jr., and Heinz H. Lettau*

## INTRODUCTION

It has been known for some time that tornadoes appear less frequently in mountainous terrain. Furthermore, spatial variations in tornado formation might also be related to surface temperature, as indicated by Kuhn, Darkow and Suomi (1958).

This study concerns a possible relationship between tornado frequency and topography, as well as the thermal structure of the earth/air interface. Specifically, the distribution of tornadoes in Wisconsin and Arkansas was studied to test the assumption that topography is a significant factor. Detailed information on tornado frequencies can be found in the literature (Flora, 1953). The overriding conclusion is that the annual variation of tornado outbreaks depends primarily on the progression of the seasonal storm track. A reduction of frequencies in northern Arkansas and Missouri may indicate suppression by the Ozark, Boston and Ouachita Mountains. Corresponding relationships can be detected by considering detailed tornado maps like those prepared for Wisconsin by Burley and Waite (1965).

One difficulty with such comparisons, however, must be considered. Since tornadoes are reported by people, the lower population in mountain regions may offer partial explanation for a relatively small number of reported tornadoes. Reduced horizontal visibility and less efficient communication in forested, mountainous or hilly areas are additional factors. Nevertheless, tornadoes leave their marks on the ground for a number of years and many of these will eventually be detected. In this study it is assumed that topography has a real influence which overrides that of a low population density.

## PART I: Arkansas Investigation

### Regional and Seasonal Variations of Tornadoes in Arkansas

Since Arkansas has interesting regional variations in tornado development, it was chosen for a preliminary study of possible ter-

[1] Part of this research has been sponsored by the United States Army Electronics Command, Atmospheric Sciences Laboratory, Fort Huachuca, Arizona, under Grant No. DA–AMC–28–043–66–G24.

rain effects. Maps published by Asp (1956) and reproduced in Lettau (1967) suggest two distinct tornado "alleys" and two belts with considerably lower frequencies which will be referred to as "shunted" regions. The southern alley lies in the flat Gulf coastal plain while the north–central alley lies in the Arkansas River Valley. The two shunted belts are the Ozark and Boston Ranges, located north of the Arkansas River valley, and the Ouachita Mountains, located in the west central area.

## Method of Investigation—Terrain Spectra

The main problem of this study was to obtain a quantitative measure of the difference between alleys and shunted belts. Five longitudinal sections were chosen in the prevailing direction (or close to it) of the tornado paths. Three of these strips covered the main tornado alleys and the two others the shunted regions; they varied in length from 120 to 200 miles. On a topographic map of Arkansas (1 to 500,000), with 250-foot contour intervals, terrain heights were read along these strips at one mile intervals. Portions of three of the resulting terrain profiles are illustrated in Figs. 1 and 2.

The single most significant statistical parameter is the total variance of terrain heights for each strip. More resolution is pro-

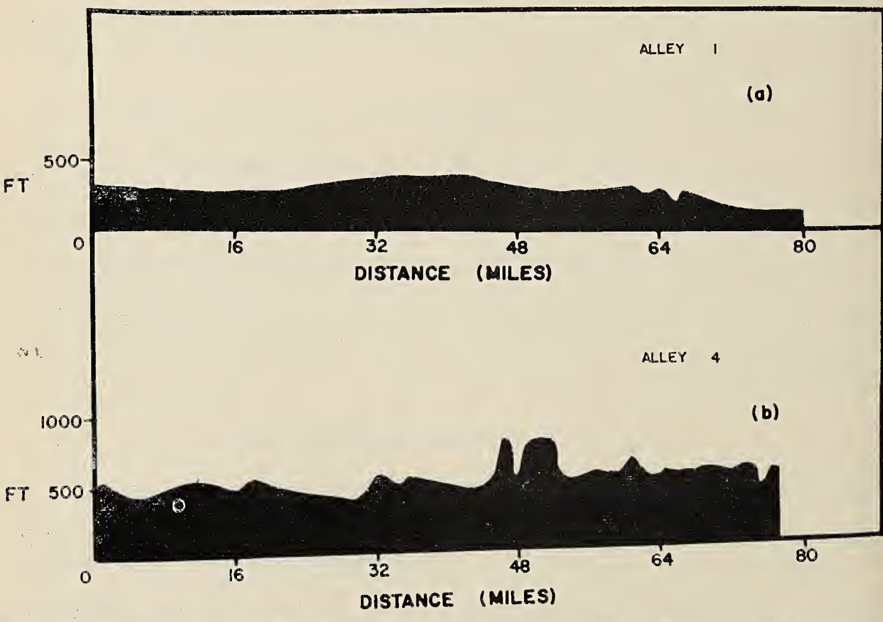



FIGURE 1. Terrain profile in Arkansas tornado alleys. Top profile in Gulf Coastal Plain and bottom profile in Arkansas River Valley.

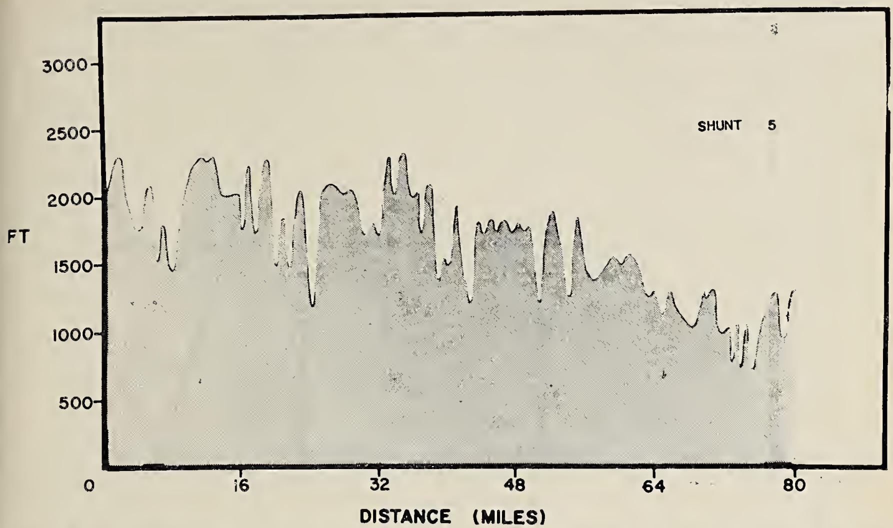



FIGURE 2. Terrain profile in Arkansas "shunt region," located north of Arkansas River Valley in the Ozark and Boston Ranges.

vided by spectral analyses of the height-data, showing relative contributions of different wavelengths or wavenumbers to the total variance. In order to compare the spectral densities of each strip, estimates were normalized. The range of wavelengths covered in this treatment was 2 to 34 miles (corresponding to wavenumbers from 0.5 to 0.029 cy/mile). A total of 17 lags was used. Aliasing was not a problem in the short wavelengths since height values were smoothed by interpolation between the generously spaced contour intervals. In fact, too much smoothing may have resulted since resolution was not optimum, particularly in the coastal plain.

The results of this spectral analysis will be labeled "Zones 1 to 5" from south to north. Zones 1, 2 and 4 are tornado alleys and Zones 3 and 5 the shunted belts. Figures 1 and 2 illustrate the terrain profiles of Zones 1, 4 and 5, respectively.

## Results and Conclusions of Spectral Analysis

The results were plotted on a log–log diagram, with the ordinate being the spectral density (p) and the abscissa being the wavenumber (k) or correspondingly the wavelength (1/k). In Fig. 3, the spectral densities for tornado alleys can be compared with that for shunted belts. The averages were computed by an arithmetical mean of the logarithm of the estimates. The individual and averaged variances corresponding to Fig. 3 are summarized in Table 1.

A significant characteristic of a spectrum is the exponent: $n = d(\log p)/d(\log k)$. Its overall numerical value in Zone 4 (tornado

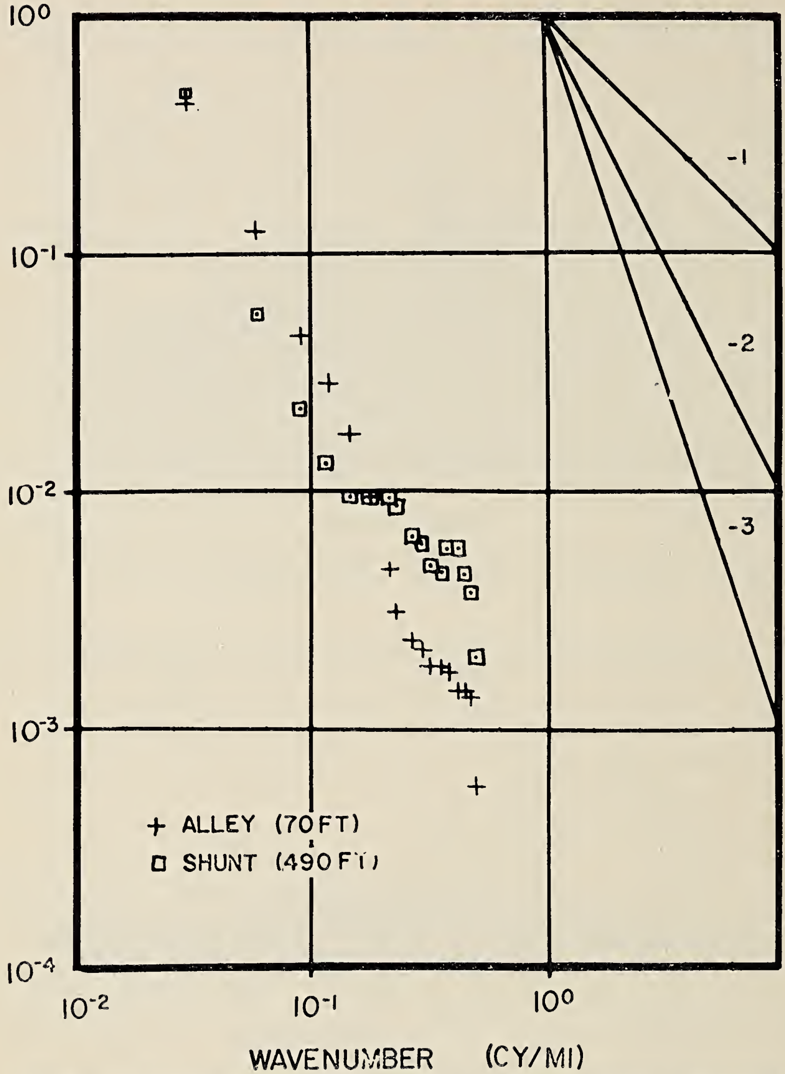



FIGURE 3. Normalized spectral plots of Arkansas terrain separately averaged for "tornado alleys" and "shunt regions." Comparative slope lines for several indicated values of the exponent n are indicated in upper right corner. Averaged standard deviations are given in legend. (Averages were computed by averaging the log of the spectral estimates.)

alley) is near —2 while for Zone 5 (shunt zone) it is close to —1 for large wavenumbers and near —3 for small wavenumbers. Zone 1 has a very pronounced value of n = —3 in medium and small wavenumbers. It is apparent that similar tornado alleys may have

TABLE 1. VARIANCE AND ARITHMETICAL MEAN OF TERRAIN HEIGHTS IN ARKANSAS FOR TORNADO ALLEYS AND SHUNTED ZONES. VARIANCE AVERAGES WERE COMPUTED LOGARITHMICALLY.

| ZONE | VARIANCE (FT.)² | MEAN (FT.) |
|---|---|---|
| Alley 1 | 1,714 | 208 |
| Alley 2 | 3,046 | 257 |
| Shunt 3 | 152,932 | 660 |
| Alley 4 | 23,645 | 489 |
| Shunt 5 | 386,910 | 1,387 |
| Averaged Zones | | |
| 1, 2, 4—Alleys | 4,930 | 318 |
| 3, 5—Shunts | 240,000 | 1,024 |

different terrain characteristics; reference can also be made to the discussion in Lettau (1967, p. 5 to 7).

The general differences are best evidenced in Fig. 3; the terrain spectra for tornado alleys "fall off" nearly at n = —3 for all wavenumbers, while the shunted belts show n = —3 only for small wavenumbers and possibly for the largest wavenumbers. At about 10 mile wavelength the two plots diverge with n = —1 prevailing for the shunted belts. It is apparent that the terrain in tornado alleys is smoother, or more "wave like," than in shunt regions. A value of n = —3 indicates that within a large family of terrain features of different sizes, the individual heights of the "obstacles" are proportional to their base–lengths. In other words, n = —3 indicates the same slope angles, or hill–steepness, regardless of base–length or wavenumber. However, the value of n = —1 indicates that the smaller the base-length the steeper the slope. Thus, Figure 3 suggests a "critical" baselength (or wavelength) of about 10 miles, since the shunted belts are distinguished by a change from n = —3 to n = —1 at and beyond wavenumbers of about 0.1 cy/mile. It could be surmised that tornadoes, when encountering a terrain type with n about equal to —1, at wavelengths smaller than about 10 miles, will be inhibited from either sustaining themselves or possibly even deevloping. In the intermediate case of n = —2 (as in tornado alley 4) the terrain may not appear rough enough or still too close to being wave-like to affect tornadoes.

## PART II: Wisconsin Investigation

### Tornado Statistics

Quite distinct from that of Arkansas, main tornado activity in Wisconsin occurs from March to September with peak intensity in May and June, and a secondary peak in September. The most destructive and longest tracked tornadoes appear in the months of April, May and June. Out of 52 severe tornadoes (according to criteria of Burley and Waite, 1965), 42 occurred during September and the spring months. About 83% of all Wisconsin tornadoes arrive from azimuths between west and south. In July and August, however, many of these storms arrive from the northwest, probably in connection with the frequent northwesterly flow aloft during middle summer. Since the overall synoptic pattern is weak during the summer, the resulting tornadoes are less intense and usually have short tracks. This study will consider tornadoes which are outstanding with respect to both path-lengths and intensity. Some bias may have resulted from the fact that the number of reported tornadoes has nearly doubled in the last 10 years of a 50 year record.

In Wisconsin neither topographical features nor the relations between terrain and tornado frequency are as clear-cut as in Arkansas. Fig. 4 shows the number of tornadoes by county from 1916–1964. Tornadoes are relatively frequent in most west–central counties, but no distinct north–south variation exists. In some summer situations, extreme eastern counties may be "saved" by cool air off Lake Michigan. Tornado frequency increases towards the west to a maximum in central Iowa. The typically flat or gently rolling, unforested farmland of central and western Iowa, which is essentially open, plowed fields in the spring, offers a relatively smooth and heat-absorbing surface probably favorable for tornado formation, while eastern Iowa and southwestern Wisconsin, with forested hills, bluffs and deep river valleys as well as occasional flat ridges, seem to reduce tornado activity.

The distribution of outstanding Wisconsin tornadoes, particularly the long tracked ones, suggests two "alleys"—the rather pronounced "west central alley" and the secondary "southern alley." The west central alley is an extension of the region of large frequency of tornadoes in south central Minnesota. The incidence of tornadoes may be less affected by Wisconsin's unglaciated area than is the ability of these storms to sustain themselves over long distances. Between the two "alleys" there is less reduction of tornado incidence than in the shunted regions of Arkansas.

The two alleys of Wisconsin are frequented at different times of the spring season. The majority of the southern–alley tornadoes occur in April and May, while the west–central alley is most often frequented in June, simultaneously with a jump in tornado activity in both southern Minnesota and west central Wisconsin. This region of Minnesota is flat open farmland, much like that of cen-

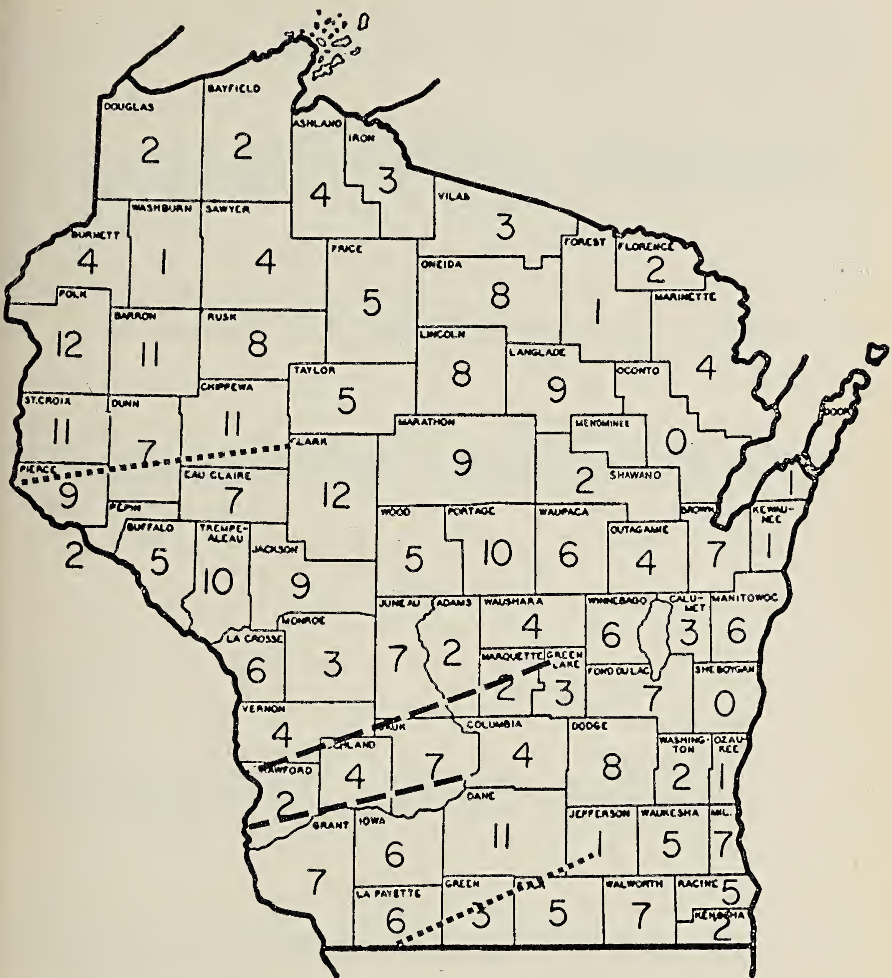



FIGURE 4. Number of reported tornadoes by county, 1916 to 1964 (after Burley and Waite, 1965). Superimposed lines (short-dash for "alleys" A and D, and long-dash for "shunted areas" B and C) indicate paths chosen for investigation.

tral Iowa. July and August tornadoes seem to show no "alleying," and often move in a southeasterly direction, but their rarity prohibits further discussion of topographic effects.

In general east to west trends, population density in Wisconsin is negatively correlated with frequency of tornadoes. However, in Central Wisconsin, just south of the main tornado alley, a sparsely populated area surrounds the forested region including many cranberry bogs east of the hills near the Mississippi River. Consequently, the lower population in areas between the two alleys requires some qualifying of terrain–tornado alley relations based on presently available statistics.

## Profiles of Topography and Terrain Slopes

Four topographic profiles were chosen. Two of them followed the tornado alleys and the remaining two were in the region of relatively low tornado frequency. All of these strips extended into adjacent states to the west. The profiles were labeled A, B, C and D from south to north; A and D represent tornado alleys, while C and B correspond loosely to shunted belts. Table 2 gives the geographic locations of these four strips.

Initially it was planned to use a radioaltimeter (type AN/APN-22) in the Cessna 310 twin-engine aircraft employed in previous work at the University of Wisconsin Department of Meteorology (see Lenschow and Dutton, 1964), but the available system was found unworkable. Consequently, the study of terrain profile structure was based on topographic maps. The airplane, however, was useful in measuring profiles of surface temperature along the selected topographical sections. Bolometric sampling of surface temperature was done every second, which corresponds to one sample every 1/20 of a mile. To ensure comparable detail, terrain heights were taken from 7.5 minute (scale 1 to 62,500) Geological Survey Quadrangles. Because these maps are often only planimetric, a portion of Wisconsin's shunted belt could not be analyzed. The contour intervals on the topographic quadrangles proved satisfactory for readings at intervals of 1/20 mile. The actual horizontal increment used was 247 feet, or about 79 meters.

For an illustration of terrain structure, heights were plotted in Figs. 5 and 6 every 4,940 feet. As can be seen from Table 2, the variance of height in the shunt region exceeds that of the tornado alleys, but the difference is less than in Arkansas. Moreover, the

Table 2. Geographic Statistical Data of Topographic Profiles in Wisconsin in connection with Tornado Statistics.

| Strip | Endpoints | Length (miles) | Variance (ft.)$^2$ | Mean (ft.) |
|---|---|---|---|---|
| A (Alley) | Anamosa, Iowa—Fort Atkinson, Wisconsin | 138 | 9,036 | 899 |
| B (Shunt) | West Union, Iowa—Lake Wisconsin | 123 | 24,785 | 911 |
| C (Shunt) | Decorah, Iowa—Princeton, Wisconsin | 141 | 44,036 | 1,010 |
| D (Alley) | Farmington, Minnesota—Stanley, Wisconsin | 121 | 13,197 | 963 |

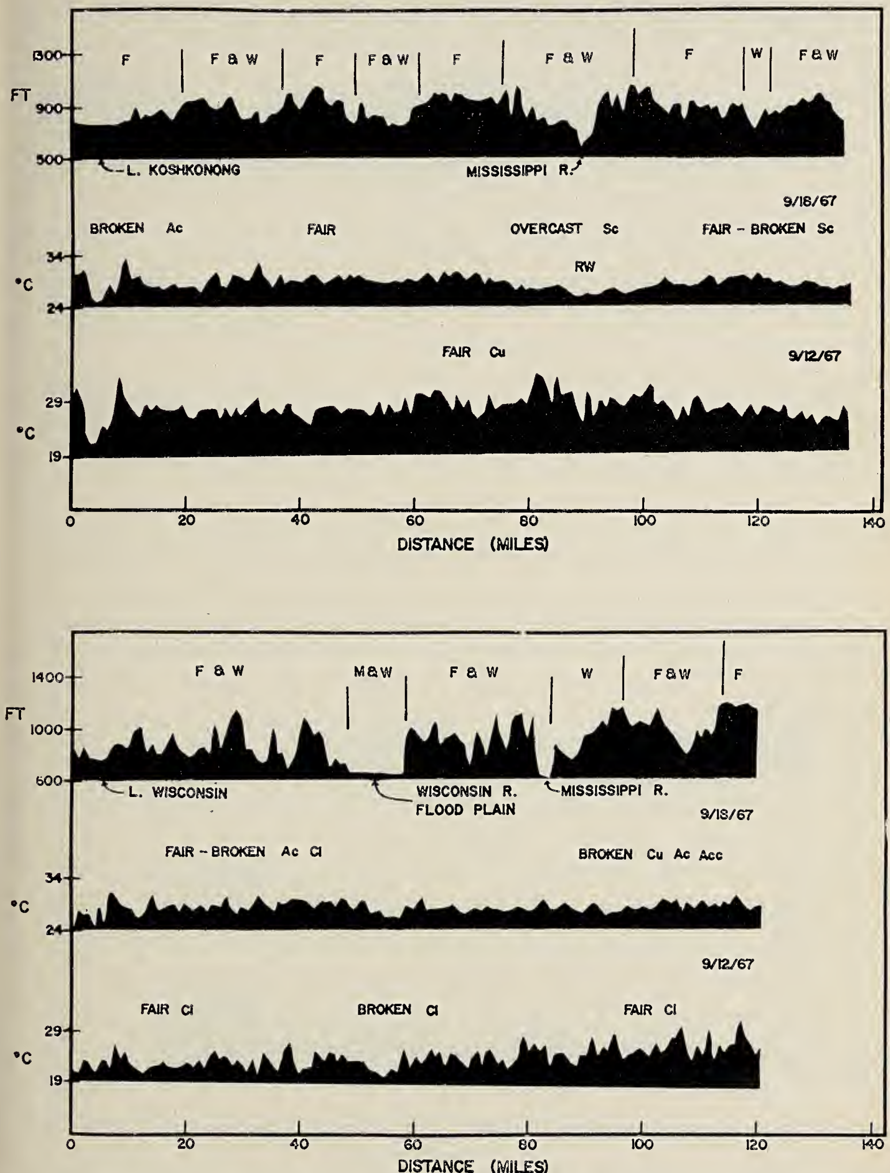



FIGURE 5. Terrain and surface temperature profiles of September 12 and 18, 1967, for Wisconsin Strips A and B (top is A). A new landmarks and a general description of the characteristic surface and sky conditions are also given. (Note: M = marshland, F = open field and farmland, and W = woodland.)

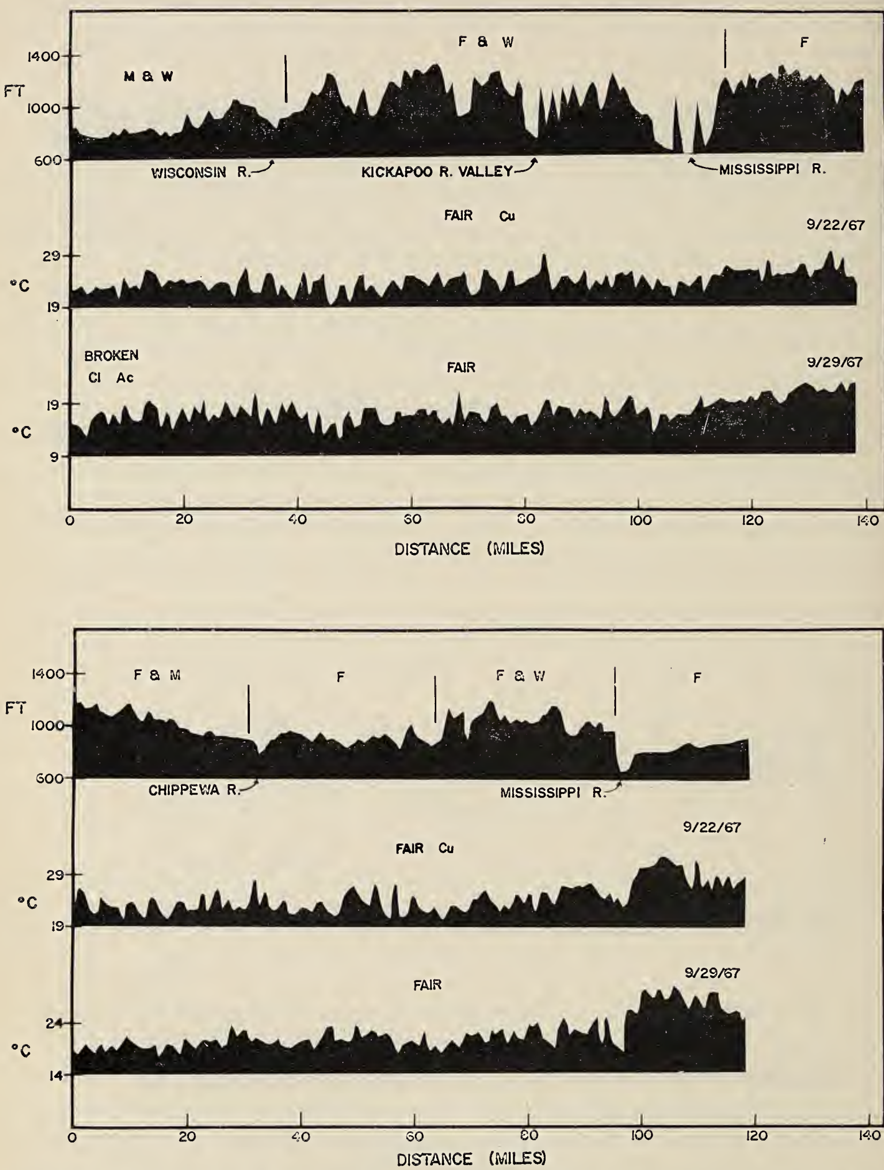



FIGURE 6. Terrain and surface temperature profiles of September 22 and 29, 1967, for Wisconsin strips C and D (Top is C). A few landmarks and a general description of the characteristic surface and sky condition are also given. Note: M = marshland, F = open field and farmland, and W = woodland.

variance along the shunted Strip B in Wisconsin is about the same as that of the Arkansas River tornado alley. If the frequency of tornadoes reported in Wisconsin were equal to that in Arkansas, Strip B might possibly not be considered typical of a shunted belt. The results of spectral analysis (presented later) bear this out to some degree. Strip C appears more representative of Wisconsin's rugged unglaciated area as well as more reliably centered in a shunted belt than Strip B. However, the terrain variation in this shunted zone is far less than in Arkansas. The fact that some active tornadoes do indeed track over this area implies a weaker relation between shunted belts and terrain roughness than is apparent in Arkansas.

The terrain profiles show that unlike the other profiles, D has relatively large variation in very long wavelengths. This implies that "Alley D" is relatively smoother than the other strips at short and medium wavelengths. The flat terrain west of the Wisconsin portion of D coincides with a region of notorious tornado activity during June.

Figure 7 suggests that tornadoes may shy away from varying slopage, i.e., terrain roughness and downslope. The positive relation of tornado frequency with upslopes toward the East may further be enhanced by middle and late afternoon heating.

Tornado frequencies appear to depend on somewhat different mechanisms than other convective phenomena. Hail and heavy rainfall are also known to be dependent on terrain slope, elevation, and roughness as well as distribution of woodlands. Hail intensity not only appears positively related to upslope, but unlike tornadoes it is positively related to downslope, roughness and woodlands (Stout, 1962). Rainfall patterns show a similar relationship except that downslopes likely reduce convective instabilities and hence reduce thunderstorm rainfall.

During spring, thunderstorm cells tend to move northeasterly; considering the previously mentioned topographical relations, this appears to be the main reason for maximum hail and rainfall in the hilly areas west and northwest of Madison and in the Northern highlands generally north of the west central tornado alley. Most of this information can be found in Wisconsin Weather (Wisconsin Statistical Reporting Service, 1967).

## Terrain Spectra

Spectral analyses were performed on the terrain profiles defined in Table 2, with a total lag of 200. Figures 8 and 9 show examples of individual spectra for Strip A (alley) and C (shunt). The spectra were plotted by computer versus increasing period. The left vertical line indicates the Nyquist wavelength of the Arkansas

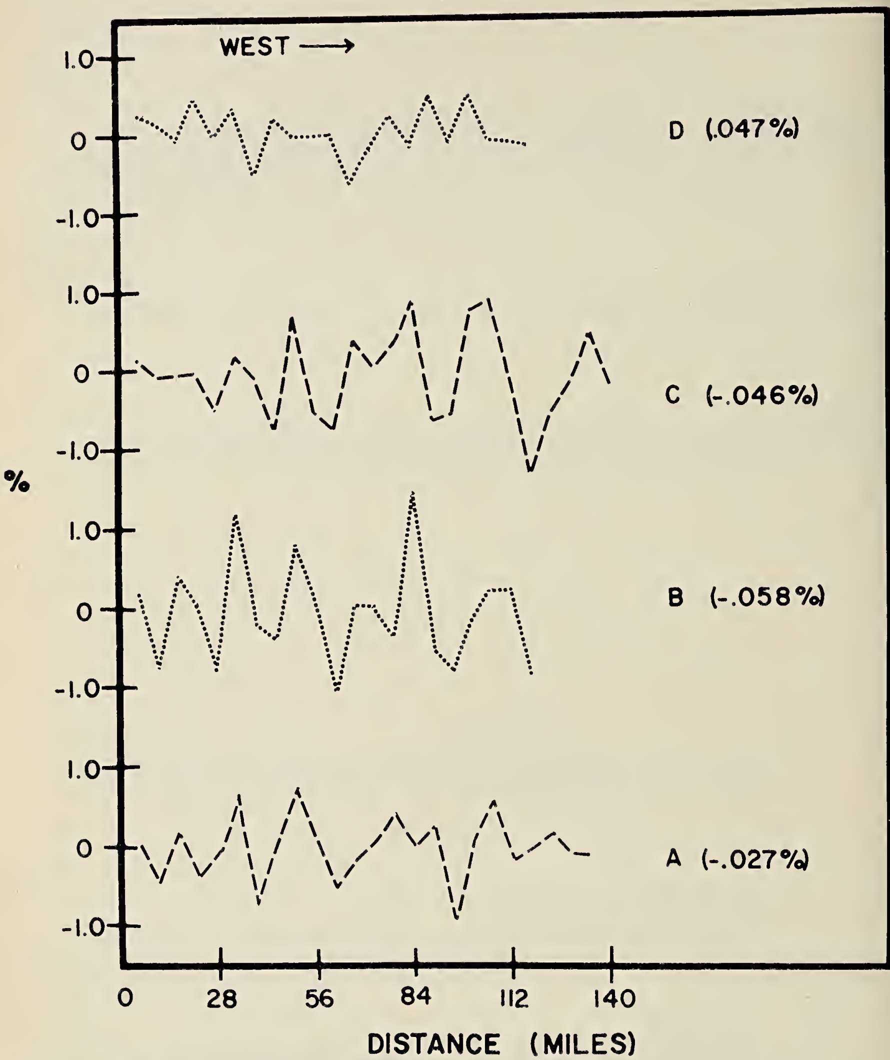



FIGURE 7. Wisconsin terrain slopes for Strips A, B, C and D, given in perctntage (positive for upsloping to the east) over 5.6 miles. The mean slope is indicated to the right of the corresponding strip.

investigation, and the right vertical line the 10-mile wavelength critical for the Arkansas shunted belts.

In view of the different total variance and the structure of the profiles of Figs. 6 and 7, it is not surprising that the spectra are also different. The plots of A, B and D are almost identical with a "critical" wavelength near one kilometer. For longer wavelengths

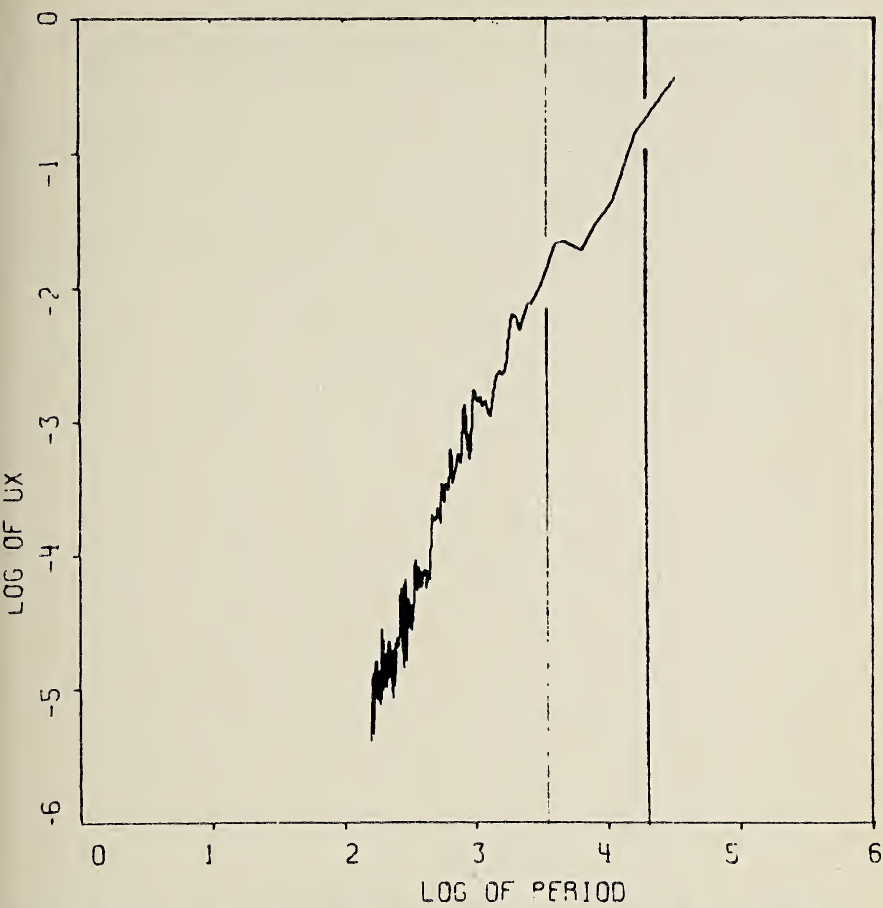



FIGURE 8. Normalized terrain spectrum of Wisconsin, Strip A (tornado alley). Vertical lines represent 2 to 10 mile spectral band covered in Arkansas spectral analysis.

the exponent (n) is near —2 whereas for shorter wavelengths n is close to —3. Strip C differs from this pattern. Here the exponent increases continuously for decreasing wavelengths starting near —2 and gradually changes to zero for wavelengths less than one kilometer. Short wavelengths contribute more variance in the shunted region C than in A, B or D.

In the 2 to 20 mile wavelength band, the spectra for A, B and D are similar to that of the Arkansas River Valley, which has a total variance reasonably close to these 3 strips. The exponent n is about —2. In marked contrast, C has a spectral variance in this band much like the shunted belts of Arkansas. Its total variance, however, is considerably smaller than in any of these belts but larger

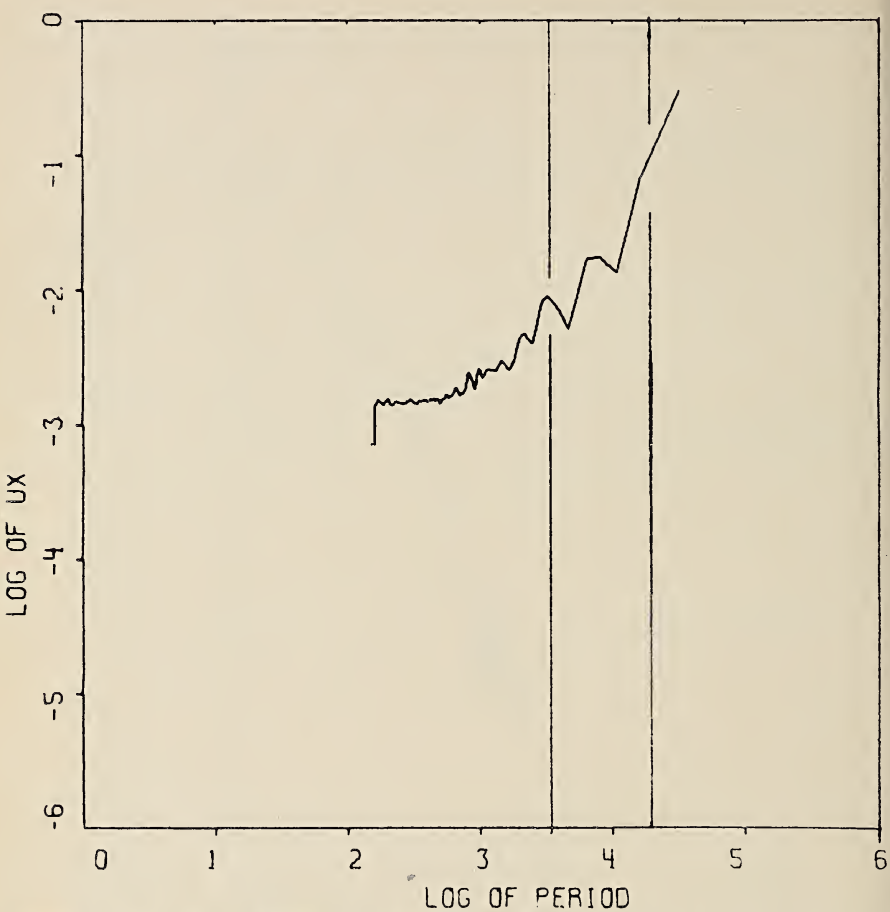



FIGURE 9. Normalized terrain spectrum of Wisconsin, Strip C (shunt). Vertical lines respresent 2 to 10 mile spectral band covered in Arkansas spectral analysis.

than in the other Wisconsin strips. Due to the difference in sampling intervals for the Arkansas and Wisconsin investigations we cannot say at present how realistic this comparison is.

Averaged spectral estimates for the two tornado alleys and the two shunted strips are illustrated in Fig. 10. Since the spectrum of B resembles more that of A than C, combination of B with C may not yield a representative average of the shunted belt of Wisconsin. More representative of a shunted strip would probably have been a profile from La Crosse to northern Juneau and Adams counties, but topographic maps were not available for this region.

A discontinuity in the spectra appeared at a wavelength of

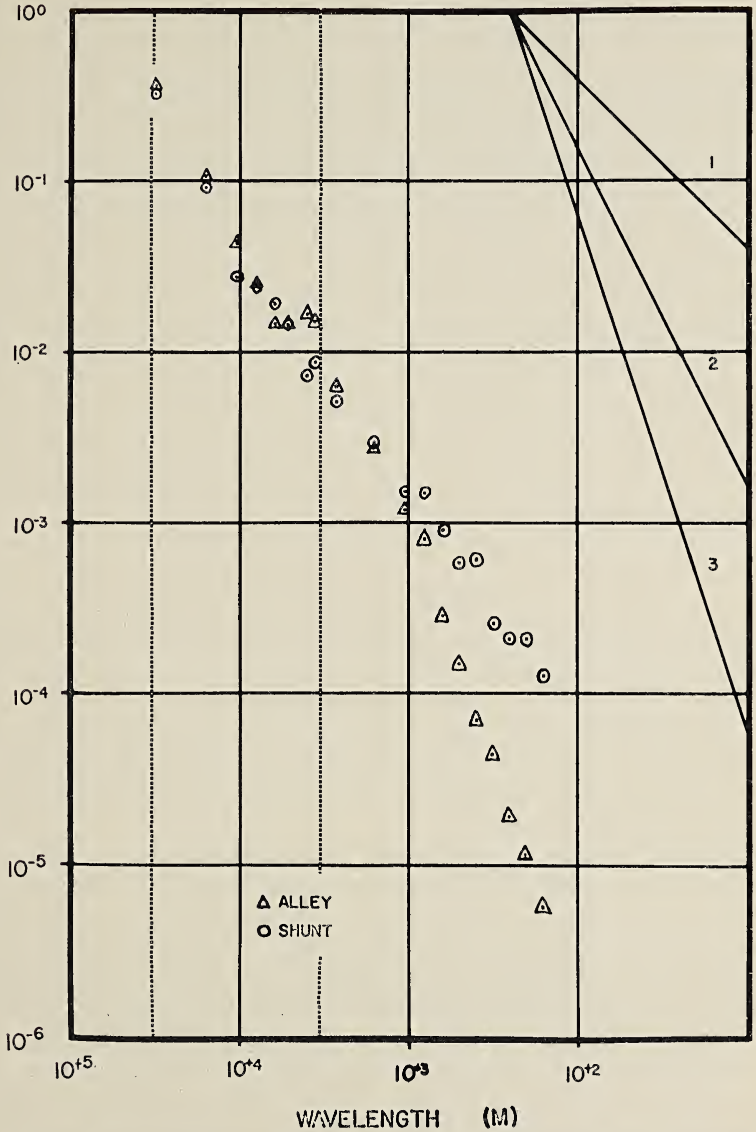



FIGURE 10. Normalized spectral plots of Wisconsin terrain separately averaged for "tornado alleys" and "shunt regions." Comparative slope lines are indicated in upper right corner. The two vertical lines are the 2 to 10 mile wavelength band covered in Arkansas spectral analysis. (Averages were computed by averaging the log of the spectral estimates.)

about one kilometer. The exponent n is near—1 for the shunted belt and near —3 for the alleys. For longer wavelengths, including the 2 to 20 mile wavelength band, both graphs suggest $n = -2$. The case $n = -1$ implies increasing hill steepness and fairly uniform hill heights with decreasing wavelength, while $n = -3$ indicates a uniform hill steepness and, thus, with heights decreasing with decreasing wavelength. The fact that the split appeared near one kilometer instead of around 10 miles (found critical for Arkansas) could be the result of more detailed data collection in Wisconsin.

The near-zero value of the exponent n for short wavelengths ($< 1$ km) of the shunted region C suggests pronounced steepening of slope with decreasing base length of the hills. It would be interesting to know if this is typical of other shunted areas like those of Arkansas. Furthermore, a critical wavelength around 10 miles corresponds to the "scale" of thunderstorms, while a critical wavelength near one kilometer corresponds to the "scale" of tornadoes. This might suggest that only tornadoes and not thunderstorms are significantly affected by topography in Wisconsin.

## Surface Temperature Measurement from an Airplane

Surface temperature was measured, along the terrain profiles shown in Fig. 4, with the aid of a Barnes IT–3 Infrared Thermometer (bolometer) mounted in the baggage section of a Cessna 310 twin engine aircraft. This bolometer has a 3° field of view corresponding to a circle of about 15.7 meter radius on the ground, at 300 meters flight altitude. The technique is described by Lenschow and Dutton (1964).

Before each flight, a pre-check of the system was made with water baths of varying temperatures. Check flights over Lake Mendota were also included on the day of a run, to insure proper functioning of the instruments when airborne. Sometimes the bolometer indicated a spurious rise of about 1° C of the Lake Mendota temperature after considerable time in the air, but such discrepancies were within error tolerance. Although all instruments were shock-mounted, some vibrational noise still occurred, and an electronic filter was used to remove it for spectral analysis of temperatures. The use of this filter, however, introduced some additional problems that will be discussed later.

According to Stefan–Boltzman's law, radiation emitted by a surface depends on both its emissivity and its temperature. Since emissivity ($\epsilon$) varies over different surfaces, errors will be introduced regardless of the accuracy of the calibration. An 8% change in emissivity corresponds to about a 6° C change in measured surface temperature (Lenschow and Dutton, 1964). Except in dry sandy areas, variations as large as 8% in emissivity are not likely in Wisconsin.

Radiation entering a bolometer depends on the radiation emitted by the environment. For the bolometer used, the radiometer filter was an 8 to 14 micron passband, with nearly zero response outside, with insignificant dependency on temperature. For the type of surfaces encountered in Wisconsin, the emissivity was assumed nearly constant for all wavelengths in the band of the filter. Errors resulting from this assumption can be reduced if the surrounding radiation is as small as possible. Tanner and Fuchs (1966) showed that the equivalent black-body temperature departs from the actual surface temperature by less than 1° C for Sudan grass ($\epsilon = 0.976$) and alfalfa ($\epsilon = 0.977$). However, Lorenz (1966) noted that for an emissivity of 0.925, the difference could be as large as 3.5° C. In general, the apparent surface temperature is sufficiently close to the actual radiation surface temperature provided the bolometer is not located far above the ground. Menon (1967) discussed surface temperature corrections for flights over Lake Michigan and Lake Superior. He found that errors of ± 0.5° C can be expected, without corrections, at 300 meter heights.

Table 3 summarizes the results of the calibration flight over Lake Mendota on August 21, 1967; a comparison of bolometric water temperature ($T_b$) with the lake temperature measured from a boat ($T_w$) showed a difference of about 0.5° C at 300 meters. The dew point was relatively high. As expected, the measured bolometric temperature decreases with height.

It should be pointed out that the bolometer "sees" an area (for our flights) of about 776 m². It records an average radiation temperature over this area that tends to be slightly higher than the

TABLE 3. RESULTS OF BOLOMETRIC FLIGHT OVER LAKE MENDOTA ON AUGUST 21, 1967. $T_a$ IS THE AIR TEMPERATURE MEASURED FROM AIRPLANE, $T_b$ IS BOLOMETRIC WATER TEMPERATURE, $T_w$ IS WATER TEMPERATURE MEASURED FROM A BOAT. SIMULTANEOUS RECORDINGS AT TRUAX FIELD SHOWED A DRY-BULB TEMPERATURE OF 21° C AND A DEW POINT OF 15° C.

| HEIGHT (FT.) | $T_w$ | $T_b$ | $T_a$ |
|---|---|---|---|
| 0 | 21 | — | — |
| 500 | — | 22 | 23 |
| 1,000 | — | 21.5 | 22 |
| 1,500 | — | 21 | 20.5 |

true area mean surface temperature. Lenschow and Dutton (1964) discussed this problem and found such errors to be less than 1° C, which was considered tolerable for this investigation.

## Data Collection and Effect of Weather

The temperature trace on the "Visicorder" was read (for the same number of points as the terrain height data) by a specially designed chart reader, and data automatically punched on cards, then transformed into surface temperature with the aid of a computer-program and a linear equation.

Of a total of 14 flights, five (4 near noon and one at dawn) covered strips A and B, two were over strip C near noon, and two were over strip D in the early afternoon. Table 4 lists the resulting means and variances as well as the time and date of each flight. It should be noted that the effect of the 5-sec filter is to reduce the variance but not to alter the mean of the actual surface temperature series. Temperature profiles were included in Figs. 5 and 6 together with the general characteristics of the terrain "landmarks" and sky conditions.

The day-to-day variation in surface temperature is due to changes in insolation (which depends on cloudiness, season, latitude, etc.), albedo, emissivity, wind (speed and prevailing direction), thermal admittance of the soil, and air temperature and moisture gradients. Significant daily variations in some of these parameters occur even when the same air mass prevails over a region for several days. The days chosen to measure the surface

TABLE 4. MEAN SURFACE TEMPERATURE AND STANDARD DEVIATION (DEG C) FROM BOLOMETRIC FLIGHT OVER THE FOUR "STRIPS" IN WISCONSIN INDICATED IN FIG. 4.

| Date 1967 | Tornado Alleys | | | Shunt Regions | | |
|---|---|---|---|---|---|---|
| | Strip | Hours | Temp. | Strip | Hours | Temp. |
| Sept. 11 | A | 10:50-11:38 | 23.1 ± 3.9 | | | |
| 12 | A | 12:47-13:35 | 27.8 ± 3.9 | B | 10:40-11:25 | 24.7 ± 5.4 |
| 18 | A | 13:14-14:03 | 27.3 ± 2.0 | B | 14:27-15:11 | 27.6 ± 1.1 |
| 21 | | | | B | 11:34-12:13 | 25.3 ± 0.9 |
| 22 | D | 14:43-15:25 | 24.3 ± 8.7 | C | 11:44-12:34 | 23.6 ± 3.3 |
| 29 | D | 14:12-14:52 | 22.3 ± 10.6 | C | 11:41-12:32 | 17.3 ± 4.5 |
| Oct. 2 | | | | B | 12:28-13:14 | 27.3 ± 3.3 |
| 3 | | | | B | 6:36- 7:26 | 15.7 ± 1.9 |
| 5 | A | 6:30- 7:10 | 13.1 ± 2.2 | | | |
| 5 | A | 12:24-13:11 | 22.8 ± 1.9 | | | |

TABLE 5. AVERAGE MAXIMUM AIR TEMPERATURE (IN °C) FOR TRIPLETS OF WEATHER BUREAU CLIMATOLOGICAL STATIONS LOCATED NEAR RESPECTIVE STRIPS. VALUES WITH ASTERISKS ARE AVERAGED MINIMUM AIR TEMPERATURE.

| DATE—1967 | STRIP A | STRIP B | STRIP C | STRIP D |
|---|---|---|---|---|
| Sept. 11 | 21.3 | | | |
| 12 | 24.3 | 24.8 | | |
| 18 | 26.7 | 26.7 | | |
| 21 | | 23.0 | | |
| 22 | | | 20.2 | 19.4 |
| | | | 12.6 | 15.6 |
| Oct. 2 | | 27.9 | | |
| 3 | | 13.0* | | |
| 5 | 9.6* | | | |
| 5 | 27.1 | | | |

temperature were selected with the intent to isolate some of the dominant parameters. Tables 5 and 6 provide information on air temperature, wind and total isolation for the days and regions.

The difference between moist and dry surface conditions is illustrated by comparing the profiles of September 12 and 18 for Strips A and B. Due to preceding rainy days, the overall variation on the 18th is relatively small. Reduced insolation due to overcast cloudiness also significantly damps out temperature variability. In general, flights were scheduled only when cloudiness was expected to be light, but, unfortunately, in view of the approach of autumn,

TABLE 6. PARTIAL SUMMARIES OF WEATHER AND CLIMATOLOGICAL DATA PERTINENT TO BOLOMETRIC FLIGHTS. VALUES IN PARENTHESES ARE MAXIMUM WIND SPEEDS DURING THE DAY.

| DATE 1967 | AVERAGE RESULTANT WIND | | | | INSOLATION (LY/DAY) | |
|---|---|---|---|---|---|---|
| | Madison | | Minneapolis | | Madison | La Crosse |
| | Direction | MPH | Direction | MPH | | |
| Sept. 11 | 140 | 7.3 (15) | | | 464.6 | 514.0 |
| 12 | 170 | 5.7 (16) | | | 461.0 | 436.5 |
| 18 | 120 | 2.6 (14) | | | 344.1 | 294.9 |
| 21 | 320 | 9.6 (22) | | | 398.3 | 444.0 |
| 22 | 030 | 3.9 ( 9) | 180 | 8.2 (17) | 465.1 | 450.0 |
| 29 | 330 | 8.8 (15) | 170 | 1.7 ( 7) | 249.0 | 440.4 |
| Oct. 2 | 200 | 9.9 (20) | | | 414.9 | 397.3 |
| 3 | 200 | 5.6 ( 9) | | | 347.0 | 342.6 |
| 5 | 020 | 7.8 (14) | | | 398.4 | 389.9 |

this requirement was often relaxed. The flight of September 18 over Strip A was under heavy cloudiness and showed reduced standard deviation of surface temperature. Several examples—notably October 5 of Strip A, September 12 of Strip B and September 18 of Strip A—illustrate how periods of overcast cloudiness can induce long "trending" in the surface temperature record.

On a given day when the soil was wet, the mean surface temperature was relatively close to the average maximum air temperature of the nearest climatic stations. The mean surface temperature was found generally higher than the air temperature for fair skies and relatively dry soils. The two dawn flights (October 3 and 5) show mean surface temperatures higher than the average minimum station temperature. The variance was also found fairly high indicating that warmer ground inversions were probably being measured as part of the effective radiative surface. Temperature trends under variable conditions appear to substantiate Lambert's investigation of thermal response of a Sumac canopy (1967) to cloud shadows.

Table 6 shows lowest average windspeeds on the 18th (Madison) and 29th (Minneapolis) of September. The large surface temperature variations on the 29th in comparison with the 22nd probably resulted from drier soils and low wind speeds. The 18th and 21st appear to have sufficiently identical soil and sky conditions that the significant difference in average wind speed appears to be the cause of the lower variance of the latter. It should be noted that the times of these two flights differed by about 3 hours. Obviously, the available information was insufficient to determine the full effect of air motion on surface temperature.

## Influence of Land Use and Surface Types

Figures 5 and 6 provide a general description of the distribution of surface types along the strips. Farmland and irregular spaced forests will respond differently to solar heating. The selected interval (4940 ft.) for plotting the temperature profiles suppresses these effects because rain and cloudiness affected most of the samples taken along Strips A and B; hence this discussion will be primarily concerned with Strips C and D.

The relatively high surface temperatures west of the Mississippi River over Strips C and D coincide with areas of extended, harvested fields of brown color. High readings also occurred in other regions of dominantly open farmland. Lowest mid-day temperatures generally appeared in the marshy and scrubby vegetated areas. Mixed areas both flat or hilly showed considerable variation but have on the average a mean temperature between that of farmland and marshy land. The relatively high surface temperatures observed near the Mississippi River along Strip A are over a region with some hills but less forested than either B or C. In essence, these findings agree with the results reported by Lenschow and Dutton (1964) for central and southern Wisconsin.

The total sample of surface data was unfortunately too small to establish conclusively differences between tornado alleys and shunted strips. Several factors can be mentioned: First, the period studied did not coincide with the maximum tornado season, while the surface structure, both in open and forested areas, varies seasonally; for example, deciduous forests are leafless during April and early May, cornfields are bare in spring but not in late summer and fall, whereas for hay and wheatfields the reverse is true. A relatively warm band of nearly 20 miles (Fig. 6) in Minnesota is interesting and invites further study, because of high tornado incidence in June in this region. The high variance of strip D (Table 4) is probably also connected with this farm area. Second, warm regions of smaller scale (several miles or less) appear rather frequently and may contribute to randomness of convection phenomena. Third, a portion of the variances of several of the days were influenced significantly by cloudiness and soil moisture. More information is needed on surface temperature response under varying weather conditions before inferences on relationships between temperature structure and tornadoes may be reached.

## Variance Spectra of Surface Temperature Profiles

Spectral analysis was performed on the surface temperature data in the same manner as for topography. Smoothing of the terrain data was a direct result of the interpolation on topographic maps. The effect of filtering on the measured surface temperature had to be considered in more detail. The bolometric averaging over a circular area of 15.7 meter radius may tend to increase the exponent $n$ at the high frequency end of the spectrum. These forms of smoothing of temperature and terrain data probably eliminated some aliasing problems. Also, a 5-sec filter was used to help prevent aliasing, but because it damped out important amplitude variations in intermediate wavelengths, the unfiltered spectral estimates had to be recovered, following a method described by Dutton (1962).

A test was conducted to compare a "red noise" spectrum against the actual spectra. (For a detailed discussion of "red noise spectra" see Gilman, et al., 1963.) In particular, for a "null" hypothesis the "red noise" was considered the underlying continuum or actual population from which the direct estimates were just random samples. A plot of the "red noise" estimates corresponding to September 22 of Strip C is given in Fig. 11. Conditions for the other

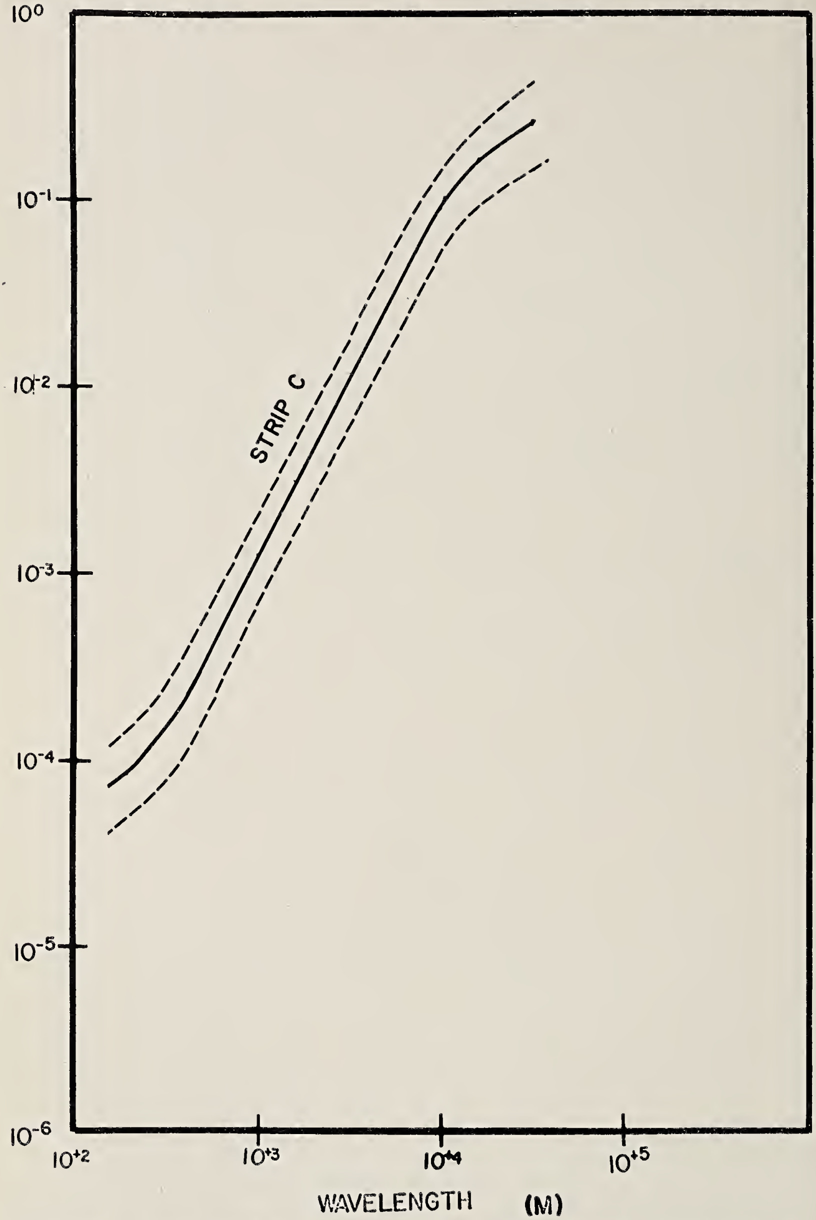



FIGURE 11. Red noise spectrum of surface temperature corresponding to September 22, 1967, of Wisconsin Strip C ("shunted strip"). Estimates based on a sample one-lag autocorrelation coefficient equal to 0.9697. Chi-square confidence lines are given in dashed curves.

dates were similar. For a testing, it is assumed that the ratio of the sample estimate to the continuum estimate is a chi-square variable divided by the number of degrees of freedom. In this way, a confidence (acceptance) region can be specified about each continuum value, according to Tukey. The estimates of September 22 differed significantly from the red noise continuum at the 5% level of significance. The sample curve appears to follow simple persistence in short (<600 meters) and long wavelengths, while intermediate wavelengths suggest a "white noise" shift. Many of the other spectral graphs also show this tendency.

For further tests, fitting lines were placed by sight through the short and intermediate period regimes. Figure 12 illustrates a pair of such lines as well as the confidence limits pertinent to Strip A of September 11. The regimes of simple persistence and "near-white-noise" are well contained inside these confidence limits. Numerous spikes and overall noisiness in the direct spectra appear to be statistically insignificant. However, more data would be needed to verify the validity of this statement. Recurring maxima or "spikes" might indeed prove physically real for an individual terrain profile.

The results above indicate that by and large, the intermediate "waves" of 0.5 to 5 km are made up of a random distribution of temperature oscillations. This may correspond to the fact that the arrangements of forests, lakes, towns, variable crop fields, and pastureland are of the order of intermediate wavelengths and tend to be fairly irregular. They include the dominant homogeneous features introduced by man. As dominating features get smaller, the temperature response decreases rather strongly.

One important exception was found on September 18 over Strip B, where the spectral density suggested an exponent n of less than 1. The wet soil and extensive cloudiness present on this day could have resulted in the damping of major randomness in intermediate wavelengths.

For the terrain spectra previously discussed, a comparison was made with the red noise spectrum. Figure 13 illustrates the red noise spectrum corresponding to Strips A and C. The topographies of A, B and D all have a high degree of simple persistence, while "white noise" in smaller wavelengths of C causes substantial deviation from red noise, although some persistence in long wavelengths may prevail.

## Concluding Remarks

The results of this study seem to pose more questions than answers. The fact that "alleys" and "shunted regions" exist suggests the qualitative picture of tornadoes shying from "rough" ter-

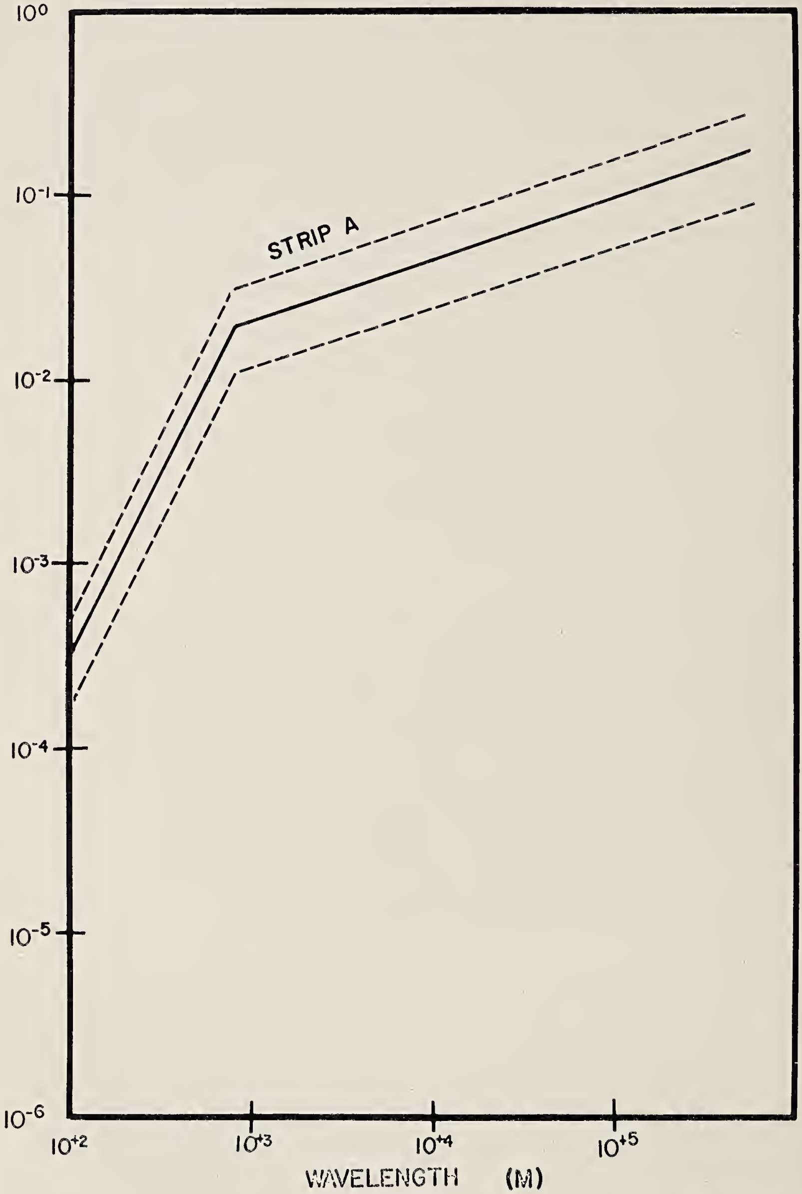



FIGURE 12. Lines (placed by sight) fitting spectral curve of surface temperature for September 11, 1967, of Wisconsin Strip A ("tornado alley"). Confidence lines are also indicated.

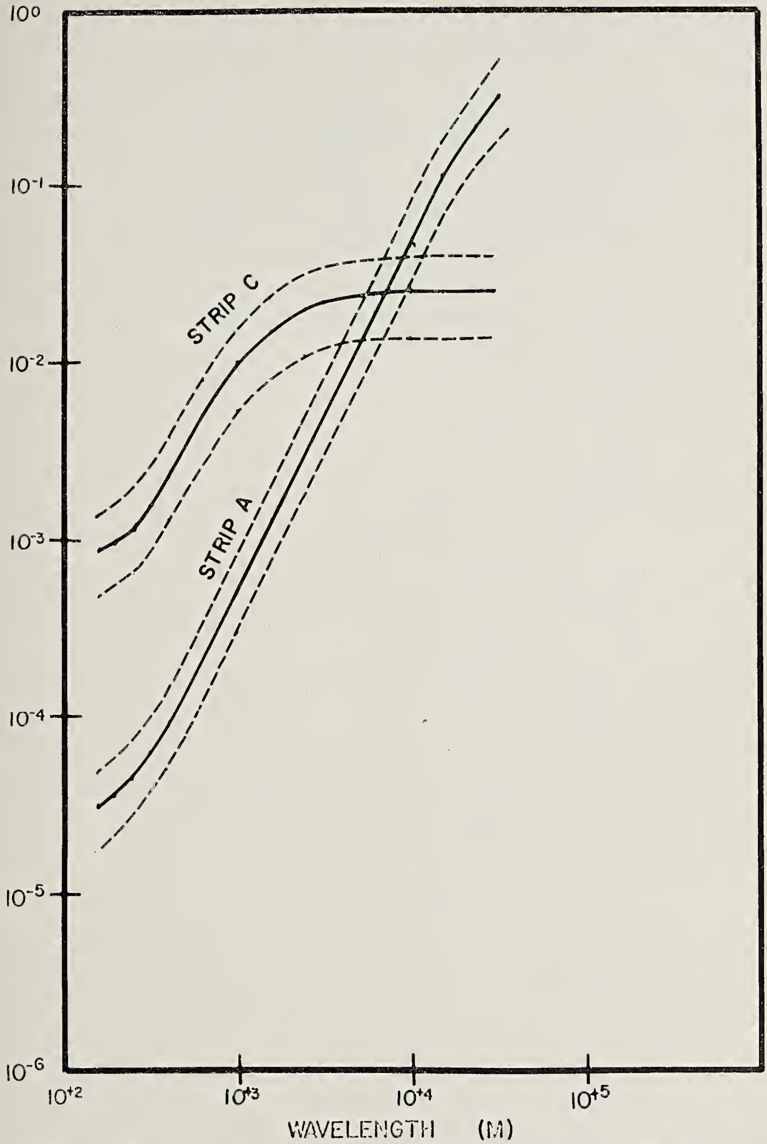



FIGURE 13. Red noise spectra corresponding to terrain of Wisconsin Strips A ("tornado alley") and C ("shunt strip"). Estimates were based on one-lag autocorrelation coefficients 0.9874 and 0.7078 respectively for Strips A and C. Chi-square confidence lines are also given.

rain. We tried to understand roughness on a quantitative scale in order to explain how terrain may affect these storms. This has been attempted through the use of spectral analysis for selected one-dimensional terrain profiles. In order to measure roughness which is representative of a region, a two-dimensionly approach will be needed to determine the full variability of surface structure.

Surface temperature is one measure of how a surface type responds to the supply of solar energy, but variations in the many factors governing thermal response make it difficult to specify tornado-suppressing and tornado-supporting trends. One possible approach would be to parameterize conditions for each "mosaic" element of a complex land/air interface like that in Wisconsin and develop a theoretical model of thermal response to radiative forcing functions, as that of "climatonomy" proposed by Lettau (to be published). Full parameterization of surface conditions must include a measure of aerodynamic roughness, of albedo and emissivity, of moisture availability, and the thermal admittance of the submedium. This study provided new information on surface roughness and its effect on surface temperature variability. One important result could be that features smaller than about 600 meters appear to have little significance for surface temperature variations. With the establishment of such limiting criteria the task may not be overwhelming.

Very little is known about how local supplies of sensible and latent heat are utilized in severe convective storms. Mesoscale meteorology has not had the benefits of intensive research that larger scale studies have. Even less is known on the generation of hail and tornadoes. Further research on the basic dynamics and energetics of the mesoscale is certainly needed.

## Acknowledgments

Commentary by Professor John Kutzbach proved very helpful in the interpretation of variance spectra. Thanks goes to Professor Charles R. Stearns for his assistance and advice concerning the instrumentation phase of the project. Additional gratitude is conveyed to Russell Johnson for his patience and help in maintaining a reasonable operation of the bolometer. And finally, Mr. Rollie Mack (pilot) and Mr. Sherman Hallen are acknowledged for their complete cooperation in scheduling successful flights.

## References Cited

Asp, M. O., Geographical Distribution of Tornadoes in Arkansas, *Monthly Weather Review, 84* (4); 143–145, 1956.

Burley, M. W. and P. J. Waite, *Wisconsin Tornadoes,* Transactions of the Wisconsin Academy of Science, Arts and Letters, Madison, Wis., 1965.

DUTTON, J. A., Space and Time Response of Airborne Radiation Sensors for the Measurement of Ground Variables, *Journal of Geophysical Research 67*(1); 195–204, 1962.

FLORA, S., *Tornadoes of the United States*, University of Oklahoma Press, Norman, 1953.

GILMAN, D. L., F. G. FUGLISTER and J. M. MITCHELL, JR., On the Power Spectrum of "Red Noise," *Journal of Atmospheric Science, 20;* 182–184, 1963.

HOLLOWAY, J. L., JR., Smoothing and Filtering of Time Series and Space Fields, *Advances in Geophysics 4;* 351–389, Academic Press, New York, 1958.

KUHN, P. M., DARKOW, G. L. and SUOMI, V. E., A Mesoscale Investigation of Pre-tornado Thermal Environments, *American Meteorological Society, Bulletin. 39*(4); 224–228, 1958.

LAMBERT, J. L., The Experimental Investigation of the Thermal Response of a Sumac Canopy, Master's Thesis (Meteorology), University of Wisconsin, 1967.

LENSCHOW, D. H., and J. A. DUTTON, Surface Temperature Variations Measured from an Airplane over Several Surface Types, *Journal of Appl. Meteorol.*, Vol. *3*, pp. 65–69, 1964.

LETTAU, H., Small to Large-Scale Features of Boundary Layer Structure over Mountain Slopes. *Proc. Symposium on Mountain Meteorology*, Fort Collins, Colorado, Colorado State University, Dept. Atmosph. Sci., 1967, Paper No. 122, pp. 1–74.

LORENZ, D., The Effect of the Long-wave Reflectivity of Natural Surfaces on Surface Temperature Measurements Using Radiometers, *Journal of Appl. Meteorol.*, 5(4): 421–430, 1966.

MENON, V. K. and RAGOTZKIE, R. A., Remote Sensing by Infrared and Microwave Radiometry, Technical Report No. 31, Task No. NR 387–022, prepared under ONR contract No.: 1202(07), University of Wisconsin, 1967.

STOUT, G. E., Factors Influencing the Climatological Distribution of Hail in Flatlands, *Nubila*, V(1): 73–84, 1962.

TANNER, C. B. and M. FUCHS, Infrared Thermometry of Vegetation, *Agronomy Journal* 58: 567–601, 1966.

Wisconsin Statistical Reporting Service Publication, *Wisconsin Weather: Causes, Variations, and Effects*, Madison, Wisconsin, 1967.

WOLFORD, L. V., Tornado Occurrences in the United States, U.S. Department of Commerce, *Technical Paper No. 20*, 1960.

# THE OTTER IN EARLY WISCONSIN

*A. W. Schorger*

The otter *(Lutra canadensis)* was one of the most valuable furs sought by trappers. During the period 1835–1848, the Northern Outfit of the American Fur Company, located on Madeline Island, collected annually an average of 1555 pelts. Based on trapping records the otter was about as plentiful as the beaver. It was much easier, however, to discover the presence of beaver than the wandering otter, so that most trappers devoted their attention to this mammal. The otter has a popular appeal from the ease with which the young can be tamed, a marked contrast to the viciousness of the other mustelids, the skunk excepted. The young in Wisconsin are born mainly in April and May (Knudsen, 1956).

## Size

Reference books vary widely on the size and weight of otters. Coues (1877) wrote that there was great variation. The average was 4 to 4.5 feet in length, though some individuals attained 5 feet. According to Jackson (1961:383) the total length of adults is 35.4 to 48 inches, and the weight 15 to 20 pounds, rarely to 30 pounds in males. Hamilton (1943) gives a length of 35.4 to 43.3 inches, and a weight of 12 to 15 pounds, the latter being seldom exceeded. Otters in Main weighed from 18 to 20 pounds, 25 being exceptionally heavy (Hardy, 1911:331). Heavy weights have been recorded. On February 17, 1771, George Cartwright (1911:50) shot an otter weighing 33 pounds. A Carolina old male was 4 feet long and weighed 23 pounds; and a specimen from Texas was 4 feet and one inch in length and weighed 20 pounds (Audubon and Bachman, 1851). An adult female *(Lutra c. sonora)* collected at Montezuma Well, Arizona, was 51.2 inches in length and weighed 19.5 pounds (Bailey, 1931); and an adult female from Idaho was 45.3 inches in length and weighed 19 pounds (Merriam, 1891).

I do not know of any data on the dimensions and weights of entire Wisconsin otters given by fully trustworthy observers. George Knudsen of the Wisconsin Department of Natural Resources has examined a large number of carcasses obtained from trappers. Quite fresh carcasses of adult males weighed 19 to 22 pounds; length from tip of nose to tip of tail vertebrae 46 to 48 inches. The green skin with adhering fat would add an additional 3 to 4 pounds. The carcasses of adult females weighed 15 to 18 pounds, and the lengths were 44 to 45 inches (Unpublished).

## FOOD

The food of the otter consists primarily of fish and crayfish, with some mussels, amphibians, insects, and birds. In 1680 Hennepin (1903) appropriated a paddlefish *(Polyodon spathula)* which an otter was eating along the Wisconsin section of the Mississippi. Along the banks of the Fox and Wisconsin rivers Featherstonhaugh (1836) found great quantities of mussel shells left by otters and muskrats. D. Cartwright (1875:60) found a bushel of the heads of bass, supposedly rejected by the otter, in the Lake Superior region. One trapper reported to Knudsen (1957:61, 62) that he watched otters catch five northern pike and eat only the heads; while another stated that he saw a "lot of bass heads" on the ice. For some unknown reason the heads of bass appear to be undesirable. Jackson (1961:388) observed in Bayfield County an otter eating a chub, beginning at the head. At Great Bear Lake, Mackenzie District, otters usually took the heads of the fish caught in nets and left the bodies (Richardson, 1829). It has been stated that all but the tail of a fish is eaten, and that when plentiful the otter may take only a bite or so from the head of each fish captured (Godwin, 1935). Apparently the head is the most desirable part of most species of fish. A study by Knudsen (1957:53) of the food habits of otters that had been trapped revealed the following frequency of occurrence: fish 90 percent, crayfish 50 percent, insects 20 percent, and debris 30 percent. In frequency of occurrence of fish, game fish were 30 perent and rough fish 80 percent.

Otters will dive deeply to secure food. Ben Gustavson, a commercial fisherman of Bayfield, Wisconsin, on February 24, 1939, found a drowned otter on one of his baited set lines. The bait was in 42 feet of water and 500 feet from the shore of Bass Island, one of the Apostle group (Waskow, 1939; Scott, 1939).

The teeth become worn with age and kind of food. An old male in Carolina had teeth much worn (Audubon and Backman, 1851). An otter trapper near Sturgeon Bay was believed to be old since "his teeth were nearly all gone," that is worn (Sturgeon Bay, 1896). The teeth of sea otters *(Enhydra lutra)* approximately 4 to 5 years old show marked wear, induced apparently by the preferred diet of the individual (Barabash-Nikiforov, 1962). The teeth of some of the Wisconsin otters examined by George Knudsen were "worn to the bone.

## Trails

Otters are great travelers and seldom stay long in one place. They will take to land to cross from one stream or lake to another and make cutoff trails at the bends of streams. Cartwright (1875: 60, 61) states that he has known them to cross from the head of one stream to another, a distance of two miles. He termed the trails portages. The winter of 1837–38 Kingston (1879) and companion explored the Lemonweir River for pine timber. Concerning their return down the river he wrote. "Following the otter trails or slides cutting the bends of the river, we found the distance greatly shortened."

## Trapping

There is no clear description of the method by which the Indians took otter prior to the availability of the steel trap. Hennepin (1903:517) stated merely that the Indians caught otters in traps and killed them with arrows or shot. Lahontan (1905) wrote: "These Traps are made of five* Stakes plac'd in the form of an oblong Quadrangle, so as to make a little Chamber, the Door of which is kept up, and supported by a Stake. To the middle of this stake they tye a string which passes thro' a little fork, and has a Trout well fastened to the end of it. Now, when the otter comes on shoar, and sees this bait, he puts above half his Body into that fatal Cage, in order to swallow the Fish; but he no sooner touches, than the string to which 'tis made fast pulls away the Stake that supports the Door, upon which an heavy and loaded Door falls upon his Reins and quashes him." This was a deadfall.

The deadfall could be used only on land while the steel trap could be set on land and in the water. Cartwright (1875:62) opposed a set on land. He favored setting the trap in about four inches of water where a slide entered and on the side of it. The reason for this is that the otter's fore feet are short and wide apart so that if the trap were placed in the middle of the slide the feet were unlikely to touch the pan of the trap. Regarding trapping at the slide, Newhouse (1874) states: "Spencer J. Clarke, . . . who formerly trapped in Wisconsin, recommends setting the trap where the Otter comes out of the water in the following position: The Otter swims to the shore, and as soon as his fore feet strike the ground his hind feet sink to the bottom and he walks out erect. Find the point where the Otter's hind feet strike the bottom, and set the trap there." The otter is frequently abroad in the daytime so that formerly many were captured by shooting.

---

* "Five" should read "small". It is *petits* in the original (Lahontan. 1703. Nouveaux voyages . . . dans l'Amerique Septentrionale. Le Haye. p. 85).

## Utilization

The Indians used the skin for medicine bags and ceremonial purposes. Carver (1784) was at a dance in western Wisconsin when: "I could not help laughing at a singular childish custom I observed they introduced into this dance . . . Most of the members carried in their hands an otter or martin's skin, which being taken whole from the body and filled with wind, on being compressed made a squeaking noise through a piece of wood organically formed and fixed in its mouth. When this instrument was presented to the face of any of the company, and the sound emitted, the person receiving it fell down to appearance dead."

The fur is very durable and equalled only by that of the wolverine, On the basis of 100 for otter, the wearing quality of other aquatic mammals such as beaver is 90 percent and muskrat 45 percent (Innis, 1927). The skins are used for collars, trim, and ladies coats.

Trappers were frequently forced to eat the animals they caught. On February 17, 1771, George Cartwright (1911:66) wrote in his journal that otters are "hard and strong eating."

## Prices

The largest market for otter fur was China. This fact is expressed frequently in the correspondence of the American Fur Company. On November 30, 1821, R. Crooks wrote to J. J. Astor that the otters will go to China (Am. Fur Co.). H. H. Sibley of Fort Snelling was informed on April 7, 1840, that the only hope for otters was resumption of trade with China; and on December 25, Pierre Chouteau and Company of St. Louis was told that there was only a limited demand for the furs for caps. A letter of April 4, 1843, to Joseph Rogers, Toronto, stated that the supply of pelts exceeded the demand of the market in Canton.

Considerable value was placed on otter in 1760 in Milwaukee by an English trader who refused payment for supplies except with otter and the finest fox skins (Western Hist. Co., 1881). The prices of the pelts varied with the demand and quality. In August, 1820, the American Fur Company credited Porlier and Rouse of Green Bay with 50 otters at $3.53 each. R. Crooks wrote on April 23, 1822, to J. J. Astor that $3.75 would be paid for Lake Superior otter, and $3.25 for those from the St. Peter (Minnesota) River. Four days later he wrote to S. Abbott at Mackinac to pay only $3.00 for otter since there were on hand the entire collections for 1820 and 1821. In June, 1827, 13 otters from La Bulle (Wausau) were invoiced at $2.50 each.

The pelts received in 1835 from Solomon Juneau of Milwaukee were graded and priced as follows: No. 1, $7.00; No. 2, $4.50; No.

3, $2.25; and cubs $0.75. Juneau in 1840 made several purchases at prices ranging from $5.00 to $7.00. Myrick and Weld (1843), merchants at La Crosse, in 1843 purchased pelts at the very low price of 20 shillings ($2.50). In November, 1847, the prices paid at Prairie du Chien were: No. 1, $4.00; No. 2, $3.00; No. 3, $2.00; and No. 1 cub, $0.50–$0.75. The winter of 1856–57, in Buffalo County, Cooke (1940) was pleased to receive $2.00 for an otter pelt. Low prices prevailed in 1859 at Eau Claire (Eau Claire, 1859), the range being $0.75 to $3.00. In 1880, in Waukesha County, the pelts were said to be worth $9.00 to $20.00 (Western Hist. Co., 1880).

## Abundance

In the first half of the 19th century, the otter appears to have been somewhat more abundant than the beaver in the Great Lakes region. Compilation of 159 inventories at various posts of the American Fur Company gave 51,067 beavers and 65,781 otters, a ratio of 1 beaver : 1.29 otters. There are insufficient data to determine the number of otters collected in Wisconsin in any one year. It has been possible from the papers of the American Fur Company possessed by the Wisconsin Historical Society to compile for a number of years the collections made by the Northern Outfit at La Pointe, Madeline Island (Table 1). Essentially all of the pelts were taken in northern Wisconsin. The principal subposts were at Lac du Flambeau and Lac Court Oreilles. The year 1835, e.g., represents the pelts taken during the winter of 1834–35.

The table shows a steady decline in the number of otters taken. Fur statistics show fluctuations in numbers, but there does not appear to be any cyclic phenomenon for the otter (Hewitt, 1921). During the 1968 season, 1007 otters, with an average value of $21.50, were taken in Wisconsin, so that the present status of the species is gratifying.

Table 1. Otters Collected at La Pointe

| Year | No. of Pelts | Year | No. of Pelts |
|---|---|---|---|
| 1835 | 4,831 | 1842 | 1,072 |
| 1836 | 1,842 | 1843 | 1,005 |
| 1837 | 2,997 | 1844 | 512 |
| 1838 | 1,270 | 1845 | 478 |
| 1839 | 2,384 | 1846 | 1,140 |
| 1840 | 1,574 | 1847 | 559 |
| 1841 | 1,791 | 1848 | 321 |

## Distribution

The otter is generally found on rivers, large creeks, and interior lakes. Large lakes such as Michigan are less attractive; however, when Fonda (1868) was carrying mail between Green Bay and Chicago the winter of 1827–28, an otter or a fisher would glide from the ice-fields to a retreat in the bank of the lake. The otter has been recorded for nearly every county in the state. More recent records and specimens examined are to be found on the map by Jackson (1961:384). According to Strong (1883) it was to be found occasionally in the northern half of the state. Subsequently Cory (1912) gave it an increased range, "the greater portion of Wisconsin." That the otter still has a wide distribution is to be seen in Fig. 1

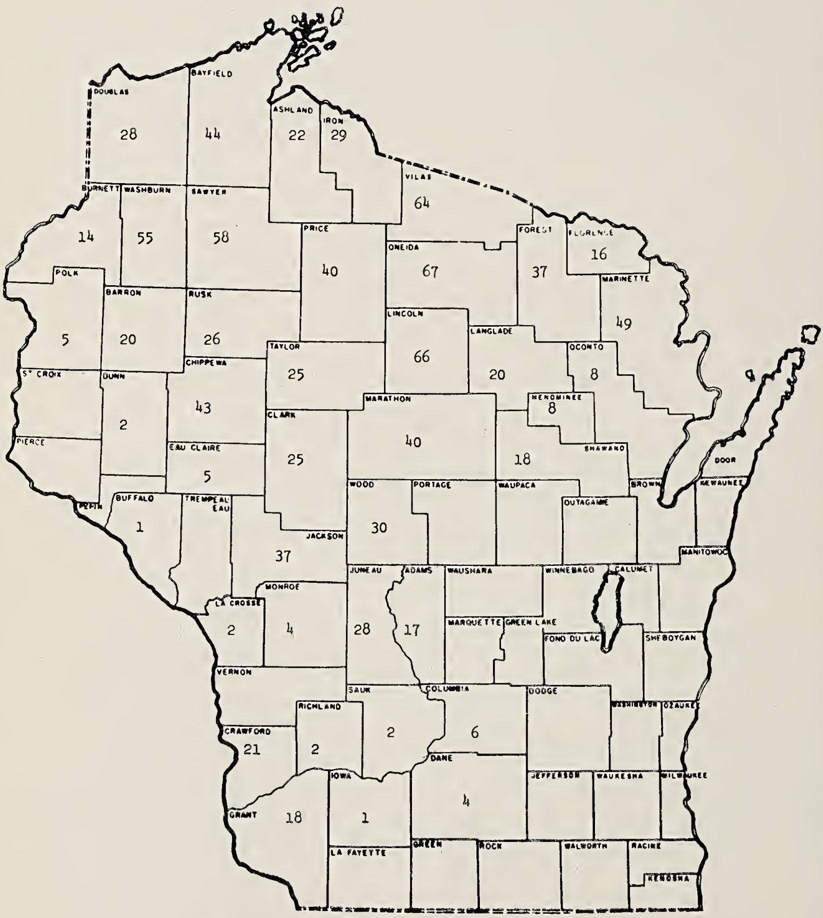



Figure 1. Otter Harvest by Counties in 1968.

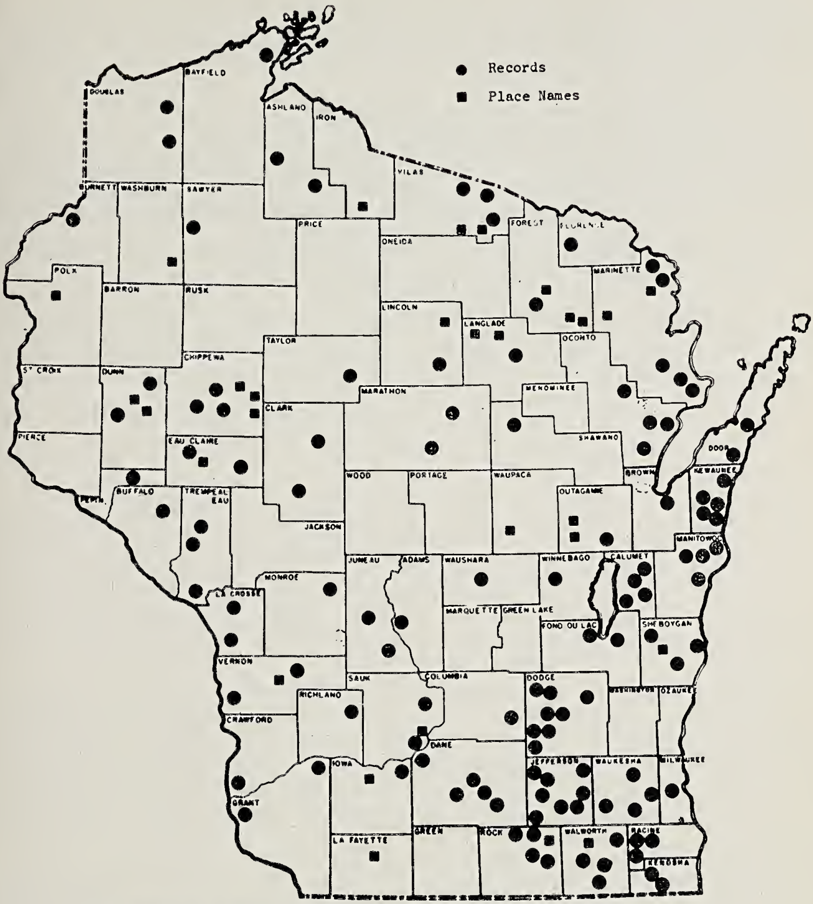



FIGURE 2. Early Distribution of the Otter in Wisconsin.

where the harvest in 1968 is shown by counties. The early records and place names are shown in Fig.2. The Sea Lion and Seal lakes of northern Wisconsin, not plotted, presumably were named from the otter through erroneous identication. A swimming otter resembles a seal.

*Adams.*—It was stated in 1919 that the otter no longer occurred (Cole and Smythe, 1919). This statement must have been made from lack of sufficient information as it is still quite common along the Wisconsin.

*Ashland.*—In the spring of 1885 E. B. Gordon and H. A. Mallory had a fine lot of otter and other furs taken near Glidden (Glidden, 1885). In the early months of 1885, George and Frank Bell trapped on the headwaters of the Bad River, said to be 15 miles west of

Penokee, and caught a number of otters (Ashland, 1885). The farthest west tributaries of Bad River are in the town of Marengo, about 10 miles from Penokee.

Otter Island is one of the Apostle group.

*Bayfield.*—A Mr. Hayward of Bayfield had a fine lot of otter pelts (Bayfield, 1877). Jackson (1908) and Cory (1912) examined specimens from the county. At present it is one of the best otter counties.

*Brown.*—The otter killed by a farmer with a heavy whip (Green Bay, 1895) was very probably traveling on land.

*Buffalo.*—The family of Cooke (1940) settled within five miles of Gilmanton in the fall of 1856. His father did much hunting and trapping, and otter was among the furs marketed.

*Burnett.*—Curot (1911) was in charge of a post on the Yellow River the winter of 1803–04. His entries show that he purchased 16 otters.

*Calumet.*—An otter was shot near Chilton (Chilton, 1880). Two were killed by N. Cheseboro near Clinton in 1887 at which time otters were rarely seen (Chilton, 1887). One was killed near Brothertown in April, 1897 (Chilton, 1897); and another was trapped at Forest Junction, town of Brillion, in March, 1899 (Chilton, 1899).

*Chippewa.*—Cartwright (1875:245), the winter of 1857–58, trapped otters on O'Neil Creek, town of Eagle Point. In the spring of 1865, otters were being caught in large numbers (Chippewa Falls, 1865). A large shipment of furs made by Mairet, Allen and Company of Chippewa Falls contained many otters (Chippewa Falls, 1871);

Otter Lake, town of Colburn, is drained by Otter Creek which flows north then west into Yellow River. Lttle Otter Creek rises in the town of Thorpe, Clark County, flows south by west and enters the Wolf River in the town of Delmar, Chippewa County.

*Clark.*—The winter of 1844–45, Manly (1927:56) and companion while trapping on the Black River above Neillsville found two otters coming towards them on the ice. One was killed, the other escaped. At the time of settlement of Neillsville, 1844, otter and other mammals were plentiful (Neillsville, 1873; French, 1875; Curtiss-Wedge, 1918).

*Columbia.*—The American Fur Company received from the Portage post 6 otters in 1827, and 17 in 1840. Wayne B. Dyer came to the present site of Columbus in 1843 and trapped many otters along the Crawfish (Butterfield, 1880). A few otters had been observed during the past year in the Wisconsin River between Kilbourn (Wisconsin Dells) and Portage (Cole, 1918).

*Crawford.*—In the early days H. L. Dousman had at Prairie du Chien a tame otter that would catch fish for him "at his bidding" (Bunnell, 1897).

Otter Creek, town of Kickapoo, flows east into the Kickapoo.

*Dane.*—When Stoner (Madison, 1899) came to Madison in 1838. the surrounding marshes and streams were full of otters and other game. The first settlers who arrived at Mazomanie in 1843 found otters and other fur bearers common (Kittle, 1900). A large otter was trapped on the north shore of Lake Mendota on April 18, 1854 (Madison, 1854). One was captured by D. A. Waterman, of the town of Rutland, in the Yahara near Lake Kegonsa in March, 1891 (Madison, 1891; Carr, 1891). According to Brown (1915) it occurred formerly at Lake Wingra.

*Dodge.*—Two otters were taken at Fox Lake in December, 1858 (Fox Lake, 1858). One weighing 16.5 pounds was killed by L. Rushlow at Beaver Dam Lake in April, 1860 (Beaver Dam, 1860). Another was caught at Fox Lake in January, 1867 (Fox Lake, 1867). A large otter was trapped in 1877 in the town of Elba by E. Sweet (Portage, 1877). A trapper caught two in the Horicon Marsh in November 1884 (Delevan, 1884). The winter of 1887–88 one was trapped in the town of Portland (Waterloo, 1888). According to Snyder (1902) the otter was common at the time of settlement. In the early 1890's Adam Ergotz, a former professional trapper, found a slide on Beaver Dam Lake but could not catch the otter. One was captured since 1890.

*Door.*—An otter, then rare, was caught by R. Haash at Forestville in the spring of 1887 (Sturgeon Bay, 1887). One weighing 20 pounds was trapped at Lilly Bay in March, 1896 (Sturgeon Bay, 1896). Lilly Bay is on the Lake Michigan shore near Clark Lake.

*Douglas.*—In the spring of 1766 while Henry (1921) was at Chequamegon Bay, the Chippewa went to war with the Sioux. A battle was fought at a river which was undoubtedly the Brule, as it was the traditional battle place for the two tribes. They returned with a rich cargo of furs and Henry purchased from them and other Indians 150 packs of beaver and 25 packs of otter and marten skins. The Brule was a noted stream for trapping. When Allen (1834) was at La Pointe in 1832 he was informed that the trading posts on this river took in primarily muskrats, bears, and otters. Cram (1841) reported that at the proper season the Indians resorted to the Brule to trap otter and beaver which occurred throughout its length; however, their numbers had been greatly reduced. Cory (1912) examined specimens from the county.

*Dunn.*—The winter of 1857–58, Cartwright (1875) and companions caught otters on Pine Creek, town of Sand Creek, and on Gilbert Creek, town of Lucas. Altogether the party of three caught 50 otters, most of them in the county.

Otter Creek, the two branches of which rise in the town of Wilson, flows south into Hay River, town of Otter Creek. Little Otter Creek rises in the later town and flows west into Otter Creek.

*Eau Claire.*—In the fall of 1883 "several more" otters were caught in Seven Mile Creek, town of Seymour (Eau Claire, 1883). Charles Martin, the famous hunter, caught an otter near Augusta in October, 1897 (Augusta, 1897).

Otter Creek rises in the town of Otter Creek, flows northwest and empties into the Eau Claire, town of Seymour.

*Florence.*—C. Hanson while hunting along Pine Creek, town of Long Lake, in October, 1884, saw seven otters and killed three of them (Florence, 1884).

*Fond du Lac.*—In 1852, a few miles east of Fond du Lac, otter and other game were "too numerous to attract much attention" (Titus, 1936). In 1881 the capture of an otter on the west side of Lake Winnebago by Jacob H. Horn resulted in the comment that it was the first taken in many years (Fond du Lac, 1881).

*Forest.*—Two males were killed two miles west of Crandon on February 12, 1908 (Jackson, 1910). Cory (1912) examined specimens from the county.

Otter Creek rises in Otter Springs, town of Lincoln, and flows northeast into the Peshtigo. A second Otter Creek, town of Wabeno, flows southeast into Otter Lake.

*Grant.*—The fall and winter of 1845–46, Robert and William McCloud, at Muscoda, purchased otter and other furs from the Indians (Butterfield and Ogle, 1884). In the spring of 1858, Austin Birge captured a large otter in the bluffs along the Mississippi (Prairie du Chien, 1858).

*Iowa.*—Cory (1912) examined specimens from Arena.

Otter Creek rises in the town of Dodgeville and flows north into the Wisconsin.

*Iron.*—Otter Lake is in the northern end of the town of Oma.

*Jefferson.*—The Coe (1908) family settled on the west bank of Rock River, town of Ixonia, in 1839. The following winter Indians camped on the opposite bank and caught otter and other fur bearers. In 1855, while going down Bark River, Cartwright (1875: 161) shot an otter. Within two weeks he and a companion captured sixteen. In the spring of 1879, an otter was shot in the town of Hebron (Fort Atkinson, 1879). Six large otters were taken at Waterloo early in 1881 (Waterloo, 1881). According to Hawkins

(1940) the otter was never common at Faville Grove, and it disappeared from the Crawfish River about 1883. About 1882 an otter was trapped at Faville Grove and another at Mud Lake, town of Lake Mills. In April, 1887, Frank Tooker shot one on Bark River at Ft. Atkinson (Ft. Atkinson, 1887). A very large otter weighing 25 pounds was killed on Bark River by Roy Chase the spring of 1890 (Ft. Atkinson, 1890). In July, 1901, there was an otter slide at Lake Koshkonong, section 34, town of Summer (Jackson, 1908).

*Juneau.*—The winter of 1837–38, Kingston (1879) and companion traveled down the Lemonweir, following the otter trails. In December, 1890, George Dillon of Lemonweir, town of Lemonweir, trapped an otter 44 inches in length (Mauston, 1890).

*Kenosha.*—In a letter dated November 7, 1837, Quarles (1933) wrote from Southport (Kenosha) that otters were very plentiful on his contemplated farm on Fox River, and sought information on trapping them. In autumn Indians came from the north to the town of Salem and camped on the Fox River. Here deer, otter, and some other fur bearers were abundant (Lyman, 1916).

*Kewaunee.*—The otter was reported scarce when one was taken late in 1886 a few miles west of Kewaunee (Kewaunee, 1886). An otter, the first in many years, was seen in April, 1893, in East Twin River, town of Carlton (Kewaunee, 1893). One was caught in the town of Ahnapee in October, 1894 (Ahnapee, 1894). In October, 1896, quite a number were shot along the Kewaunee River (Kewaunee, 1896). M. Vesseley trapped a large otter in the town of West Kewaunee in January, 1897 (Kewaunee, 1897).

*LaCrosse.*—At the time of settlement there were otters in Lewis Valley through which flows Fleming Creek (Sisson, 1955). There were brought to La Crosse the pelts of four otters which were trapped a few miles from the city the winter of 1880–81 (La Crosse, 1881).

*Lafayette.*—Jesse Shull came to the present site of Shullsburg in 1818 and established a post to trade for furs (Gregory, 1932). In so sparsely wooded a county, it is probable that otter and an occasional beaver were the only valuable furs obtainable.

Otter Creek rises in the town of Mineral Point, Iowa County, and flows south into the Pecatonica.

*Langlade.*—Otters were among the fur bearers taken (Dessureau, 1922). Cory (1912) examined specimens from the county.

Otter Lake is in the town of Elcho. There is also a small Otter Lake in the northwest corner of the town of Parrish.

*Lincoln.*—Two otters were trapped in May, 1884, on Pine River, town of Pine River (Merrill, 1884).

Otter Lake is in the town of Skanawan.

*Manitowoc.*—August Sprecht, in January, 1894, complained of the ravages of otters at his carp pond at Mishicot (Manitowoc, 1894). In the fall of 1895, Joseph Stangel caught in the town of Two Creeks an otter weighing 27 pounds (Kewaunee, 1895). Another was shot by Peter Zinn in the fall of 1896 (Two Rivers, 1896). The winter of 1897–98, trappers at Neshoto (Shoto), town of Two Rivers, captured five otters (Two Rivers, 1898).

*Marathon.*—In the early days Michael De Jardin, a Chippewa, assisted his father at Mosinee in trapping otter and other fur bearers which were plentiful (Ladu, 1907). The small post of the American Fur Company at La Bulle (Wausau) shipped 13 otters in 1827.

*Marinette.*—Stanislaus Shappus reported that he had on hand June 27, 1834, at the American Fur Company post on the Menominee River, only one pack of furs in which were some otters. On June 5, 1835, he had 80 otters. A black otter was trapped on the Peshtigo in December, 1875 (Marinette and Peshtigo, 1875). In November, 1889, two otters were killed near the village of Peshtigo (Marinette, 1889). The fall of 1895, Gus Wendt caught two otters up the Peshtigo (Peshtigo, 1895). One was shot in November, 1898 (Peshtigo, 1898). At that time the capture of the fourth otter near the village of Peshtigo was reported (Marinette, 1898). The same fall Tom Bone trapped two otters six miles up the Menominee (Marinette, 1898.1).

Otter Lake is in the town of Pembine. Otter Creek, town of Silver Creek, flows east into the Peshtigo.

*Marquette.*—On December 5, 1824, Jacques Porlier wrote to A. Grignon that he had obtained 12 otter pelts from the Indians at Buffalo Lake (Porlier, 1911). In 1849 there were otters and other fur bearers (Acme, 1890). In July, 1880, a den of young otters was discovered at the foot of Buffalo Lake. They were being raised on a bottle (Montello, 1880). An otter was seen swimming in the mill pond at Westfield, October 1, 1882. It evaded capture (Montello, 1882).

*Milwaukee.*—The otter was listed by Lapham (1853) as one of the indigenous mammals of the county.

*Monroe.*—In the late fall of 1844, Manly (1927:52) found sign of otter on the headwaters of the Lemonweir and set traps.

*Oconto.*—J. I. Bovee caught two otters on the upper Pensaukee in the spring of 1884 (Oconto, 1884). In the fall of 1885 an otter was caught in Leigh (Lee) Lake, town of Bagley, and another was shot within the corporate limits of Oconto (Oconto, 1885). A large otter was killed in December, 1886, a few miles west of Oconto where it was considered rare (Oconto, 1886).

*Oneida.*—Specimens from the county were examined by Jackson (1908).

*Outagamie.*—In April, 1873, Louis West shot an otter on the edge of the city of Appleton (Appleton, 1873).

Black Otter Lake is in the town of Hortonia. It is drained by Black Otter Creek which flows north into the Wolf.

*Pepin.*—On April 16, 1888, Benjamin Dickinson shot an otter on Plumer (Plummer) Lake (Durand, 1888). It was 4 feet in length from tip to tip and weighed 20 pounds. The lake, in sections 30 and 31, town of Durand, has nearly disappeared.

*Polk.*—According to Surface Water Resources of Polk County (1961), Otter Lake with an area of 8.3 acres is in the town of Milltown.

*Racine.*—Dr. H. V. Ogden had in his collection a skull from the town of Waterford (Cory, 1912). On December 12, 1879, Charles Graves speared near Waterford an otter weighing 20 pounds (Waterford, 1879). E. Alaxson, in April, 1886, killed one otter and wounded another which escaped (Waterford, 1886).

*Richland.*—C. C. Derrickson caught a black otter in Willow Creek, in the town of Willow (Richland Center, 1889).

*Rock.*—Caswell (n.d.) came with his parents to section 7, town of Fulton, in 1837. At that time there were many otters. On February 24, 1839, Ogden (1839) wrote in his diary that he saw two otters in the town of Milton, presumably on Otter Creek. This creek's name was derived from the number of otter slides on its banks when first surveyed (Guernsney, 1856; Smith, 1872). An otter was captured alive on Bass Creek in the town of Rock in January, 1870 (Janesville, 1870). In the spring of 1876 an otter was taken at Otter Creek near Milton (Janesville, 1876). In June, 1902, Jackson (1961:383) saw tracks along Otter Creek, section 5 (probably 3) town of Milton.

Otter Creek rises in the town of Lima, flows west into the town of Milton, then north into Lake Koshkonong.

*Sauk.*—Canfield (1870:38) stated that the otter was "quite plentiful." In March, 1887, a trapper of North Freedom caught an otter four feet in length in the Baraboo River where there were several others (Wonewoc, 1887). Occasionally seen along the Wisconsin River (Cole, 1922).

Otter Creek rises in the town of Freedom, flows south and enters the Wisconsin 1.5 miles below Sauk City.

*Sawyer.*—The American Fur Company on July 22, 1822, reported 80 otters among the furs received from Lac Court Oreilles.

*Sheboygan.*—In 1859 a boy caught two young otters near Sheboygan (Sheboygan, 1859). Otters were present and their skins were purchased by traders (Buchen, 1944). Prior to 1870 the Indians took in the town of Rhine about $800 worth of deer, muskrat, and otter in a season (Gerend, 1920).

Otter Pond, very small, is in the northwest corner of the town of Plymouth.

*Taylor.*—The summer of 1885, A. Bonneville of Medford was keeping two young otters as pets (Medford, 1885).

*Trempealeau.*—James Reed, a well known trapper, settled at Trempealeau in 1840 when otter was one of the abundant fur bearers (Pierce, 1915). In the spring of 1850, Grignon (1914) traded with the Indians who had trapped up the Trempealeau and secured a fine lot of furs including otter. Two otters were seen on a slide on the Trempealeau as late as 1880 (Bunnell, 1897). The species disappeared long ago (Curtiss-Wedge, 1917).

*Vernon.*—The winter of 1839–40 Robert Douglas came upon an otter using a slide on the Bad Axe River (Polleys, 1948). Mather (1896) and his trapping companion caught several otters on the headwaters of the Kickapoo (erroneously called the Bad Axe) the winter of 1855–56.

Otter Creek rises in the town of Webster, flows southeast, and enters the Kickapoo at La Farge.

*Vilas.*—Perrault (1909–10) in 1791 bought of Dufund Dufault the furs, including one pack of otter, for which he had traded at Lac du Flambeau. The winter of 1804–05 Malhiot (1910) was in charge of a post at this lake. On October 5, 1804, his inventory of furs included 44 otters, and on May 21, 1805, he recorded a return of 20 otters. Cram (1841) stated that the Lac Vieux Desert region was tolerably well provided with otters. In the spring of 1857 H. P. Poler of Eagle Lake arrived in Wausau (1857) with furs including otter. Jackson (1910) had the report that during the winter of 1908–09 otters were quite common at Oak Lake and Mamie Lake, which are at the Michigan boundary.

Otter Lake is in the town of Lincoln, and Otter Rapids on the Wisconsin River about five miles west of the village of Eagle River.

*Walworth.*—W.H.M. came to the town of East Troy in 1845. Honey Creek was full of fish, and lakes and streams were "alive with muskrat, mink, and otter" (Burlington, 1882). In the early days otters were seen occasionally, the town of Sugar Creek being mentioned specifically (Western Hist. Co., 1882). The Indians hunted otter in the vicinity of Lake Geneva (Simmons, 1875).

Otter (Wandewaga) Lake is in the northeast corner of the town of Sugar Creek.

*Washburn.*—At present one of the most productive counties for otter.

*Waukesha.*—A settler who came to Waukesha in the spring of 1841 wrote that an otter would occasionally plunge into the Little Fox (Waukesha, 1890). Two young otters were captured by Rolla Clark at Big Bend, town of Vernon, near the Fox River in April, 1876 (Waukesha, 1876). About a dozen otters were taken in a month's time during the past season (c. 1880) by A. Vieu, who lived near Little Muskego Lake, town of Muskego (Western Hist. Co., 1880). An otter measuring three feet and eleven inches was shot at the head of Eagle (Spring) Lake. It was carrying a trap (Kaukauna, 1889).

*Waupaca.*—Otter Lake is in the southeastern part of the town of Farmington.

*Waushara.*—A farmer living a few miles north of Wautoma is said to have trapped a large otter (Chilton, 1889.1).

*Winnebago.*—At the Menominee payment at Lake Poygan in 1847 the Indians traded a large number of otter and other furs (Anon., 1847).

## References

*Acme Publ. Co.* 1890. Portrait and biographical album of Green Lake, Marquette and Waushara counties, Wisconsin. Chicago. p. 313.

*Ahnapee (Algoma) Record.* 1894. Oct. 18.

ALLEN, LIEUT. J. 1834. Journal of an expedition into the Indian country . . . in 1832. House of Rep., 23rd Cong., 1st Sess., Doc. 223, Ser. No. 257. p. 26.

*American Fur Company Papers.* Wis. Hist. Soc.

Anon. 1847. Menominee payment. *Watertown Chronicle* Nov. 3.

*Appleton Post.* 1873. April 17.

*Ashland Press.* 1885. March 28.

AUDUBON, J. J. and J. BACHMAN. 1851. The quadrupeds of North America. New York. II:4, 5.

*Augusta Eagle.* 1897. Oct. 30.

BAILEY, V. 1931. Mammals of New Mexico. N. Am. Fauna 53:323.

BARABASH-NIKIFOROV, I. I. 1962. The sea otter. Jerusalem. p. 43.

*Bayfield Press.* 1877. June 27.

*Beaver Dam Citizen.* 1860. April 12.

BROWN, C. E. 1915. Lake Wingra. Wis. Arch. 14:79.

BUCHEN, G. W. 1944. Historic Sheboygan County. n.p. pp. 53, 57, 67.

BUNNELL, L. H. 1897. Winona and its environs. Winona. pp. 331–32.

*Burlington Free Press.* 1882. Sept. 26.

BUTTERFIELD, C. W. 1880. The history of Columbia County, Wisconsin. Chicago. p. 666.

———— and G. A. OGLE. 1884. History of Crawford and Richland counties, Wisconsin. Chicago. p. 899.

CANFIELD, W. H. 1870. Outline sketches of Sauk County. Third sketch. Baraboo. p. 38.

CARR, C. F. 1891. Otter. Wis. Nat. 1:128.

CARTWRIGHT, DAVID W. 1875. Natural history of western wild animals. Toledo.

Cartwright, Capt. George. 1911. Labrador journal (1792). Boston.
Carver, J. 1784. Three years travels through the interior parts of North America. Philadelphia. p. 118.
Caswell, Lucien B. n.d. Reminiscences. Wis. Hist. Soc. Ms. p. 19.
*Chilton Times*. 1880. Dec. 4.
————. 1887. Dec. 3.
————. 1897. April 24.
————. 1899. March 18.
————. 1899.1. March 25.
*Chippewa Falls Union*. 1865; *Madison State Journal* March 30.
———— *Democrat*. 1871. June 1.
Coe, E. D. 1908. Reminiscences of a pioneer in the Rock River country. Proc. Wis. Hist. Soc. for 1907. p. 191.
Cole, H. E. 1918. A standard history of Sauk County, Wisconsin. Chicago. I:122.
————. 1922. Summary of the archeology of western Sauk County. Wis. Arch. n.s. 1:83–84.
———— and H. A. Smythe. 1919. Adams County. Wis. Arch. 18:46.
Cooke, W. W. 1940. A frontiersman in northwestern Wisconsin. Wis. Mag. Hist. 23:295.
Cory, C. B. 1912. The mammals of Illinois and Wisconsin. Chicago. p. 331.
Coues, E. 1877. The fur-bearing animals of North America. Washington. p. 299.
Cram, Capt. T. J. 1841. Report on the survey of the boundary between the state of Michigan and the territory of Wisconsin. Senate, 26th Cong., 2nd Sess. Doc. 151. pp. 12, 13.
Curot, M. 1911. A Wisconsin fur-trader's journal. 1803–04. Wis. Hist. Colls. 20:396–471.
Curtiss–Wedge, F. 1917. History of Trempealeau County, Wisconsin. Chicago. p. 71.
————. 1918. History of Clark County, Wisconsin. Chicago. p. 37.
*Delavan Enterprise*. 1884. Nov. 26.
Dessureau, R. M. 1922. History of Langlade County, Wisconsin. Antigo. p. 25.
*Durand Pepin County Courier*. 1888. April 20.
*Eau Claire Free Press*. 1859. Jan. 20.
————. 1883. Oct. 11.
Featherstonhaugh, G. W. 1836. Report of a geological reconnaissance made in 1835 . . . Green Bay and the Wisconsin Territory . . . Washington. p. 123.
*Florence Mining News*. 1884. Oct. 18.
*Fond du Lac Commonwealth*. 1881; *Arena Star*. March 25.
Fonda, J. H. 1868. Early Wisconsin. Wis. Hist. Colls. 5:230.
*Fort Atkinson Union*. 1879. March 28.
————. 1887. April 15.
————. 1890; *Whitewater Register* April 17.
*Fox Lake Gazette*. 1858. Dec. 14.
———— *Representative*. 1867; *Beaver Dam Citizen* Jan. 31.
French (Swisher), Bella. 1875. Neillsville and Clark County, Wisconsin. Am. Sketch Book I(5):222.
Gerend, A. 1920. Sheboygan County. Wis. Arch. 19:170–71.
*Glidden Pioneer*. 1885. April 2, 9.
Goodwin, G. G. 1935. The mammals of Connecticut. Conn. Geol. Nat. Hist. Surv. Bull. 53:72.
*Green Bay Advocate*. 1895. Jan. 31.

GREGORY, J. G. 1932. Southwestern Wisconsin. Chicago. I:665.
GRIGNON, A. 1914. Recollections. Proc. Wis. Hist. Soc. for 1913. p. 118.
GUERNSEY, O. 1856. History of Rock County. Janesville. p. 41.
HAMILTON, W. J. 1943. The mammals of eastern United States. Ithaca. p. 151.
HARDY, M. 1911. The otter. Forest and Stream 76:331, 371.
HAWKINS, A. S. 1940. A wildlife history of Faville Grove, Wisconsin. Trans. Wis. Acad. Sci. . . . 32:59.
HENNEPIN, L. 1903. A new discovery of a vast country in America (1698). Chicago. p. 517.
HENRY, A. 1921. Travels and adventures. Chicago. p. 197.
INNIS, H. A. 1927. The fur trade of Canada. Toronto. p. 116.
JACKSON, H. H. T. 1908. A preliminary list of Wisconsin mammals. Bull. Wis. Nat. Hist. Soc. 6:27–28.
————. 1910. The distribution of certain Wisconsin mammals. Bull. Wis. Nat. Hist. Soc. 8:89.
————. 1961. Mammals of Wisconsin. Madison.
*Janesville Gazette*. 1870. Jan. 20.
————. 1876. May 16.
*Kaukauna Sun*. 1889. April 12.
*Kewaunee Enterprise*. 1887. Dec. 3.
————. 1893. April 7.
————. 1895. Nov. 15.
————. 1896. Oct. 6.
————. 1897. Jan. 22.
KINGSTON, J. T. 1879. Early exploration and settlement of Juneau County. Wis. Hist. Colls. 8:373.
KITTLE, W. 1900. History of the township and village of Mazomanie. Madison. p. 11.
KNUDSEN, G. J. 1956. Preliminary otter investigations. Wis. Pittman–Robertson Quart. Prog. Rept. 15(2):132, 139.
————. 1957. Preliminary otter investigations. Wis. Pittman–Robertson Quart. Prog. Rept. 15(4):51–69.
*La Crosse Daily News*. 1881. Feb. 23.
LADU, E. A. 1907. Early and late Mosinee. Wausau. p. 107.
LAPHAM, I. A. 1853. A systematic catalogue of the animals of Wisconsin. Trans. Wis. State Agr. Soc. for 1852. 2:338.
LYMAN, F. H. 1916. The city of Kenosha and Kenosha County, Wisconsin. Chicago. p. 344.
LAHONTAN, BARON DE. 1905. New voyages to North-America. Chicago. p. 113.
*Madison Argus and Democrat*. 1854. April 19.
———— *State Journal*. 1891. March 6.
MALHIOT, F. V. 1910. A Wisconsin fur-trader's journal, 1804–05. Wis. Hist. Colls. 19:223, 225.
*Manitowoc Pilot*. 1894. Jan. 18.
MANLY, W. L. 1927. Death Valley in '49. Chicago.
*Marinette Eagle*. 1889. Nov. 16.
————. 1898. Nov. 19.
————. 1898.1. Nov. 26.
*Marinette and Peshtigo Eagle*. 1875. Dec. 11.
MATHER, FRED. 1896. Men I have fished with. Forest and Stream 47:331, 371.
*Mauston Star*. 1890. Dec. 18.
*Medford Star and News*. 1885. Aug. 8.
MERRIAM, C. H. 1891. Biological reconnaissance of Idaho. N. Am. Fauna 5:82.
*Merrill Northern Wisconsin News*. 1884. May 23.

*Montello Express.* 1880. July 3.
————. 1882. Oct. 7.
MYRICK and WELD. 1843. Account book. Wis. Hist. Soc.
*Neillsville Republican.* 1873. Oct. 18.
NEWHOUSE, S. 1874. The trapper's guide. New York. p. 40.
*Oconto Enquirer.* 1884. March 6.
————. 1885. Oct. 31.
————. 1886. Dec. 12.
OGDEN, G. W. 1839. Diary at Milton, Wisconsin. Copy Wis. Hist. Soc.
PERRAULT, J. B. 1909–10. Narrative of the travels and adventures of a merchant voyageur. Mich. Hist. Colls. 37:559.
*Peshtigo Times.* 1895. Nov. 9.
————. 1898. Nov. 12.
PIERCE, E. D. 1915. James Allen Reed. Proc. Wis. Hist. Soc. for 1914. p. 116.
POLLEYS, A. D. 1948. Stories of pioneer days in the Black River Valley. Black River Falls. p. 16.
PORLIER, J. 1911. Letter December 5, 1824. Wis. Hist. Colls. 20:363.
*Portage Democrat.* 1877. April 13.
*Prairie du Chien Leader.* 1858. April 3.
QUARLES, J. V. 1933. Letters. Wis. Mag. Hist. 16:299.
RICHARDSON, J. 1829. Fauna boreali-americana: quadrupeds. London. p. 58.
*Richland Center Rustic.* 1889. Dec. 7.
SCOTT, W. E. 1939. Swimming power of the Canadian otter. Jour. Mamm. 20:371.
*Sheboygan Times.* 1859; *Madison State Journal* May 9.
SIMMONS, J. 1875. The history of Geneva, Wisconsin. Lake Geneva. p. 9.
SISSON, O. S. 1955. Lewis Valley. La Crosse Co. Hist. Sketches 8:11.
SMITH, I. T. 1872. Journal, 1835–36: early settlement of Rock County. Wis. Hist. Colls. 6:425.
SNYDER, W. E. 1902. A list, with brief notes, of the mammals of Dodge Co., Wis. Bull. Wis. Nat. Hist. Soc. 2:123.
STONER, G. W. 1899. Early Madison. *Madison Democrat* Dec. 3.
STRONG, M. 1883. List of the mammals of Wisconsin. In Geology of Wisconsin. Madison. I:437.
*Sturgeon Bay Independent.* 1887. April 8.
———— *Advocate.* 1896. March 28.
TITUS, W. A. 1936. The westward trail. Wis. Mag. Hist. 19:414.
*Two Rivers Chronicle.* 1896. Sept. 8.
————. 1898. Jan. 4.
WASKOW, B. 1939. Bayfield otter. Wis. Consv. Bull. 4(4):61.
*Waterford Post.* 1879. Dec. 18.
————. 1886. April 8.
*Waterloo Journal.* 1881. Jan. 20.
————. 1888. March 1.
*Waukesha Freeman.* 1876. April 13.
————. 1890. July 10.
*Wausau Central Wisconsin.* 1857. May 13.
Western Hist. Co. 1880. History of Waukesha County, Wisconsin. Chicago. p. 385.
————. 1881. History of Milwaukee, Wisconsin. Chicago. p. 56.
————. 1882. History of Walworth County, Wisconsin. Chicago. pp. 316, 938.
*Wonewoc Reporter.* 1887; *Arena Rural Eye* March 19.

# VENTIFACTS ASSOCIATED WITH THE CAMBRIAN–PRECAMBRIAN UNCONFORMITY AT NEKOOSA, WISCONSIN

*Ronald W. Tank*

Technological advances in science and engineering have enabled geologists to approach many of the problems of geology with a high degree of sophistication and precision. Radiometric dating has led to our modern concept of time, geophysical techniques have enabled the exploration geologist to locate new ore bodies, and observations by satellites have improved our understanding of the structure of the earth. However, the nature of the rock record argues against the suggestion that someday technology will enable the geologist to solve all the problems of earth history with similar precision. One reason is that wherever sedimentary rocks are studied there are gaps or unconformities marking interruptions of the stratigraphic record. In 1788 James Hutton first recognized these temporal breaks in the rock record, and later Charles Darwin, in his monumental *Origin of Species,* emphasized the "imperfection of the geologic record". These imperfections have frustrated the efforts of historical geologists for almost two centuries.

In Wisconsin, more of geologic time is probably represented by uncomformities, or temporal breaks, than is represented by the rocks themselves. For example, approximately 600 million years have elapsed since the beginning of Cambrian times (Holmes, 1959). The post-Precambrian rock record of Wisconsin records less than 200 million years of this interval in earth history. There are many small gaps in the stratigraphic record of Wisconsin, but one of the largest and most noteworthy gaps occurs at the contact between the Cambrian and Precambrian rocks (Weidman, 1907, Atwater, 1935, Raasch, 1950, Thwaites, 1957). The Cambrian-Precambrian unconformity is perhaps the most striking and universal break in the succession of rocks covering the earth. The period of world-wide erosion associated with this unconformity was called the Lipalian interval by Walcott (1910), who was intrigued by its possible relationship with the problem of the first appearance of a rich fauna in the rock record. The areal extent of this unconformity in Wisconsin in shown in Figure 1. Although the map pattern of the unconformity traces a sinuous line across the entire state, actual exposures are limited to only a few quarries and river valleys.


FIGURE 1. Map of Wisconsin showing Nekoosa locality and northern limit of Cambrian-Precambrian contact (dashed line) from geologic map of Wisconsin by Bean (1949).

The purpose of this paper is to report on the occurrence of ventifacts in the exposure of the Cambrian-Precambrian unconformity at Nekoosa, Wisconsin. Ventifacts are stones that have had their surfaces or shape modified by wind-driven sand. Their surface is generally characterized by a high polish and by a variety of facets, ridges and pits. They are rarely found in older rocks but are not uncommon in Recent and Pleistocene materials. Several specimens collected from modern environments are shown in Figure 2. Ventifacts are useful as indicators of prolonged wind erosion commonly associated with the desert, polar or beach en-

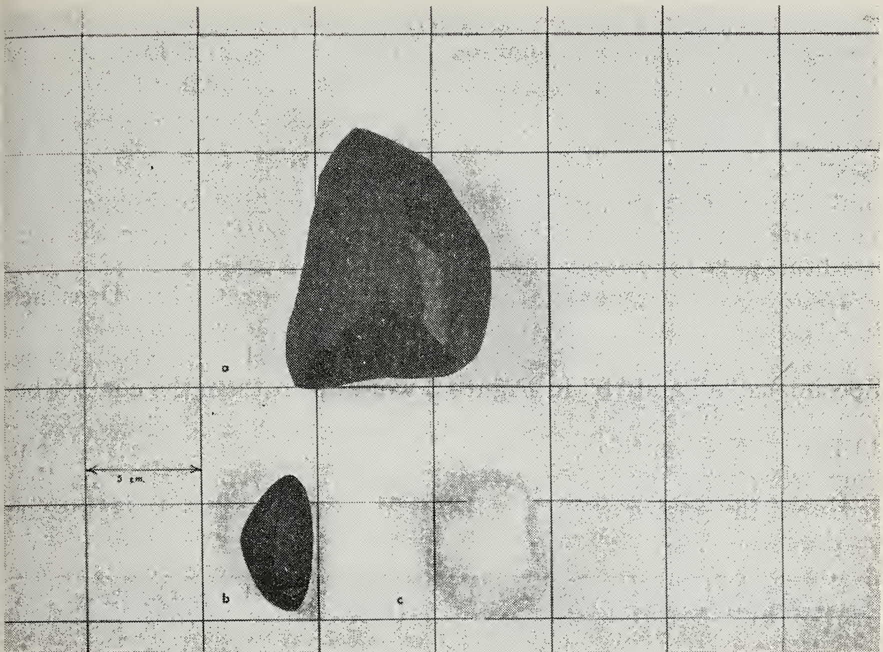



FIGURE 2. Modern ventifacts collected from the Green River Basin, Wyoming (specimen a; sandstone), Terry Andrae State Park, Wisconsin (specimen b; basalt) and Mojave Desert, California (specimen c; vein quartz).

vironment. Although the writer has been unable to find ventifacts at other exposures of the Cambrian-Precambrian unconformity, Parker (1965) reports an occurrence near Crivitz, Wisconsin and Wentworth and Dickey (1935) report an occurrence near Chippewa Falls, Wisconsin.

The Nekoosa exposure is located along the east bank of the Wisconsin River and extends from the foot of the mill dam of the Nekoosa Edwards Paper Company to a point approximately 200 yards downstream (SW ¼, NW ¼, SE ¼, Section 10, T 21 N, R 5 E, Wood County, Wisconsin). Cambrian Dresbach Group sandstones outcrop along the east bank of the river and are in nonconformable contact with Precambrian gneiss and schist near river level. The contact represents an old erosion surface with approximately four feet of relief at this exposure.

Unaltered Precambrian granite gneiss and schist are exposed near the dam. The gneiss and schist are cut by numerous quartz and granite veins, and the entire exposure is interrupted by numerous joints. High water levels during the summer of 1968 prevented a more detailed examination of these rocks, but Weidman (1907) reports northeast strikes and steep dips in the schist plus schistose greenstrone. Above the unaltered gneiss and schist is a zone of altered schist which ranges from a few inches to five feet in thickness. The quartz veins are unaltered in this zone, but textures and banding in the schist are only faintly visible. The altered schist is locally overlain by yellowish-gray, structureless, kaolinitic clay up to 6″ thick. Fine- to medium-grained, cross-bedded, orthoquartzitic sands of the Dresbach Group overlie the clay, or, where the clay is absent, rest directly on altered schist. A thin bed of pebble conglomerate is generally present at the base of the Dresbach sands.

Two vein quartz ventifacts were discovered *in situ* at Nekoosa. Specimens "a" and "b" in Figure 3 were taken from the contact between the pebble conglomerate and the highly-altered clayey schist. Although the ventifacts cannot be correlated to a specific vein, they were most probably derived from nearby quartz veins that cross-cut the gneiss and schist and represent a residual weathering

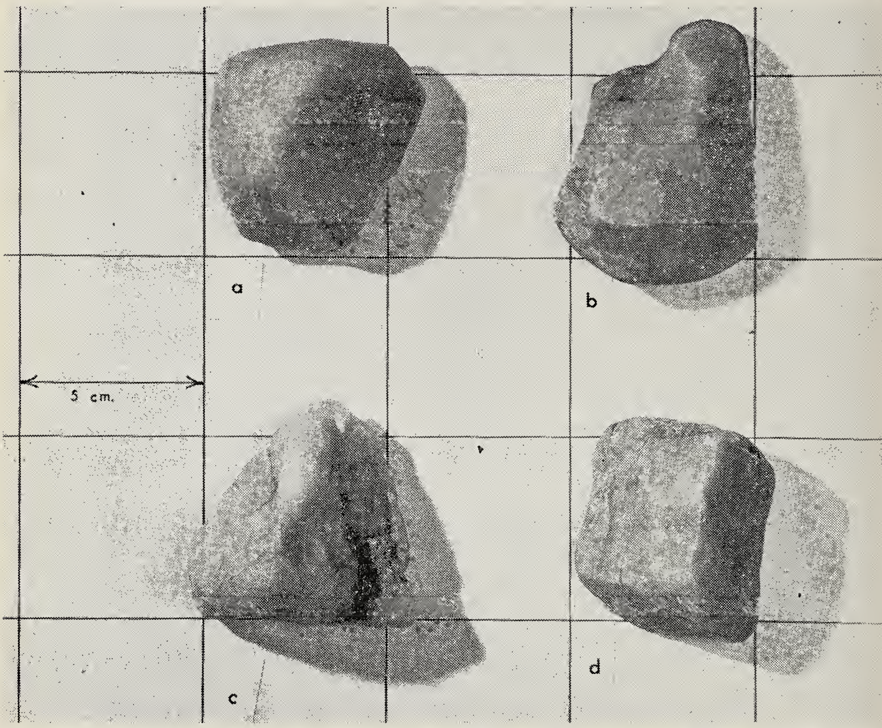



FIGURE 3. Ventifacts (specimens a and b) from Cambrian-Precambrian contact and cobbles of vein quartz (specimens c and d) from bed of Wisconsin River; Nekoosa, Wisconsin.

product. Specimen "a" measures 6.50 x 6.00 x 3.55 cm. and specimen "b" 7.59 x 5.58 x 2.88 cm. The basal surfaces are somewhat pock-marked and several distinctly developed facets are present. The facets are well-worn, smooth and slightly curved and form well-developed ridges where they intersect.

Two cobbles collected from the river bed adjacent to the outcrop are illustrated as specimens "c" and "d" in Figure 3. These specimens are representative of the numerous rough-surfaced cobbles that are present on the river bed. These cobbles were probably released from quartz veins through modern stream erosion and should not be confused with the ventifacts.

The world-wide extent of the Cambrian-Precambrian unconformity indicates a general lowering of sea-level and correspondingly high-continentality. The ultimate cause of the lowering of sea-level in late Precambrian time is unknown. Some geologists have suggested late Precambrian glaciation, while others have suggested epeirogenic movements or even extraterrestrial forces. Whatever the cause, the agents of erosion operating on the exposed continents were certainly as varied then as they are today. The occurrence of ventifacts at the top of the Precambrian erosion surface at Chippewa Falls, Nekoosa and Crivitz indicates that during the late Precambrian wind erosion was an active agent in Wisconsin.

## References


Atwater, Gordon, 1935, The Keweenawan-Upper Cambrian unconformity in the upper Mississippi Valley: *Kansas Geol. Soc. 9th Ann. Field Conf. Guidebook*, p. 316–320.

Bean, E. F., 1959, Geological Map of Wisconsin.

Darwin, Charles, 1859, *On the origin of species by means of natural selection*, London, Murray.

Holmes, Arthur, 1959, A revised geological time-scale: *Edinburgh Geol. Soc. Tr.*, v. 17, p. 183–216.

Hutton, James, 1795, *Theory of the earth with proofs & illustrations*, v. 1 & 2, Edinburgh, v. 3, London, 1899.

Parker, Allen, 1965, Cambrian-Precambrian contact in Wisconsin: unpublished senior thesis, Lawrence University, Appleton, Wisconsin.

Raasch, G. O., 1950, Current evaluation of the Cambrian-Keweenawan boundary: *Ill. Acad. Sci. Trans.*, v. 43, p. 137–150.

Thwaites, F. T., 1957, Map of buried Precambrian of Wisconsin: Univ. Wisc. Geol. & Nat. Hist. Survey.

Walcott, C. D., 1910, Cambrian geology and paleontology: *Smithsonian Miscel. Coll.*, v. 57, 412 p.

Weidman, Samuel, 1907, The geology of north central Wisconsin: *Wisc. Geol. and Nat. Hist. Survey, Bull.* 16, ser. 4, 497 p.

Wentworth, C. and Dickey, R., 1935, Ventifact localities in the United States: *Jour. Geol.* V. 43, p. 97–104.

# PALEO-GEOGRAPHIC IMPLICATIONS OF CLAY BALL DEPOSITS UNDER VALDERAN TILL IN EASTERN WISCONSIN

*Barbara Zakrzewska**

The late Valderan glacial deposits of eastern Wisconsin are discussed in the general literature on Pleistocene geomorphology (1) as well as in specific papers (2). There is, however, no mention in this literature of red clay ball deposits found under the Valderan till just north of Two Rivers, Wisconsin, in a north–south trending ridge in Sec. 31, T20 N, R25 E (Fig. 1). In this ridge numerous distinct layers of red clay balls are found in stratified sands and silts which are overlain by 7 to 10 feet of red Valderan till.

The clay balls vary from less than half an inch to four inches in diameter, with one to two inches being the predominant size. Usually the size of the clay balls varies less within a given layer than between layers. The balls have a high degree of sphericity, but some have a flat ring around them suggesting rolling in one direction. They are composed of red blocky clay and contain small pebbles, or occasionally a large pebble as a core, but do not have a conspicuous coating of gravel. The balls occur in layers imbedded in and separated by stratified coarse and fine sands, silts, and very small pebbles (Fig. 2). The overlying red Valderan till usually rests on an undisturbed surface of sand or silt but occasionally is partly interbedded with them or contains sand lenses. (Figs. 3, 4).

The literature reviewed suggests that similar clay balls have been found in other areas, including contemporary beaches. The old but comprehensive paper on "armored mud balls" by Bell (3) deals with clay balls formed on stream bottoms. Leney and Leney (4) discuss clay balls found in outwash in front of a moraine. Kugler and Saunders (5) describe clay balls formed on present beaches backed by unstable marl and clay cliffs providing, through land sliding, lumps of clay which are rolled by waves into round balls. The characteristics of clay balls found near Two Rivers and their stratigraphic and topographic positions suggest that they probably formed under beach-nearshore conditions in front of an ice sheet heavily laden with red clayey till.

---

* I would like to acknowledge extensive assistance in data collection and interpretation received during the field stage of this study from Howard Deller, a geography graduate student at the University of Wisconsin–Milwaukee. The idea of curling mud cracks developing into clay balls is predominantly his.


FIGURE 1.

An analysis of the geomorphic history of Eastern Wisconsin and further study of the topographic and geographic positions of the clay ball deposit suggest its significance in the reconstruction of the paleogeography of Eastern Wisconsin.

It is generally accepted that the red Valderan deposits, of which the clay balls seem to be composed, are derived partly from reworked mid-Wisconsin till and partly from red lake sediments transported from Lake Superior (2, Petersen and others, p. 187) during the retreat of the Cary ice through channels established across Upper Michigan and connecting Glacial Lake Keweenaw in the Lake Superior area with Glacial Lake Chicago (2, Murray, p.

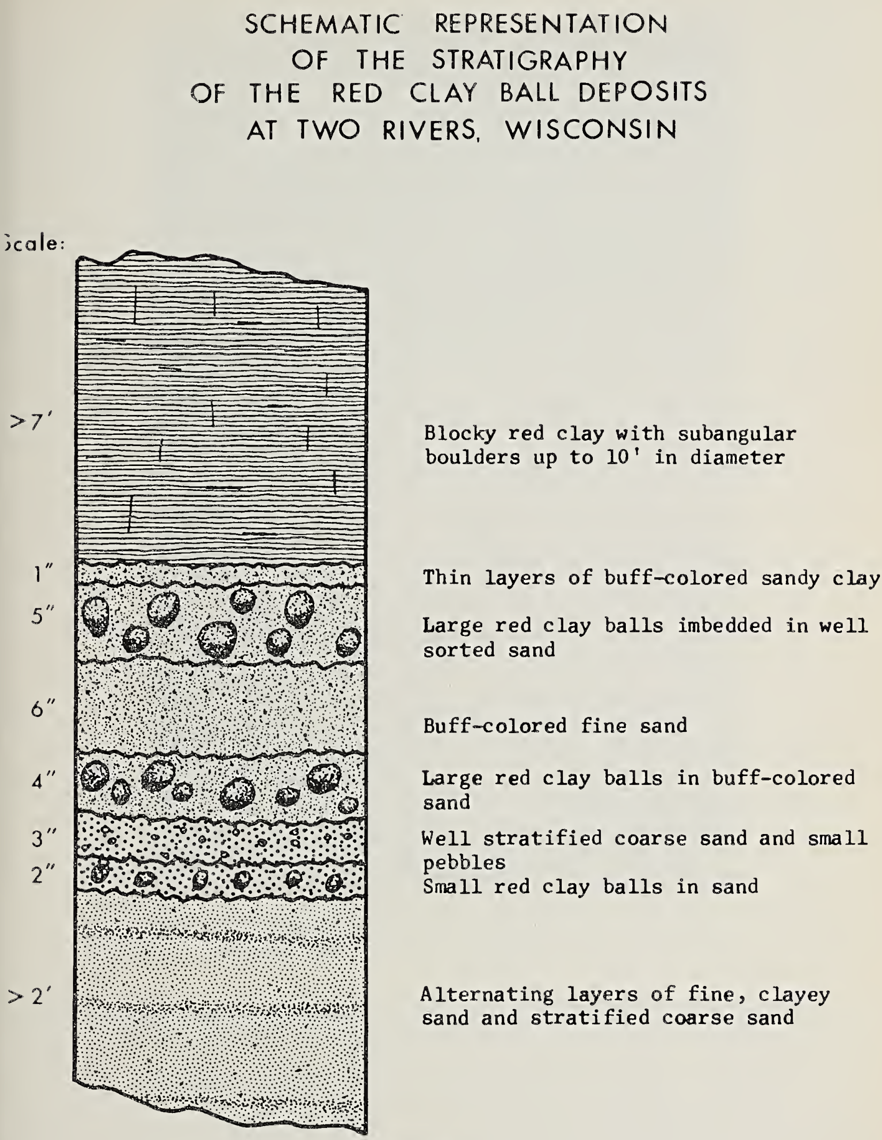



FIGURE 2.

153). The advancing Valderan ice later eroded these red silts and clays, mixed them with the underlying materials, and deposited them as the red clayey till on the uplands of eastern Wisconsin (6). In front of the advancing Valderan ice the lake level of the Lake Calumet stage of Glacial Lake Chicago rose to 620 feet (7). Dur-

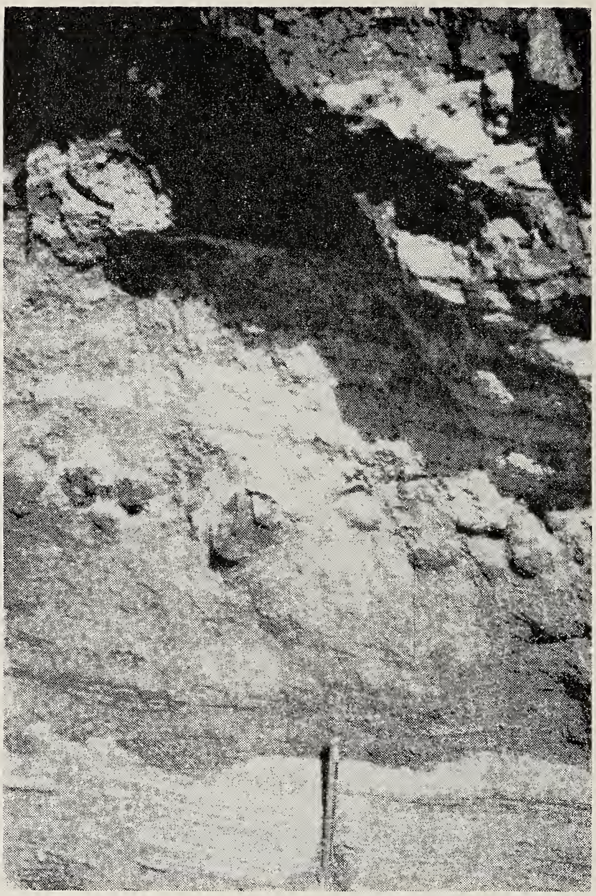


FIGURE 3. Clay Balls in Stratified Sands and Silts under Valderan Till, Two Rivers, Wisconsin.

ing the retreat of the Valderan ice, extensive marginal lakes formed in which the red glacio-lacustrine sediments, also found in this area, were laid down (2, Petersen and others, p. 187).

Many of the glacial events of Eastern Wisconsin have been reconstructed through the study of the Two Creeks Forest bed site at Two Creeks, Wisconsin, eleven miles north of the area of this study. Wilson suggested (8) and others confirm (9) that the Two Creeks Forest grew in this area on mid-Wisconsin till and lake deposits during the low stage of Lake Calumet, called Lake Bowmanville (7), which probably stood at the 580 feet level (1, Thwaites and Bertrand, p. 859). Readvance of the ice in the Valderan glacial substage caused the lake to flood the Two Creeks site and bury the forest in stratified clays, silts, and sands. Subsequent

FIGURE 4. Typical Clay Ball in Stratified Sand under Valderan Till, Two Rivers, Wisconsin.

advance of the ice broke the trees and covered the site and the surrounding area with almost 10 feet of red till. According to Thwaites and Bertrand (1) and Hough (9, p. 98), well developed Calumet stage level beaches have not been discovered in Eastern Wisconsin. This paper reports on field evidence of what is probably a buried beach of the Calumet II stage of Glacial Lake Chicago.

As the clay balls found near Two Rivers occur in several layers in generally undisturbed stratigraphic sections underlying Valderan till (in which we found a large tree log probably derived from the nearby Two Creeks Forest bed), it can be suggested that in this locality the advancing Valderan ice was fringed by a shallow marginal lake or a lagoon formed behind offshore sand bars. As a result of wave erosion or melting along the advancing Valderan ice, small chunks of clayey Valderan till were brought to this marginal lake. The high degree of cohesion and compactness of the till, or its frozen state, could have kept the clay chunks from disintegrating. In the shore environment the chunks of till were probably rolled on the beach by successive waves until they acquired a high degree of sphericity. Evidence supporting the suggestion that the clay balls may represent beach environment was found at the nearby Point Beach State Park. Red clay balls are present on the inner part of the beach where red clay (probably from parking lot construction) projects through the sand. These balls must have been formed recently by waves which reached the clay bed, detached segments of it, and rolled them into round balls. Shallow lakes or lagoons with waves of smaller magnitude could have provided a more suitable environment for clay balls to be preserved in successive layers of sands and silts varying in thickness from several inches to a few feet. Intermittently-dry lagoon bottoms could have also provided thick flakes of red clay curling up between dessication cracks, easy to roll into oval clay balls when washed over by small waves. However, while several elongated clay balls composed of layered rather than blocky clay have been found at the site of study, most balls are composed of blocky red clay containing small pebbles.

The present topographic setting of the study site further contributes to the understanding of the paleogeographic conditions in the area during the formation of the red clay balls. The mile-long north–south trending ridge in which the clay balls are found reaches an elevation of about 640 feet above sea level (see Fig. 1) and is located one and a half miles west from the present shore of Lake Michigan. It rises about 30 feet above a gently sloping plain whose eastern edge is marked by a north–south trending 600 feet contour line interpreted to be an abandoned shoreline of Glacial Lake Nipissing (1, Thwaites and Bertrand, Plate 8). Immediately east of this shoreline lies the Point Beach State Park consisting of a broad overgrown lagoon fringed on the east by crescent-shaped, north–south trending, parallel alternating lagoons and sand bars forming a peninsula-like projection into Lake Michigan. These ridges and lagoons are of post-glacial origin and are not covered by glacial till. The north–south trending ridge in which the buried clay balls are found may be a remnant of a beach ridge analogous to the present beach ridges located to the east of it. On the basis of its altitude, the ridge may be interpreted to be a part of the Glacial Lake Calumet II shoreline, whose elevation is estimated at 620 feet (7). The maximum elevation of the ridge is just over 640 feet, and the elevation of the buried beach ridge, overlain in places by as much as 10 feet of Valderan till, is not much over 630 feet.

The clay ball deposits are located below that elevation, or around 620 feet. Since the beach ridge is buried by the Valderan till, the lake whose shoreline it represents must have existed just prior to the maximum extent of the Valderan ice.

Wayne and Zumberge summarize the chronology of glacial lakes in Lake Michigan Basin as shown in Table 1.

Inasmuch as the clay balls are found in the upper strata of water-deposited sands and silts which appear to be of Two Creeks age and are overlain by the red Valderan till, they had to be formed at the end of the Two Creeks period but before the maximum advance of the Valderan ice. It is therefore suggested that they represent a beach ridge of Glacial Lake Calumet II.

A search for other sites containing layers of clay balls which would further help interpret the site described was conducted through a 75 square mile area around Two Rivers (in ten sand and gravel pits), but similar beach-ridge deposits were not found. A distinct layer of red clay balls was found at only one other place:

Table 1.

| Years B. P. | Name of Lake and Elevation in Feet |
|---|---|
| | Lake Michigan (580) |
| 2,000 | |
| | Lake Algoma |
| 3,000 | |
| | Lake Nipissing |
| 4,000 | |
| | (slow crustal uplift due to glacial unloading) |
| | Chippewa (230) |
| 9,500 | |
| | Post Algonquin<br>Main Algonquin<br>Kirkfield |
| 11,000 | |
| Valders Maximum | Tolleston (605) |
| | Calumet II (620) |
| Two Creeks | Bowmanville |
| 12,000 | |
| | Calumet I (620) |
| 13,000 | |
| | Glenwood (640) |
| 14,000 | |

Source: W. Wayne and J. Zumberge, *The Quaternary of the United States*, p. 76.

a small sand and gravel pit on a gently rolling upland immediately adjacent to and south of West Twin River valley, just west of Shoto (Sec. 29, T19 N, R24 E). The site is located seven miles from the shore of Lake Michigan at an approximate elevation of 620 feet. The layer of clay balls found here lies below 620 feet and is imbedded predominantly in gravel deposits, overlain by about five feet of well sorted sands, and about two feet of buff-colored till containing ice wedges. A few small clay balls are present in the lowest layers of the sand, but the underlying gravel deposits contain most of the red clay balls, which are of varying sizes up to 7 inches in diameter and have an occasional distinct pebble armor around them. The clay balls in this site are less consistently round; many are oval or cigar-shaped with a flat ring suggesting rolling in one direction. Inasmuch as red till is not present in this area, though the area is mapped as Valderan (6, p. 170), the red clay balls were probably brought into this locality with outwash gravels from an area of red Valderan till and, therefore, differ in origin from the clay balls at Two Rivers. Furthermore, the clay balls at Shoto do not occur in a distinct ridge parallel to the shores of Lake Michigan beach. Therefore, there is little to suggest at present that they represent a beach ridge environment such as that at Two Rivers.

A few scattered red clay balls were also found near Sheboygan, which is located about 35 miles south of Two Rivers, but the topographic and stratigraphic conditions again were different from those at Two Rivers. Horn (2, p. 174) found one clay ball southwest of Omro, west of Lake Winnebago, imbedded in sand under 20 feet of stratified material covered by 6 to 12 feet of red Valderan till. However, distinct clay ball layers, such as those at Two Rivers, were not reported. All these sites, therefore, though containing clay balls, are not comparable to the site at Two Rivers and do not contribute directly to its interpretation. Further search may, however, reveal sites which are comparable to that at Two Rivers.

In summary, the field findings presented in this paper suggest that marginal lakes, probably with fluctuating water level, fringed the advancing Valderan ice near Two Rivers. The clay ball deposit is interpreted to be a beach ridge of Glacial Lake Calumet II, which was present in this area just prior to the maximum advance of the Valderan ice. The deposit appears to be a beach deposit because of the presence of distinct layers of highly spherical clay balls imbedded in stratified sands and silts, similar to clay balls found on nearby modern beaches, and because of the topographic position of the clay balls in a north–south trending ridge roughly parallel to the shores of Lake Michigan basin. The deposit is inferred to represent a beach ridge of Glacial Lake Calumet II on the basis of its geographic position, its specific elevation, and, through its stratigraphic position, its place in the chronology of geomorphic events of this area. This conclusion assumes that the sequence of geomorphic events proposed in the literature reviewed (7) is correct.

Further search around Lake Michigan for sites containing layers of clay balls imbedded in beach deposits under Valderan till may help determine whether the deposit described in this paper represents the shoreline of Glacial Lake Calumet II, and may help map this shoreline. Findings of this nature should help reconstruct the paleogeography of Eastern Wisconsin during the most recent advance of the continental ice into this area (10).

## References Cited

1. Alden, W. C., "Quaternary Geology of Southeastern Wisconsin," *U.S.G.S. Prof. Paper* 106 (1918); Thwaites, F. T., "Pleistocene of Part of Northeastern Wisconsin," *G.S.A. Bull.* 54, 84–144 (1943); Frey, J. C., and Willman, H. B., "Classification of the Wisconsin Stage in the Lake Michigan Glacial Lobe," *Ill. G. S. Circ.* 285, 1–16 (1960); Wright, H. E., Jr., and Frey, D. C., (ed.), *The Quaternary of the United States* (Princeton Univ. Press, 1965); Thwaites, F. T., and Bertrand, K., "Pleistocene Geology of the Door Peninnsula, Wisconsin," *G.S.A. Bull.* 68, 831–880 (1957); Black, R. F. and M. Rubin, "Radiocarbon Dates of Wisconsin," *Trans. Wisc. Ac. Sci.* LVI, 91–115 (1967–68).
2. Murray, R. C., "The Petrology of the Cary and Valders Tills of Northeastern Wisconsin," *Amer. Jour. Sci.* 251, 140–155 (1953); Horn, M. E., "A Pedological Study of Red Clay Soils and Their Parent Materials in Eastern Wisconsin," Ph.D. Thesis (Univ. of Wisc., 1960); Lee, G. B., Janke, W. E., and Beaver, A. J., "Particle Size Analysis of Valders Drift in Eastern Wisconsin," *Science* 138, 154–155 (1962); Janke, W. E., "Characteristics and Distribution of Soil Parent Material in the Valderan Drift Region of Eastern Wisconsin," Ph.D. Thesis (Univ. of Wisc., 1962); Petersen, G. W., Lee, G. B., and Chester, G., "A Comparison of Red Clay Glacio-Lacustrine Sediments in Northern and Eastern Wisconsin," *Trans. Wisc. Ac. Sci.* LVI, 185–196 (1957–68).
3. Bell, H. S., "Armored Mud Balls—Their Origin, Properties, and Role in Sedimentation," *Jour. Geol.* 48, 1–31 (1940).
4. Leney, G. L., and Leney, A. T., "Armored Till Balls in the Pleistocene Outwash of Southeastern Michigan," *Jour. Geol.* 65, 105–106 (1957).
5. Kugler, H. G., and Saunders, J. B., "Occurrence of Armored Mud Balls in Trinidad, West Indies," *Jour. Geol.* 67, 533–565 (1959).
6. Black, R. G., "Valders Glaciation in Wisconsin and Upper Michigan—A Progress Report," *Univ. of Michigan Great Lakes Research Oivision* (1966), pp. 169–175, suggests that these deposits are present only in northeastern Wisconsin, though originally they were also recognized in northwestern Wisconsin and Upper Michigan.
7. Wayne, W. J., and Zumberge, J. H., "Pleistocene Geology of Indiana and Michigan," in Wright and Frey, *op. cit.*, (footnote 1), Fig. 6, p. 76. It is apparent from Bretz, J. H., "The Double Calumet Stage of Lake Chicago," *Jour. Geol.* 67, 675–684 (1959) that he and Hough (footnote

9) do not agree on the interpretation of Glacial Lake Chicago. For this reason the correlations compiled by Wayne and Zumberge from writings by both Bretz and Hough are used in this paper.

8. WILSON, L. R., "The Two Creeks Forest Bed, Manitowoc County, Wisconsin," *Trans. Wisc. Ac. Sci.* 27, 31–46 (1932); and "Further Fossil Studies of the Two Creeks Forest Bed, Manitowoc County, Wisconsin," *Torrey Bot. Club Bull.* 66, 317–325 (1936).
9. For example: Hough, J. L., "The Prehistoric Great Lakes of North America," *Amer. Scientist* 51, No. 1, 100 (1936); or Wayne, W., and Zumberge, H., *op. cit.*, pp. 73–80; or Thwaites, F. T., and Bertrand, K., *op. cit.*, pp. 859–860.
10. I thank Professors K. Nelson and N. Lasca of the Department of Geology, University of Wisconsin–Milwaukee, for their comments on the ideas contained in the early version of this paper, and Professor J. Flannery and the UWM Cartographic Laboratory for the preparation of illustrations. Figure 4 was provided by Mr. Charles Collins.

# NOTES ON THE ECOLOGY OF THE HARVEST MOUSE, *REITHRODONTOMYS MEGALOTIS*, IN SOUTHWESTERN WISCONSIN

*Gerald E. Svendsen*

## Introduction

The harvest mouse, *Reithrodontomys megalotis*, occurs throughout most of the central and western United States and Mexico. It is the most widespread of all species of harvest mice, preferring thick stands of grass (Hall and Kelson, 1959). Local abundance depends on a variety of vegetation that provides food at all seasons. Uncultivated fields and areas having grasses bearing large seeds are favored. In Wisconsin, as far as is known, the distribution of this species is limited to the driftless region, and it favors more or less open, grassy, neglected fields, grassy borders of cultivated fields, and grain fields (Jackson, 1961).

The first specimens of the harvest mouse collected in Wisconsin were taken in La Crosse county in 1930 by Vernon Bailey, and Francis Hammerstrom procured a specimen from Juneau county in 1936 (Jackson, 1961). Subsequent specimens were collected from Columbia and Sauk counties by Hansen (1944a). Personal records include specimens from La Crosse, Wood, and Vernon counties. Hansen (1944a) and Jackson (1961) recognize this harvest mouse to be *Reithrodontomys megalotis pectoralis*, but Hooper (1952) and Hoffmeister and Warnock (1955) find it indistinguishable from *Reithrodontomys megalotis dychei.*

This paper presents some observations on habitats used by this animal, population densities, and a record of some relationships with associated species in southwestern Wisconsin.

## Methods and Materials

Population and vegetation analysis were determined in a 9 acre field which has not been under cultivation for 8 years. This neglected field is bordered on the north by a wooded area, on the east by a wet marsh, and on the west and south by a 3 track railroad right-of-way and cultivated fields planted in soybeans and corn. The abandoned field is essentially isolated from any other area of similar vegetational composition. A snap trap grid was arranged in 1 acre plots with traps stationed every 30 feet. The grids were run for six consecutive nights and the population estimates were made from data based on the removal of the animals (Zippen, 1958).

Vegetational analysis was accomplished by randomly selecting five 1 meter plots within the grids and determining species composition. Light intensity was measured with a light meter at noon on a clear sunny day, and expressed as percent of overhead light.

## Habitat Preference

Trapping efforts in the wooded area, the marsh, the railroad right-of-way, and in the cultivated fields yielded no harvest mice. The only habitat from which the harvest mouse was collected was the abandoned field. This field is in an early stage of succession, with sapling elm, oak, and sumac (½–1 inch d.b.h.) at a density of 3 to 5 per acre. The ground cover is dense, total foliage cover is 90 percent. Light intensity at ground level is 15 to 20 percent of full sunlight. The areas of sparse vegetation are due to places where animals' digging and denning activities have brought up large quantities of sand.

Seventy-two percent of the total species of plants are the grasses *Phleum, Agropyron,* and *Panicum,* and the legumes *Lespedeza* and *Trifolium.* The forbes *Aster, Asclepias, Aplopappas* and *Solidago,* the grasses *Andropogon, Elumus* and *Setaris,* the blackberry *Eubatus,* and the composites *Tragopogon* and *Tarazacum* make up 23 percent of the plants. The remaining 5 percent of the species are woody plants and other grasses and forbes.

Average height of the vegetation varies from 12 to 20 inches, with no ground litter over most of the area. The soil is a sandy loam with very good drainage. The mice live mainly in burrows.

## Population Density of Reithrodontomys

The population density of *Reithrodontomys megalotis* was measured in the falls of 1967 and 1968 in the abandoned field where previous trapping indicated the presence of a substantial population of this species. The fall population, estimated by the removal method, was 18 animals per acre. This represents 0.046 animals per trap night. The spring trapping yielded 0.012 animals per trap night. The fall population based on animals per trap night is almost four times that of the spring population. Hansen (1945) estimated a maximum density of harvest mice in foxtail-smartweed cover type as 2.4 per acre. Birkenholz (1967) estimated a fall population of 17 animals per acre in central Illinois.

## Associated Species

The harvest mouse is found in the same area with a variety of other small animals. *Peromyscus maniculatus* is the only species which outnumbers the harvest mouse. The estimated density of *Peromyscus maniculatus* is 72 animals per acre, representing 56 percent of the total population of animals in the old field study area. The percent of the total population represented by the other animals is *Reithrodontomys megalotis* 14 percent, *Blarina brevicauda* 10 percent, *Microtus pennsylvanicus* 7 percent, *Mus musculus* 4 percent, *Peromyscus leucopus* 4 percent, *Zapus hudsonius* 3 percent, *Sorex cinerus* 1 percent, and *Spermophillus tridecemlineatus* 1 percent.

Eleven percent of the total population is composed of two species of predators *Blarina brevicauda* and *Sorex cinerus,* the former being the most common. *Peromyscus leucopus* were all captured not more than 30 feet from the edge of the woods. These individuals were probably wanderers from the woods rather than permanent residents of the field. *Microtus* were trapped mainly in areas of the field where lespedeza and clover were especially thick, and infrequently over the rest of the field. *Mus, Zapus,* and *Peromyscus* were continually trapped with the harvest mouse, especially in areas of the field where the seed-bearing plants were more common. These four species appear to compete directly with one another. *Zapus* hibernates from late October to May and at this time would be removed from competition, and Catlett and Shellhammer (1962) suggest that *Mus* and *Reithrodontomys* form a cospecies social hierarchy and that little competition exists between these species. *Peromyscus maniculatus* appears, therefore, to compete most strongly with the harvest mouse throughout the year in this study area.

## Discussion

It can be assumed that clearing of woodlands and establishing grasslands and grainfields has aided the distribution of the harvest mouse. Birkenholz (1967) reports an eastward range extension in Illinois during the past century in response to the clearing of woodlands. The harvest mouse populates new habitats suddenly and attains a high local abundance if the habitat alteration favors its establishment. These habitats are usually transitory resulting in a decrease in abundance if the vegetation composition becomes less favorable.

The harvest mouse can become established in these local and transitory habitats in two ways. Individuals from widely distributed but small and relic populations can populate the new areas, or a saltatorial colonization can occur from isolated, well-populated pockets. Saltatorial colonization by vertebrates is considered unlikely by Smith (1957), although Leopold (1947) reports that outlying individuals are common in species in the process of expanding their range.

Five years of intensive trapping of all types of habitats has yielded only one harvest mouse from an area which could be considered nontypical, and Hansen (1944) reported catching one individual on a juniper bluff. The trapping data would, therefore, favor saltatorial colonization of new areas, due to the lack of individuals, representing a scattered population, in nontypical habitats. It is reasonable that saltatorial colonization can take place if the harvest mouse has a tendency to wander, and if it has a low degree of motivation to return home. Fisler (1966) reported that the homing tendencies of the harvest mouse would be best described as nonrandom throughout the terrain and that the mice lack motivation to return home from unknown areas.

## References Cited

Birkenholz, Dale E. 1967. The harvest mouse *(Reithrodontomys megalotis)* in Central Illinois. Trans. Ill. State Acad. Sci., 60, No. 1.

Catlett, R. H., and H. S. Shellhammer. 1962. A comparison of behavorial and biological characteristics of house and harvest mice. J. Mamm. 43: 133–144.

Fisler, George F. 1966. Homing in the western harvest mouse, *Reithrodontomys megalotis*. J. Mamm. 47: 53–58.

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. The Ronald Press Co., New York. 1083 p.

Hansen, H. C. 1944a. A new harvest mouse from Wisconsin. Field Mus. Nat. Hist., Zool. Ser. 29: 205–209.

Hansen, H. C. 1945. Small mammal census near Prairie du Sac, Wisconsin. Trans. Wisconsin Acad. Sci., 47: 161–164.

Hooper, Emmet T. 1952. A systematic review of the harvest mouse (Reithrodontomys) of Latin America. Misc. Publ. Mus. Zool., Univ. Mich., no. 77.

Jackson, H. H. 1961. Mammals of Wisconsin. Univ. of Wisconsin Press, Madison, 504 p.

Leopold, A. 1947. The distribution of Wisconsin hares. Trans. Wisc. Acad. Sci., Arts and Letters, 37: 1–14.

Smith, P. W. 1957. Analysis of post-Wisconsin biogeography of the prairie peninsula region based on distribution phenomena among terrestial vertebrate populations. Ecol. 38: 205–219.

Zippen, C. 1956. An evaluation of the removal method of estimating animal populations. Biometrics, 12: 163–189.

# AN ANNOTATED CHECK LIST OF THE GEOMETRIDAE (LEPIDOPTERA) OF WISCONSIN[1]

*Charles V. Covell, Jr.*

Upon completing the task of identifying some 1,700 undetermined specimens of Geometridae for the University of Wisconsin Insectarium, I felt that a Wisconsin list of this family of moths would be useful to lepidopterists. To this end I examined additional material: 1,300 more specimens from the University of Wisconsin; 1,800 specimens from William E. Sieker; and over 2,000 specimens taken by Harold Bower. Over 7,000 specimens provided the data in this list, and localities in at least 30 counties are represented.

Previous check lists including Wisconsin Geometridae are those of Rauterberg (1900), Fernekes (1906), and Muttkowski (1907), all of which are restricted to Milwaukee County. I have not included their records here because of subsequent changes in nomenclature of species, and because some of their identifications are dubious (e.g., Fernekes, p. 54, lists *Melanchroia cephise* Cramer, a Florida species). However, most of their records are corroborated here; and other species are recorded from Wisconsin for the first time.

Although this list is based upon specimens I have actually examined, a few records are included which were taken from recent revisionary literature. These cases are so noted in the text, and appropriate references are cited.

The nomenclature and arrangement of taxa follow generally those of McDunnough (1938), since that list has long been the basis for organization of most collections of North American moths. I have used Forbes (1948) and the revisionary works of McDunnough, Rindge, Capps, Rupert, and others as aids in my determinations; consequently some digressions from McDunnough (1938) have been made here. Numerous genera, such as *Semiothisa,* badly need revisionary study. It therefore follows that certain long-standing errors in nomenclature are unfortunately continued in this list. These must wait for future correction.

Most of the specimens studied were collected by the following, each listed with the localities where he made most of his captures: Harold Bower (Lake Katherine in Oneida County, Milwaukee, and

[1] University of Louisville Publications in Biology (New Series) No. 110.

Wausau); Louis Griewisch (Green Bay and other "Brown County" labels); Gary Lachmund (Sauk City); Gary Ross (Florence County); and William E. Sieker (Bailey's Harbor in Door County, other "Door County" labels, and Madison). All of the Bower specimens are in the Los Angeles County Museum, and most of the Sieker and Lachmund material is in my collection; the rest is at the University of Wisconsin.

I am deeply indebted to the following for their contributions to this effort: Dr. Roy D. Shenefelt, Curator of the University of Wisconsin Insectarium, and his project assistants, Lutz J. Bayer and Isabel Arevalo, for providing material and important information; William E. Sieker of Madison and Gary Lachmund of Sauk City for numerous specimens; Lloyd M. Martin, Los Angeles County Museum, for making the Bower collection available; Dr. Frederick H. Rindge, American Museum of Natural History, for nomenclatural advice; and Patricia K. Liles, my curatorial assistant, for compiling data. I am also very grateful to Dr. John A. Dillon, Jr., Dean of the Graduate School, University of Louisville, for making graduate school funds available to me for the visit to the Los Angeles County Museum.

## Family Geometridae
### Subfamily Brephinae

1. *Brephos infans* Möschler — Apr. 10–May 7
   Lake Katherine, Oneida Co.
2. *Leucobrephos brephoides* Walker
   Synonym *hoyi* Grote was described from Wisconsin.

### Subfamily Oenochrominae

3. *Alsophila pometaria* Harris — Apr. 18; Oct. 25–Nov. 5
   Crandon; Madison; Wausau, Marathon Co.

### Subfamily Geometrinae

4. *Nemoria mimosaria* Guenée — May 14–July 11
   Bailey's Harbor; Florence Co.; Griffith State Nursery, Wood Co.; Lake Katherine; Marinette Co.; Wausau.
5. *Nemoria rubrifrontaria* Packard — May 20–June 27
   Lake Katherine; Sauk City; Vilas Co.
6. *Dichorda iridaria* Guenée — May 31–June 7
   Door Co.; Sauk City.
7. *Synchlora liquoraria* Guenée
   Lake Katherine. This is, according to Ferguson (1969), subspecies *albolineata* Packard.

8. *Synchlora aerata Fabricius* June 11–Aug. 27
Columbia Co.; Lake Katherine; Madison; Trout Lake, Vilas Co.; Sayner; Wausau. These records include *rubrifrontaria* Packard, synonymized by Ferguson (1969).
9. *Chlorochlamys chloroleucaria* Guenée June 4–Sept. 8
Belleville; Columbia Co.; Door Co.; Green Bay; Harrisville; Madison; Rusk Co.; near Sayner, Vilas Co.; Wausau.
10. *Hethemia pistaciaria* Guenée June 11–July 10
Florence Co.; Lake Katherine.
11. *Mesothea incertata* Walker May 10–30
Cranmoor, Wood Co.; Lake Katherine; Marinette Co.

Subfamily Sterrhinae

12. *Metasiopsis balistaria* Guenée May 14–July 22
Boscobel St. Nursery, Grant Co.; Dane Co.; Griffith St. Nursery, Wood Co.; Milwaukee; Sturgeon Bay, Door Co.
13. *Scopula cacuminaria* Morrison June 18–Sept. 13
Lake Katherine; N.E. Price Co.; Wausau.
14. *Scopula quadrilineata* Hulst (probably June–Aug.)
"Wis." on pin label.
15. *Scopula ancellata* Hulst Aug.
Bailey's Harbor.
16. *Scopula junctaria* Walker May 7–July 26
Bailey's Harbor; Crandon; Florence Co.; Lake Katherine.
17. *Scopula limboundata* Haworth June 10–Aug. 16
Bailey's Harbor; Crandon; Dousman; Florence Co.; Lake Katherine; Madison; Marinette Co.; Milwaukee; Sauk City; Trout Lake, Vilas Co. Known widely as *enucleata* Guenée.
18. *Scopula frigidaria* Möschler July 3
Florence Co.
19. *Scopula inductata* Guenée May 30–Sept. 14
Columbia Co.; Door Co.; Gordon Nursery, Douglas Co.; Green Bay; Lake Katherine; Madison; Milwaukee; Sauk City; Waushara Co.
20. *Idaea demissaria* Hübner May 25–July 21
Door Co.; Madison. Fletcher (1966, p. 12) synonymizes the familiar *Sterrha* Hübner to *Idaea* Treitschke.
21. *Haematopis grataria* Fabricius May 31–Oct. 4
Badger Ordnance Works, Sauk City; Boscobel; Brown Co.; Columbia; DeForest; Door Co.; Lake Katherine; Madison; Milwaukee; Rusk Co.; Sauk City; Tower Hill State Park, Iowa Co.; Washburn Co.; Waushara Co.; Wood Co.

22. *Calothysanis amaturaria* Walker July 14–Sept. 14
Columbia Co.; Lake Katherine; Madison.

23. *Pleuroprucha insulsaria* Guenée June 9– Oct. 1
Dane Co.; Door Co.; Lake Katherine; Milwaukee.

24. *Cyclophora pendulinaria* Guenée May 21–Sept. 4
American Legion State Forest, Oneida Co.; Lake Katherine; Rusk Co.; Trout Lake; Wausau.

25. *Cyclophora packardaria* Prout June 16–Aug. 29
Lake Katherine.

Subfamily Larentiinae

26. *Acasis viridata* Packard May 16–31
Lake Katherine.

27. *Nyctobia limitaria* Walker May 1–June 9
Lake Katherine.

28. *Nyctobia anguilineata* Grote and Robinson May 28
Lake Katherine.

29. *Cladara atroliturata* Walker Apr. 15–May 22; Aug. 9
Lake Katherine.

30. *Lobophora nivigerata* Walker May 18–July 12
Brown Co.; Dane Co.; Florence Co.; Green Bay; Lake Katherine; Sauk City; near Sayner, Vilas Co.

31. *Heterophleps refusata* Walker June 20–July 12
Florence Co.; Milwaukee; Wausau.

32. *Heterophleps triguttaria* Herrich-Schäffer June 17–July 11
Madison; Milwaukee; Wausau.

33. *Dyspteris abortivaria* Herrich-Schäffer June 4–Aug. 11
Madison; Selzer Farm near Holy Hill.

34. *Trichodezia albovittata* Guenée May 26–July 23
Kewaunee Co.; Lake Katherine; Madison; Milwaukee.

35. *Oporophtera bruceata* Hulst Oct. 15–Nov. 12
Lake Katherine; Wausau.

36. *Triphosa affirmaria* Walker Apr. 19–Oct. 28
Dane Co.; Florence Co.; Lake Katherine; Wausau. Known widely as *haesitata* Guenée.

37. *Hydria undulata* Linnaeus June 11–Aug. 15
Door Co.; Dousman; Florence Co.; Kenosha Co.; Lake Katherine; Madison; Milwaukee.

38. *Coryphista meadi* Packard May–Sept. 10
Dane Co.; Green Bay.

39. *Eupithecia miserulata* Grote May 30–Oct. 19
Columbia Co.; Dane Co.; Door Co.; Florence Co.; Lake Katherine; Rusk Co.; University of Wisconsin Arboretum, Madison.

40. *Eupithecia castigata* Hübner June 12–26
Lake Katherine.

41. *Eupithecia palpata* Packard June 9
Florence Co.; Vilas Co.

42. *Eupithecia transcanadata* MacKay May 19–June 17
Lake Katherine.

43. *Eupithecia columbiata* Dyar Apr. 30–May 24
Lake Katherine. Determined by Bower as subspecies *erpata* Pearsall.

44. *Eupithecia herefordaria* Cassino and Swett June 9–Sept. 15
Columbia Co.; Florence Co.

45. *Eupithecia carolinensis* Grossbeck June 10
Lake Katherine. Determined by R. Leuschner.

46. *Eupithecia russeliata* Swett May 24–July 27
Lake Katherine.

47. *Eupithecia indistincta* Taylor July 10
Trout Lake, Vilas Co.

48. *Eupithecia coagulata* Guenée July 21–Aug. 22
Lake Katherine; Milwaukee; Wausau.

49. *Eupithecia perfusca* Hulst June 18–July 20
Lake Katherine. Determined by Bower as subspecies *youngata* Taylor.

50. *Eupithecia ravocostaliata* Packard Apr. 26–30
Lake Katherine.

51. *Horisme intestinata* Guenée May 30–Aug. 23
Bailey's Harbor; Brown Co.; Green Bay; Lake Katherine; Milwaukee; Sauk City.

52. *Eustroma semiatrata* Hulst June 10–Aug. 4
Crandon; Lake Katherine near Hazelhurst; N.E. Price Co. Known widely as *E. nubilata* Packard.

53. *Eulithis diversilineata* Hübner June 24–Aug. 30
Brown Co.; Florence Co.; Kenosha Co.; Madison; Milwaukee; Sauk City; Wausau. Fletcher (1966, p. 15) cites *diversilineata* as type of *Eulithis* Hübner [1821] which antedates *Lygris* Hübner [1825].

54. *Eulithis gracilineata* Guenée June 24–Sept. 16
Brown Co.; Griffith State Nursery; Madison.

55. *Eulithis testata* Linnaeus June 14–Sept. 5
Florence Co.; Lake Katherine; Wausau.

56. *Eulithis molliculata* Walker June 14–Aug. 20
Milwaukee; Platteville.

57. *Eulithis destinata* Möschler July 3–Aug. 22
Florence Co.; Lake Katherine.

58. *Eulithis explanata* Walker June 24–Aug. 25
Florence Co.; Lake Katherine.

59. *Eulithis xylina* Hulst July 6–Aug. 2
Lake Katherine.

60. *Diactinia silaceata* Hübner June 14–Sept. 16
Forest Co.; Lake Katherine.

61. *Plemyria georgii* Hulst Aug. 11–18
Lake Katherine.

62. *Dysstroma citrata* Linnaeus June 4–Sept. 1
Florence Co.; Lake Katherine; Trout Lake.

63. *Dysstroma hersiliata* Guenée June 19–Aug. 28
Bailey's Harbor; Crandon; Dodgeville; Door Co.; Florence Co.; Lake Katherine; Washburn Co.; Wausau.

64. *Stamnodes gibbicostata* Walker Aug. 31–Sept. 4
Lake Katherine.

65. *Hydriomena transfigurata* Swett May 11
Dane Co. This is subspecies *manitoba* Barnes and McDunnough.

66. *Hydriomena perfracta* Swett May 6–June 24
Lake Katherine; Vilas Co. near Sayner.

67. *Hydriomena divisaria* Walker May 6–July 16
Lake Katherine; Vilas Co. near Sayner.

68. *Hydriomena renunciata* Walker May 11–Aug. 5
Bailey's Harbor; Dane Co.; Door Co.; Florence Co.; Green Bay; Griffith State Nursery; Lake Katherine; Milwaukee; Summit Lake, Langlade Co.; Trout Lake; Waterloo; Wausau.

69. *Xanthorhoe lacustrata* Guenée May 29–Aug. 10
Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; "Peaks Lake" (this is probably Peat's Lake, Brown Co.); Wausau.

70. *Xanthorhoe emendata* Pearsall May 21–Aug. 1
Lake Katherine; N.E. Price Co.

71. *Xanthorhoe ferrugata* Linnaeus May 21–Aug. 29
Bailey's Harbor; Columbia Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Wausau.

72. *Xanthorhoe algidata* Möschler July 10–Aug. 3
Florence Co.; Lake Katherine; N.E. Price Co.

73. *Xanthorhoe iduata* Guenée June 20–July 8
Lake Katherine.

74. *Xanthorhoe abrasaria* Herrich-Schäffer June 22–Aug. 23
Columbia Co.; Florence Co.; Lake Katherine.

75. *Xanthorhoe luctuata* Denis and Schiffermüller May 28–Aug. 1
Forest Co.; Lake Katherine.

76. *Xanthorhoe intermediata* Guenée May 17–Oct. 13
Dane Co.; Door Co.; Lake Katherine; Milwaukee Co.; Spencer; Spooner; Univ. Wisc. Arboretum, Madison.

77. *Mesoleuca ruficillata* Guenée May 27–Aug. 21
Florence Co.; Lake Katherine; Milwaukee; "Peaks Lake"; Wausau.

78. *Epirrhoe alternata* Müller June 10–Aug. 6
Florence Co.; Lake Katherine; Wausau.

79. *Spargania magnoliata* Guenée June 10–Aug. 12
Crandon; Lake Katherine; N.E. Price Co.; Wausau.

80. *Percnoptilota obstipata* Fabricius May 3–Oct. 13
Bailey's Harbor; Columbia Co.; Florence Co.; Green Bay; Grant Co.; Lake Katherine; Madison; Milwaukee; Rusk Co.; Sauk City; Spooner; Sturgeon Bay, Door Co.

81. *Percnoptilota centrostrigaria* Wollaston May 19–Oct. 31
Bailey's Harbor; Brown Co.; Door Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee; Sauk City; Washburn Co.

82. *Rheumaptera hastata* Linnaeus June 11–July 6
Green Bay; Kewaunee Co.; Lake Katherine; Madison; Milwaukee; "Peaks Lake."

83. *Perizoma basaliata* Walker July 4–30
Lake Katherine; N.E. Price Co.

84. *Earophila vasiliata* Guenée Apr. 26–June 9
Florence Co.; Lake Katherine.

85. *Earophila multiferata* Walker May 17–June 10
Lake Katherine; Madison.

86. *Venusia comptaria* Walker Apr. 25–May 19
Lake Katherine; Milwaukee.

87. *Hydrelia condensata* Walker June 5–July 1
Lake Katherine; Milwaukee.

88. *Hydrelia inornata* Hulst June 10–July 20
Florence Co.; Lake Katherine.

89. *Hydrelia albifera* Walker July 3–25
Florence Co.; Lake Katherine.

90. *Eudule mendica* Walker June 10–July 24
Bailey's Harbor; Florence Co.; Green Bay; Griffith State Nursery; Kenosha Co.; Madison; Mather; Milwaukee; Oconto Co.; "Peak's Lake"; Sauk City; Trout Lake, Vilas Co.; Wausau.

Subfamily Ennominae

91. *Bapta semiclarata* Walker May 15–July 6
Crandon; Door Co.; Marinette; Washburn Co.

92. *Bapta vestaliata* Guenée May 29–July 11
Bailey's Harbor; Blue Mounds; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee.

93. *Bapta glomeraria* Grote May 3–31
Lake Katherine; Waupaca.

94. *Cabera quadrifasciaria* Packard June 7–24
Green Bay; Sauk City. Fletcher (1966, p. 12) shows *Deilinia* Hübner (1825) to be a junior objective synonym of *Cabera* Treitschke (1825).

95. *Cabera variolaria* Guenée June 20–Aug. 12
Bailey's Harbor; Brown Co.; Florence Co.; Forest Co.; Madison; Milwaukee; N.E. Price Co.

96. *Cabera erythemaria* Guenée May 28–Aug. 26
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Milwaukee; N.E. Price Co.

97. *Apodrepanulatrix liberaria* Walker
Rindge (1949, p. 293) states that this species ranges "to Wisconsin."

98. *Syrrhodia cruentaria* Hübner June 25
Milwaukee.

99. *Isturgia truncataria* Walker May 11–June 29
Crandon; Lake Katherine; Marinette Co.

100. *Heliomata cycladata* Grote June 26–July 2
Brown Co.; Sauk City.

101. *Semiothisa aemulataria* Walker May 21–July 30
Bailey's Harbor; Florence Co.; Lake Katherine; Madison, Dane Co.; Marinette Co.; Sauk City; Wausau.

102. *Semiothisa ulsterata* Pearsall June 5–22
Lake Katherine; Vilas Co.

103. *Semiothisa minorata* Packard June 25–July 13
Dane Co.; Lake Katherine; Trout Lake; Wausau.

104. *Semiothisa bisignata* Walker June 23–Sept. 13
Bailey's Harbor; Florence Co.; Green Bay; Lake Katherine; Madison; Trout Lake; Vilas Co.; Wausau.

105. *Semiothisa bicolorata* Fabricius May 19–July 26
Lake Katherine.

106. *Semiothisa distribuaria* Hübner May 5–July 19
Arena, Iowa Co.; Lake Katherine; Madison; Trout Lake; Wausau.

107. *Semiothisa punctolineata* Packard Sept. 7
Dane Co.

108. *Semiothisa granitata* Guenée May 29–Aug. 15
American Legion State Forest, Oneida Co.; Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Trout Lake; Vilas Co.; Wausau. This name represents a complex of several species, needing revisionary study.

109. *Semiothisa oweni* Swett May 28–July 11
Lake Katherine.

110. *Semiothisa sexmaculata* Packard May 13–Aug. 9
Florence Co.; Green Bay; Lake Katherine.

111. *Semiothisa denticulata* Grote June 23–Aug. 1
Milwaukee; Poynette.

112. *Semiothisa eremiata* Guenée July 12
Dane Co.

113. *Semiothisa orillata* Walker May 24–Aug. 29
Bailey's Harbor; Dane Co.; Door Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Sauk City; Wausau.

114. *Semiothisa ocellinata* Guenée July 8–Oct. 3
Kenosha Co.; Madison; Milwaukee.

115. *Semiothisa mellistrigata* Grote May 15–Aug. 25
Belleville; Crandon; Door Co.; Florence Co.; Green Bay; Madison; Milwaukee; Oconto Co.

116. *Semiothisa snoviata* Packard Aug. 30
Columbia Co.

117. *Semiothisa gnophosaria* Guenée May 13–Aug. 17
Bailey's Harbor; Dane Co.; Florence Co.; Lake Katherine; Madison; Wausau; Wood Co.

118. *Itame pustularia* Guenée June 5–Sept. 8
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee; N.E. Price Co.; Sauk City; Trout Lake; Wood Co.

119. *Itame ribearia* Fitch May 15–July 30
Belleville; Dodgeville, Iowa Co.; Madison; Milwaukee; Sauk City; Wausau.

120. *Itame argillacearia* Packard June 9–July 23
Bailey's Harbor; Lake Katherine.

121. *Itame occiduaria* Packard June 28–July 20
Lake Katherine.

122. *Itame evagaria* Hulst June 20–Aug. 2
Crandon; Lake Katherine; Madison; N.E. Price Co.; Wausau.

123. *Itame fulvaria* deVillers June 12–July 10
Crandon; Florence Co.; Lake Katherine; Spooner; Summit Lake; Wood Co.

124. *Itame subcessaria* Walker June 21–Aug. 20
Crandon; Florence Co.

125. *Itame coortaria* Hulst June 5–July 30
Door Co.; Madison; Milwaukee; Sauk City.

126. *Itame anataria* Swett July 7–13
Lake Katherine.

127. *Itame bitactata* Walker July 3–Aug. 4
Lake Katherine; N.E. Price Co.

128. *Itame loricaria* Eversmann June 19–July 13
Lake Katherine; Wausau.

129. *Eumacaria latiferrugata* Walker June 1–Aug. 28
Griffith State Nursery; Lake Katherine; Sauk City; Wausau.

130. *Thysanopyga intractata* Walker
The type of synonym *gausaparia* Grote is from Wisconsin.

131. *Hesperumia sulphuraria* Packard June 18–Aug. 4
Madison; Wausau.

132. *Ematurga amitaria* Guenée May 30–Aug. 10
Crandon; Marinette Co.; Vilas Co.

133. *Eufidonia notataria* Walker June 7–July 23
Griffith State Nursery, Wood Co.; Lake Katherine; Marinette Co.; Northern Highlands; Vilas Co.

134. *Eufidonia discospilata* Walker June 10–22
Lake Katherine; Vilas Co.

135. *Orthofidonia tinctaria* Walker May 8–June 17
Lake Katherine; Sauk City.

136. *Hypagyrtis pustularia* Hübner July 4–Aug. 21
Lake Katherine; Wausau.

137. *Hypagyrtis subatomaria* Wood June 4–Aug. 23
Dane Co.; Douglas Co.; Florence Co.; Lake Katherine; N.E. Price Co.; Trout Lake.

138. *Hypagyrtis piniata* Packard June 19–Aug. 6
Bailey's Harbor; Florence Co.; Gordon, Douglas Co.; Griffith State Nursery, Wood Co.; Madison; Summit Lake; Trout Lake, Vilas Co.

139. *Tornos scolopacinarius* Guenée
Rindge (1954, p. 221) includes "southern Wisconsin" in his range notes for this species.

140. *Melanolophia canadaria* Guenée Apr. 27–July 22
Bailey's Harbor; Lake Katherine; Madison; Milwaukee; Patton Lake Spur, Florence Co.

141. *Melanolophia signataria* Walker May 14–July 3
Bailey's Harbor; Lake Katherine; Patton Lake Spur, Florence Co.

142. *Protoboarmia porcelaria* Guenée June 10–Aug. 12
Bailey's Harbor; Florence Co.; Sayner; Summit Lake.

143. *Cleora manitoba* Grossbeck May 8–July 13
Lake Katherine.

144. *Pseudoboarmia umbrosaria* Hübner June 29–July 28
Crandon; Lake Katherine; N.E. Price Co.

145. *Stenoporpia polygrammaria* Packard June 27
Waushara Co.

146. *Anavitrinella pampinaria* Guenée May 8–Sept. 15
Bailey's Harbor; Bone Rock, Sauk Co.; Columbia Co.; Gays Mills; Griffith State Nursery; Lake Katherine; Madison; Patton Lake, Florence Co.; Neshkoro; Platteville; Sauk City; Waushara Co.

147. *Iridopsis larvaria* Guenée June 20–July 20
Bailey's Harbor; Florence Co.; Lake Katherine.

148. *Anacamptodes ephyraria* Walker June 29–Aug. 12
Crandon; Florence Co.; Forest Co.; Lake Crandon; Lake Katherine; Madison; Milwaukee.

149. *Anacamptodes humaria* Guenée May 5–Aug. 14
Griffith State Nursery; Lake Katherine, near Hazelhurst; Madison; Neshkoro.

150. *Anacamptodes vellivolata* Hulst May 8–Aug. 22
Lake Katherine; Wausau.

151. *Aethalura anticaria* Walker May 30–July 3
Lake Katherine.

152. *Ectropis crepuscularia* Denis and Schiffermüller Apr. 15–Aug. 5
Arbor; Boscobel State Nursery; Door Co.; Florence Co.; Grant Co.; Lake Latherine; Madison; Milkaukee; Patton Lake, Florence Co.; Vilas Co.; Northern Highlands; Wausau.

153. *Phaeoura quernaria* Abbott and Smith May 19–July 11
Bailey's Harbor; Door Co.; Florence Co.; Lake Katherine; Milwaukee; Neshkoro. One reared larva emerged Apr. 4.

154. *Phigalia olivacearia* Morrison Apr. 17–May 7
Dane Co.; Lake Katherine; Madison; Milwaukee; Wausau.

155. *Phigalia titea* Cramer Apr. 18–May 12
Griffith State Nursery; Lake Katherine; Madison; Milwaukee.

156. *Palaeacrita vernata* Peck March 13–Apr. 28
Lake Katherine; Madison; Milwaukee; Wausau.

157. *Erannis tiliaria* Harris Oct. 6–Nov. 2
Brown Co.; Dane Co.; Kewaunee Co.; Lake Katherine; Madison; Wausau.

158. *Biston ursaria* Walker Apr. 12–May 23
Dane Co.; Griffith State Nursery; Lake Katherine; Madison; Milwaukee; Wausau.

159. *Biston cognataria* Guenée May 15–Sept. 19
Arlington; Bailey's Harbor; Boscobel State Nursery; Brown Co.; Columbia Co.; DeForest, Dane Co.; Green Bay; Lake Katherine; Madison; Marinette Co.; Milwaukee; Sauk City; Trout Lake, Vilas Co.; Washburn Co.

160. *Eugonobapta nivosaria* Guenée June 28–Aug. 12
Bailey's Harbor; Door Co.; Florence Co.; Madison; Milwaukee; Sauk City.

161. *Lytrosis unitaria* Herrich-Schäffer June 24–July 30
Madison; Sauk City; Wausau.

162. *Euchlaena serrata* Drury "May"; June 28–Aug. 14
Bailey's Harbor; Brown Co.; Dousman; Door Co.; Green Bay; Griffith State Nursery; Lake Katherine; Madison; "Peaks Lake"; Sauk City; Sturgeon Bay.

163. *Euchlaena obtusaria* Hübner June 9–July 19
Bailey's Harbor; Crandon; Dane Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Summit Lake.

164. *Euchlaena effecta* Walker June 18–July 30
Florence Co.; Lake Katherine; Madison; Wausau.

165. *Euchlaena johnsonaria* Fitch June 9–Aug. 29
Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Marinette Co.; Sauk City; Trout Lake; Wausau; Wood Co.

166. *Euchlaena amoenaria* Guenée June 22
Marinette Co.

167. *Euchlaena marginata* Minot May 30–July 8
Florence Co.; Lake Katherine; Vilas Co.; Waushara Co.

168. *Euchlaena tigrinaria* Guenée June 14–July 15
Bailey's Harbor; Florence Co.; Lake Katherine; Milwaukee; Summit, Langlade Co.

169. *Euchlaena irraria* Barnes and McDunnough June 17–July 10
Florence Co.; Lake Katherine; Madison; Marinette Co.; Sauk City.

170. *Euchlaena milnei* McDunnough July 1
Sauk City.

171. *Xanthotype sospeta* Drury June 6–Aug. 25
Bailey's Harbor; Brown Co.; Crandon; Door Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee; "Peaks Lake"; Rusk Co.; Sauk City; Shawano Co.; Star Lake; Trout Lake, Vilas Co.

172. *Xanthotype urticaria* Swett July 5–Sept. 8
Arpin; Brown Co.; Columbia Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Wausau.

173. *Campaea perlata* Guenée June 1–Oct. 2
Bailey's Harbor; Columbia Co.; Door Co.; Florence Co.; Lake Katherine; Madison; N.E. Price Co.; Oneida Co.; Patton Lake; Sauk City; Summit Lake, Langlade Co.; Trout Lake, Vilas Co.; Verona; Wausau.

174. *Gueneria basiaria* Walker July 8–11
Florence Co.

175. *Homochlodes fritillaria* Guenée May 28–July 23
Door Co.; Florence Co.; Lake Katherine; Vilas Co.

176. *Tacparia detersata* Guenée May 21–July 8
Florence Co.; Lake Katherine; Madison.

177. *Lozogramma subaequaria* Walker May 19–Aug. 10
Brown Co.; Dane Co.; Florence Co.

178. *Cepphis armataria* Herrich-Schäffer Apr. 21–Aug. 24
Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Milwaukee; Washburn Co.

179. *Plagodis serinaria* Herrich-Schäffer May 22–June 27
Florence Co.; Lake Katherine; Sauk City.

180. *Plagodis keutzingi* Grote July 1–13
Bailey's Harbor; Door Co.; Madison.

181. *Plagodis fervidaria* Herrich-Schäffer May 24–July 5
Bailey's Harbor; Brown Co.; Dane Co.; Door Co.; Sauk City.

182. *Plagodis alcoolaria* Guenée May 17–July 29
Bailey's Harbor; Dane Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Patton Lake; Sauk City; Vilas Co.

183. *Plagodis phlogosaria* Guenée Apr. 30–Aug. 1
Bailey's Harbor; Florence Co.; Lake Katherine; Milwaukee; Sauk City; Trout Lake; Wausau. I have seen typical *phlogosaria, p. keutzingaria* Packard, and *p. purpuraria* Pearsall.

184. *Anagoga occiduaria* Walker May 29–July 12
Bailey's Harbor; Florence Co.; Lake Katherine; Vilas Co.

185. *Hyperetis amicaria* Herrich-Schäffer May 29–Aug. 29
Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Marinette Co.; Milwaukee; Patton Lake; Rush Co.; Vilas Co.; Wausau; Waushara Co.

186. *Hyperetis alienaria* Herrich-Schäffer May 22–July 4
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Milwaukee; "Peaks Lake"; Wausau.

187. *Nematocampa filamentaria* Guenée June 4–Aug. 26
Bailey's Harbor; Florence Co.; Madison; Milwaukee; Rusk Co.; Rust Lake; Sauk City.

188. *Metarranthis hypochraria* Herrich-Schäffer Apr. 13–Aug. 10
Brown Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Marinette Co.; Milwaukee.

189. *Metarranthis broweri* Rupert May 29–July 8
Bailey's Harbor; Dodgeville; Florence Co.; Madison.

190. *Metarranthis apiciaria* Packard May 29
Lake Katherine.

191. *Metarranthis warneri* Harvey June 4–6
Wausau; a paratype ♂ of *M. warneri cappsaria* Rupert collected 4 June, 1932, is from Madison.

192. *Metarranthis duaria* Guenée May 28–June 20
Lake Katherine; Madison; Milwaukee; Vilas Co.; Wausau; Waushara Co.

193. *Metarranthis amyrisaria* Walker May 27–July 4
Bailey's Harbor; Florence Co.; Madison.

194. *Metarranthis angularia* Barnes and McDunnough July 8
Milwaukee.

195. *Metarranthis obfirmaria* Hübner June 30
Milwaukee.

196. *Metanema inatomaria* Guenée May 29–Aug. 15
Bailey's Harbor; Dane Co.; Florence Co.; Lake Katherine; Milwaukee; Rusk Co.; Sauk City; Waushara Co.

197. *Metanema determinata* Walker June 17–Aug. 16
Bailey's Harbor; Florence Co.; Lake Katherine; Milwaukee; Rusk Co.; Summit Lake.

198. *Selenia alciphearia* Walker May 7–June 7
Lake Katherine.

199. *Selenia kentaria* Grote and Robinson Apr. 30–July 22
Florence Co.; La Crosse; Lake Katherine.

200. *Ennomos subsignarius* Hübner June 19–Sept. 10
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee.

201. *Pero honestaria* Walker May 16–Sept. 1
Bailey's Harbor; Brown Co.; Dane Co.; Green Bay; La Crosse; Madison; Milwaukee; Platteville; "Shaw" (probably Shawano) Co.

202. *Pero morrisonaria* H. Edwards May 28–July 9
Dane Co.; Door Co.; Florence Co.; Lake Katherine; Washburn Co.

203. *Pero marmorata* Grossbeck July 29–Aug. 9
Dane Co.; Platteville.

204. *Caripeta divisata* Walker June 23–Aug. 14
Door Co.; Florence Co.; Lake Katherine; N.E. Price Co.; Northern Highlands, Vilas Co.; Trout Lake; Wausau.

205. *Caripeta piniata* Packard May 26–Aug. 5
Lake Katherine; Northern Highlands; Trout Lake; Wausau.

206. *Caripeta angustiorata* Walker June 4–Aug. 6
American Legion State Forest, Oneida Co.; Florence Co.; Lake Katherine; Trout Lake, Vilas Co.; Washburn Co.; Wausau.

207. *Lambdina athasaria* Walker May 13–July 8
Florence Co.; Lake Katherine; Sauk City.

208. *Lambdina fiscellaria* Guenée July 10–Oct. 5
Bailey's Harbor; Columbia Co.; Dane Co.; Ephraim; Lake Katherine; Shanty Bay.

209. *Besma endropiaria* Grote and Robinson June 1–July 15
Bailey's Harbor; Boscobel State Nursery; Florence Co.; Lake Katherine; Madison; Milwaukee; Patton Lake; Sauk City.

210. *Besma quercivoraria* Guenée May 28–Aug. 19
Arlington; Dane Co.; Florence Co.; Green Bay; Griffith State Nursery; Lake Katherine; Madison; Neshkoro; Platteville; Sauk City.

211. *Cingilia catenaria* Drury Aug. 9–Oct. 2
Columbia Co.; Eau Claire; Lake Katherine; Madison; "Peaks Lake."

212. *Cingilia canosaria* Walker July 11–Oct. 10
Bailey's Harbor; Dousman; Lake Katherine; Wausau; Wood Co.

213. *Cingilia pellucidaria* Packard Sept. 7–Oct. 4
Lake Katherine.

214. *Sicya macularia* Harris June 5–Aug. 18
Bailey's Harbor; Door Co.; Florence Co.; Griffith State Nursery; Lake Katherine; Madison; Sauk City; Trout Lake.

215. *Deuteronomos magnarius* Guenée July 30–Nov. 11
Arlington; Bailey's Harbor; Brown Co.; DeForest; Green Bay; Kenosha Co.; Lake Katherine; Madison; Middleton; Milwaukee; "Peaks Lake"; Sturgeon Bay; Trout Lake.

216. *Apicia confusaria* Hübner June 4–Aug. 29
Bailey's Harbor; Brown Co.; Cedar Grove; Door Co.; Dousman; Griffith State Nursery; Madison; Marinette Co.; Milwaukee; Oconto Co.; Sauk City.

217. *Patalene puber* Grote and Robinson Aug. 7
Dane Co.

218. *Tetracis crocallata* Guenée May 29–July 8
Brown Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Sauk City.

219. *Tetracis cachexiata* Guenée Apr. 21–July 29
Bailey's Harbor; Door Co.; Florence Co.; Green Bay; Madison; Milwaukee; Patton Lake; Sauk City; Spooner.

220. *Abbottana clemataria* Abbott and Smith May 14–Sept. 26
Bailey's Harbor; Boscobel State Nursery; Door Co.; Florence Co.; Griffith State Nursery; Lake Katherine; Milwaukee Co.; Patton Lake; Sauk City; Wausau.

221. *Sabulodes thiosaria* Guenée May 29–June 30
Lake Katherine.

222. *Prochoerodes transversata* Drury June 18–Oct. 5
Bailey's Harbor; Ferry Bluff; Florence Co.; Lake Katherine; Madison; Milwaukee; "Peaks Lake"; Rusk Co.; Sauk City; Wausau.

## References


Capps, H. W. 1943. Some geometrid moths of the subfamily Ennominae heretofore associated with or closely related to *Ellopia* Treitschke. Proc. U.S. Nat. Mus. No. 93, pp. 115–151, 10 pls.

Ferguson, D. C. 1969. A revision of the moths of the subfamily Geometrinae of America north of Mexico (Insecta, Lepidoptera). Peabody Mus. Bull. 29, 251 pp., 49 pls.

Fernekes, V. 1906. List of Lepidoptera occurring in Milwaukee County. Bull. Wisconsin Nat. Hist. Soc., vol. 4, nos. 1–2, pp. 39–58.

Fletcher, D. S. 1966. Some changes in the nomenclature of British Lepidoptera. Ent. Gazette, vol. 17, pp. 9–18.

Forbes, W. T. M. 1948. Lepidoptera of New York and neighboring states. Part II. Cornell Univ. Exp. Sta. Mem. No. 274, 263 pp., 255 figs.

McDunnough, J. H. 1938. A check list of the Lepidoptera of Canada and the United States of America, Part 1. Mem. Southern Calif. Acad. Sci., vol. 1, 275 pp.

——— 1949. Revision of the North American species of the genus *Eupithecia* (Lepidoptera, Geometridae). Bull. Amer. Mus. Nat. Hist., vol. 93, art. 8, pp. 537–728, 20 figs., 7 pls.

——— 1954. The species of the genus *Hydriomena* occurring in America north of Mexico (Geometridae, Larentiinae). Bull. Amer. Mus. Nat. Hist., vol. 104, art. 3, pp. 241–358, 185 figs., 3 pls.

Munroe, E. G. 1959. The *phlogosaria* complex of the genus *Plagodis* (Lepidoptera, Geometridae). Can. Ent., vol. 91, pp. 193–208, 63 figs.

Muttkowski, R. A. 1907. Additions to the lepidopterous fauna of Milwaukee County. Bull. Wisconsin Nat. Hist. Soc., vol. 5, no. 2, pp. 128–133.

Rauterberg, F. 1900. List of Lepidoptera of the County of Milwaukee. Bull. Wisconsin Nat. Hist. Soc., vol. 1, no. 2, pp. 111–126.

Rindge, F. H. 1949. A revision of the geometrid moths formerly assigned to *Drepanulatrix* (Lepidoptera). Bull. Amer. Mus. Nat. Hist., vol. 94, art. 5, pp. 235–298, 14 figs.

——— 1954. A revision of the genus *Tornos* Morrison (Lepidoptera, Geometridae). Bull. Amer. Mus. Nat. Hist., vol. 104, art 2, pp. 181–236, 35 figs.

——— 1956. A revision of the American species of *Deilinia* (Lepidoptera, Geometridae). Amer. Mus. Nov. No. 1810, 23 pp., 30 figs.

——— 1964 A revision of the genera *Melanolophia*, *Pherotesia*, and *Melanotesia* (Lepidoptera, Geometridae). Bull. Amer. Mus. Nat. Hist., vol. 126, art. 3, pp. 243–434, 163 figs., 9 pls.

——— 1966. A revision of the moth genus *Anacamptodes* (Lepidoptera, Geometridae). Bull. Amer. Mus. Nat. Hist., vol. 132, art. 3, pp. 177–243, 53 figs.

——— 1967. The North American moths of the genus *Earophila* Gumppenberg (Lepidoptera, Geometridae). Amer. Mus. Nov. No. 2306, 12 pp., 9 figs.

——— 1968. A revision of the moth genus *Stenoporpia* (Lepidoptera, Geometridae). Bull. Amer. Mus. Nat. Hist., vol. 140, art. 2, pp. 67–134, 16 pls.

Rupert, L. R. 1943. A specific revision of the genus *Metarranthis* (Lepidoptera, Geometridae, Ennominae). J. New York Ent. Soc., vol. 51, pp. 133–158, 3 pls.

——— 1949. A revision of the North American species of the genus *Plagodis* (Lepidoptera, Geometridae, Ennominae). J. New York Ent. Soc., vol. 57, pp. 19–49, 5 pls.

# FOUR NEW SPECIES RECORDS OF *SIALIS* (MEGALOPTERA: SIALIDAE) FOR WISCONSIN

*K. J. Tennessen*

There has been very little collecting of adult Megaloptera in Wisconsin since Ross's work on the Sialidae in the 1930's, when he reported finding two species in this state, *Sialis mohri* and *S. velata*. While recording distribution data on the order Megaloptera during the summer of 1968, I found four additional species of *Sialis* that had not been previously recorded from the state. The identifications have been confirmed by Dr. Ross. The new records are as follows:

*Sialis vagans* Ross. Twelve males and six females of this species have been taken, as it appears to be quite common, especially in the north-central area. Collection dates range from June 2 in the south to June 20 in the north.

County Records—Clark, Dane, Forest, Polk, Price, Taylor, Washburn, Waukesha, Waushara.

*Sialis itasca* Ross. Three males were taken, and the species appears to be as widespread as *S. velata*. The collection dates, June 10 and 20, indicate that this species emerges comparatively late in the seasonal succession of species.

County Records—Bayfield, Florence, Jefferson.

*Sialis infumata* Newman. Only two males of this species have been collected, one each from two central counties, indicating that it may not be as common as the former species. The collection date was June 5.

County Records—Clark, Wood.

*Sialis americana* (Rambur). Three males and seven females were collected on June 12 near the Mississippi River in Grant County. The surrounding area was quite unique, like a lagoon, and therefore this species most likely does not occur much further inland due to a habitat restriction. Adults were present in fair abundance. The collection date suggests a comparatively late emergence period.

County Record—Grant.

In addition, the following new county records were found for the two previously reported species:

*Sialis mohri* Ross. Kenosha County, Racine County.

*Sialis velata* Ross. Winnebago County.

The specimens are in the University of Wisconsin collection. Future collecting, especially early in May and June, will undoubtedly discover new county records as larvae have been found in a large number of streams and lakes; but as there is yet no key separating the larvae, species determinations must rely on adults.

## References Cited

Ross, H. H. September, 1937, Studies of Nearctic Aquatic Insects. *Illinois Natural History Survey Bulletin.* 21:57–78.

The research was carried out when the author was an undergraduate student at the University of Wisconsin, Madison.

# JUNCUS EFFUSUS. I. THE SITUATION IN WISCONSIN

*Seymour H. Sohmer*

*Juncus effusus* is a species with world-wide distribution (Weimark, 1946). It is a relatively hardy perennial and can withstand considerably more abuse than most of the other species in the genus. Postgalacial conditions in Wisconsin may have been ideal for colonizing elements of the species. Indeed, such was probably the case wherever land was uncovered by the melting ice. It is believed, in this regard, that colonizing elements from disjunct populations of the species may have entered Wisconsin after the last retreat of the ice (Iltis, 1968).

As would be expected of a species with a wide distribution, the variations of form in *Juncus effusus* are numerous. Many variations have been described for North America, and many more could probably be named. The difficulty and confusion here is the same as in other widely distributed species, in that there are as many opinions regarding the basis for the delimitation of these varieties as there are taxonomists involved. The hopeful goal in these situations is a compromise between taxonomic conservatives and radicals. Certainly there are more variations in this species that can be easily delimited from one another on a general and practical basis than Gleason (1952) would recognize, but probably less than the number of varietal names presently available. One should strive to avoid carrying the recognition of variations too far. In such a case the logical conclusion is ultimately to describe and name *all* variation present. This is not only cumbersome and impractical, but the same variation may not be present some years hence—even disregarding the destructiveness of man to his environment. A great deal of the individual variation may be due more to environmental differences than genetic ones. (Snogerup, 1963. Sohmer, unpublished). A method of dealing with such a situation is shown by Davidson and Dunn (1967).

The varietal names listed below are presently available to describe the variations of *Juncus effusus* in North America. It is pointed out that though some of these varietal names may not be valid, in the author's opinion, they will be used to describe the species in Wisconsin where applicable. The question of validity may be determined at a future date by systematic work now underway in the author's laboratory.

Var. *compactus* Lejeune et Courtois Fl. Belg. ii. 23 (1831), also see Fernald and Wiegand (1910).
Var. *conglomeratus* Engelm. in Gray, Manual, ed. 5, (537, 1867), also see Fernald and Wiegand (1910).
Var. *decipiens* Buchenau in Engler's Bot. Jahrb. Xii. 229 (1890), also see Fernald and Wiegand (1910).
Var. *exiguus* Fernald and Wiegand (1910).
Var. *gracilis* Hooker, Fl. Bor. Am. ii 190 (1840).
Var. *brunneus* Engelm., Trans. St. Louis Acad. ii. 491 (1868). According to Fernald and Wiegand (1910) *Juncus effusus* var. *hesperius* Piper is synonomous with this.
Var. *pacificus* Fernald and Wiegand (1910).
Var. *caeruleomontanus* St. John (1931).
Var. *solutus* Fernald and Wiegand (1910).
Var. *pylaei* (Laharpe) Fernald and Wiegand (1910).
Var. *costulatus* Fernald (1922).

In Wisconsin the species demonstrates a considerable amount of individual variation, principally within the variety *pylaei.* This variation, however, does not appear spatially related to given areas.

The information concerning the species in Wisconsin that will be presented here has come through study of the specimens available from the herbaria of the Universities of Wisconsin and Minnesota as well as the Milwaukee Public Museum. The variable characters measured were: culm length; number of flowers per inflorescence; length of bract subtending the inflorescence (but in the species appearing as a continuation of the culm); width of culm above the sheath; length of perianth parts; length of capsule; and length of seed. Figure 1 illustrates the distribution of the species in Wisconsin as revealed by the specimens mentioned above. There are reports from 45 counties. Among the specimens available the sepals were found to exceed the petals in most cases. The length of the former ranged from 1.9 mm (N. C. Fassett #22676, Chippewa County) to 3.9 mm (H. Brawn #69228, Forest County). The correlation between sepal and petal length is illustrated in figure 4. Figures 2 and 3 illustrate the occurrence of petal and sepal variability by county within the state.

There were no significant differences observed in the length or the shape of the seeds. They were found to vary between .5 and .6 mm in length and were generally fusiform.

The bracts varied between 6 cm (D. F. Grether #6855, Jackson County), and 38 cm (R. Melville #397). The latter was two-thirds the length of the culm itself.

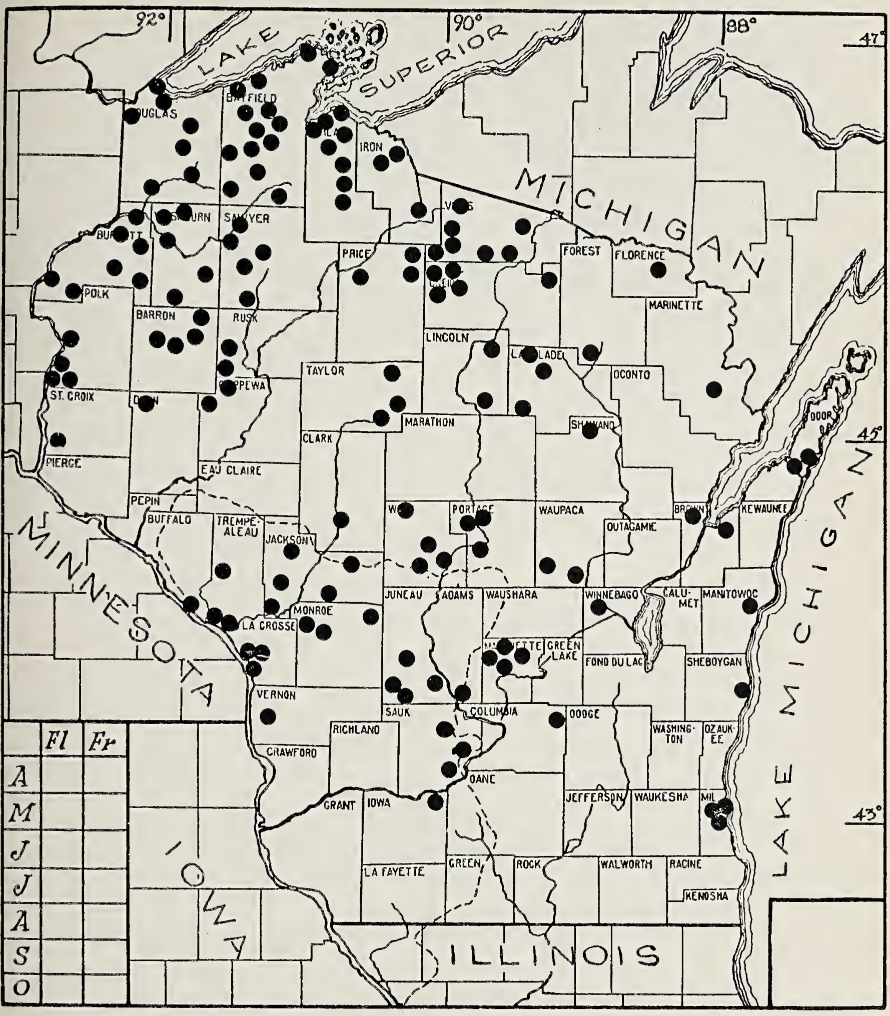
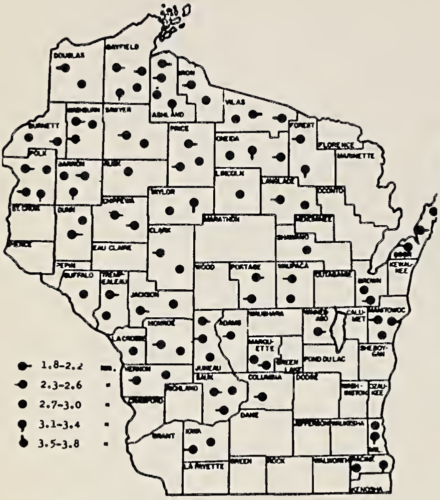
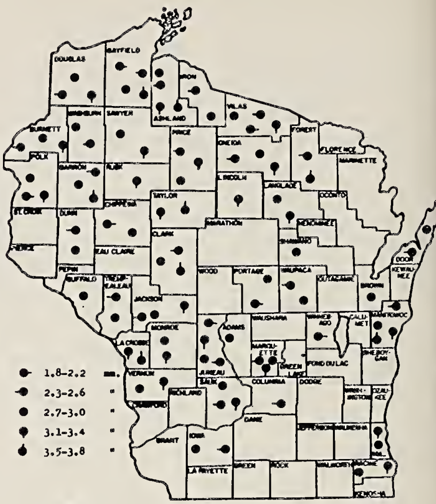



FIGURE 1. Distribution of *Juncus effusus* in Wisconsin. Each symbol represents an individual. Information from herbarium specimens of the University of Wisconsin, University of Minnesota, and the Milwaukee Public Museum. Map provided by H. Iltis.

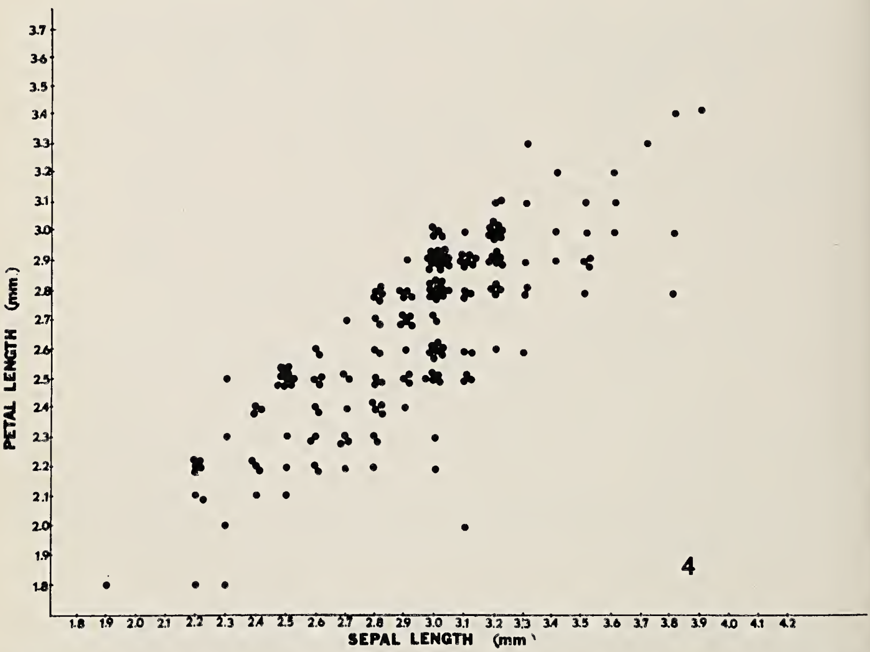
The most striking variability is expressed in the length of these culms and the number of flowers per inflorescence. Only mature plants with intact culms and inflorescences were utilized. The length of these culms in mature specimens was found to vary from 25 cm (L. S. Cheney, #1068, Oneida County) to 118 cm (N. C. Fasset, #16190, Oneida County). It is interesting to not that the minimum and maximum lengths examined occurred in populations within




2




3




4

FIGURES 2 and 3. Spatial relationships of artificial groupings of petal and sepal lengths by county within Wisconsin. Each symbol represents one or more individuals within each county whose specific character attributes fall into the artificial groups shown. 2-petal lengths; 3-sepal lengths.

FIGURE 4. Scatter diagram illustrating the correlation between petal and sepal lengths. Each symbol represents an individual.

TABLE 1. VARIABILITY IN CULM LENGTH AND FLOWER NUMBERS IN WISCONSIN REPRESENTATIVES OF *Juncus Effusus*

| CULM LENGTH (185 SPECIMENS) | | FLOWER NUMBER (183 SPECIMENS) | |
|---|---|---|---|
| Length (in cm) | % of Plants | No. of Flowers | % of Plants |
| 31 | 6 | 21 | 6 |
| 31 to 50 | 27 | 21 to 60 | 28 |
| 51 to 70 | 40 | 61 to 100 | 39 |
| 71 to 90 | 17 | 101 to 200 | 17 |
| 90 | 10 | 200 | 10 |

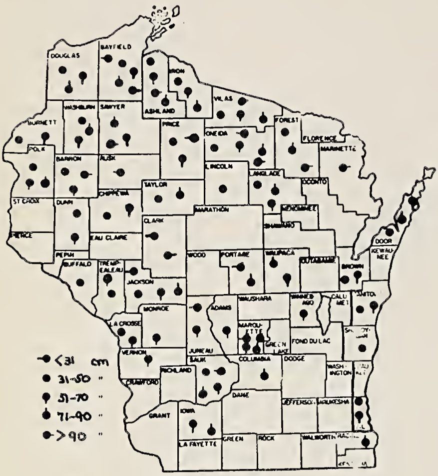
the same county. The number of flowers was found to vary from 11 (H. H. Iltis, #6882, Juneau County) to 370 (C. Gossel #1393, Clark County) per inflorescence. Table 1 illustrates the proportions of the individuals studied that fall into artificial groups based on culm length and flower number.

There does not appear to be a relationship between the number of flowers per inflorescence and location within the state. This is shown in Figure 6. Nor is there an apparent relationship between culm length and location. The shortest and tallest plants, on the basis of the specimens available, seem to have equal probability of occurring anywhere in the state. This is illustrated in Figure 5. The correlation between culm length and the number of flowers per inflorescence is illustrated in Figure 7.

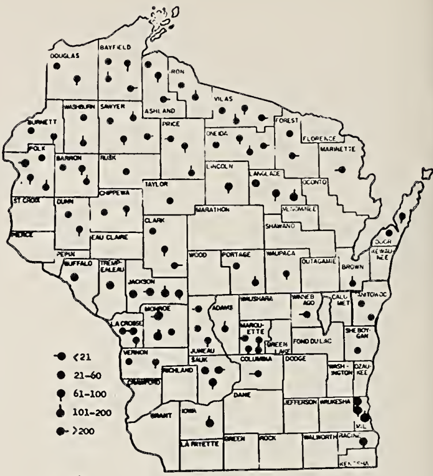
The varieties *pylaei* and *solutus* are found within the state, with the former much more frequent. There is also a dubius report for var. *costulatus* from Lincoln county. Most members of variety *solutus* appear in the northeastern part of the state, with scattered reports elsewhere. Some individual examples of *Juncus effusus* are shown in figures 8–12. Figure 13 represents the distribution of these varieties within the state by county.

## SUMMARY

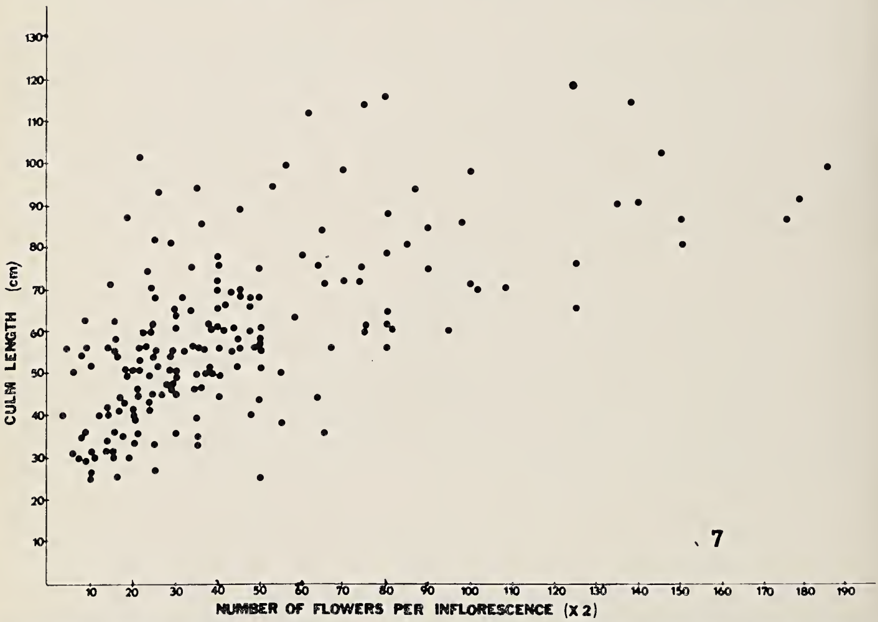
Specimens of *Juncus effusus* from the herbaria of the Universities of Wisconsin and Minnesota, and the Milwaukee Public Museum were studied with regard to the kind of variation present. It appears that two varieties are established in the state (*pylaei* and *solutus*) and possibly a third (*costulatus*). There is a considerable amount of individual variation within the delimited varieties, which is not, however, apparently correlated with space within the state of Wisconsin.




5 Culm length

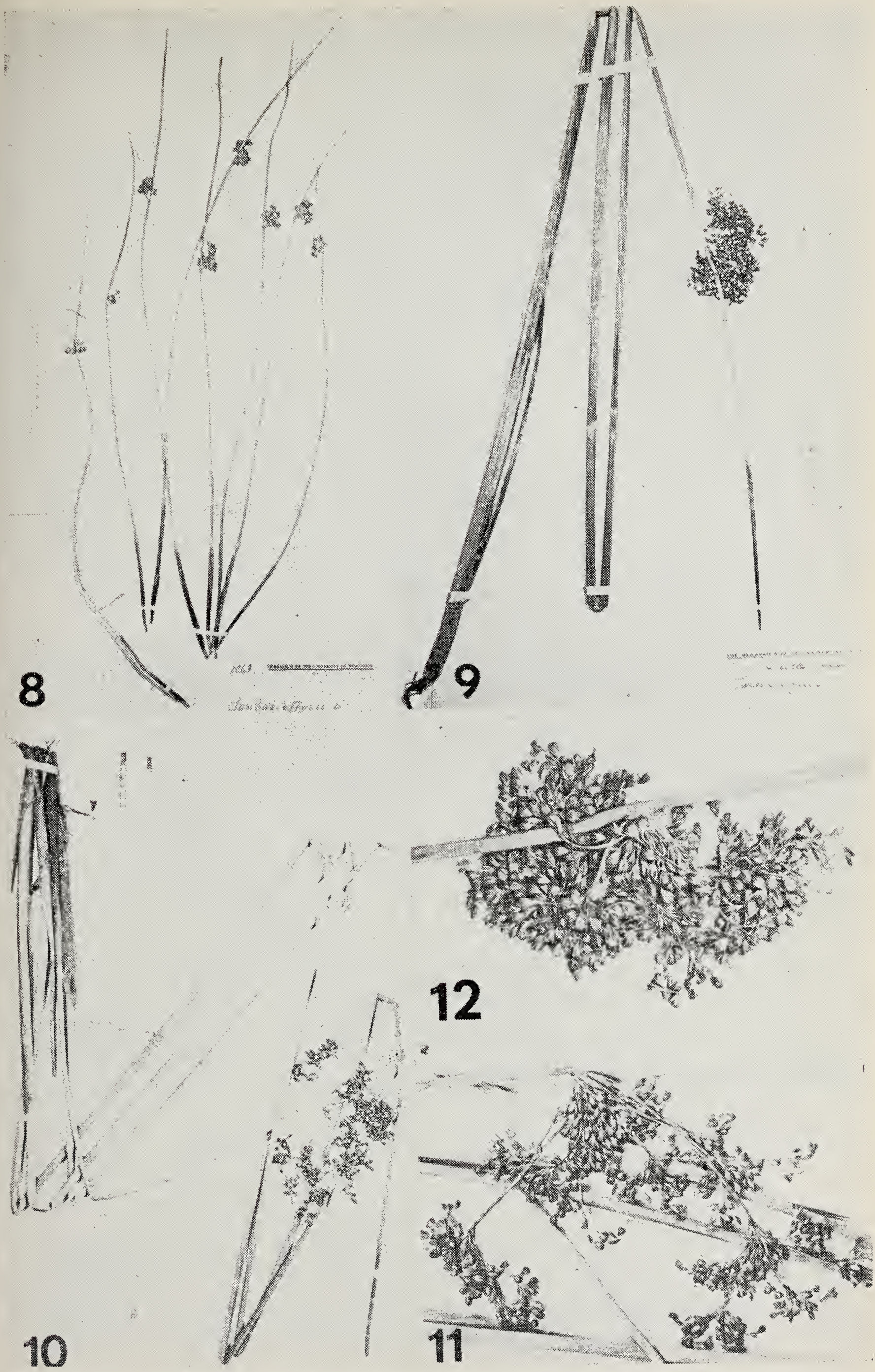



6 No. of flowers




FIGURES 5 and 6. Spatial relationships of the variability present in the length of culm and number of flowers per inflorescence respectively. Each symbol represents at least one individual within each county whose specific character attribute falls into an artificial group as shown.

FIGURE 7. Scatter diagram illustrating the relationship between culm length and number of flowers per inflorescence. Each symbol represents an individual.



FIGURES 8–12. Examples of variation in *Juncus effusus* in Wisconsin. 8-Var. pylaei, L. S. Cheney #1068, Oneida Co.; 9-Var. solutus, N. C. Fassett #16190, Oneida Co.; 10-Var. solutus, N. C. Fassett #5699, Ashland Co.; 11-close-up of inuorescence of plant in figure 10; 12-close-up of inflorescence of plant in figure 9.

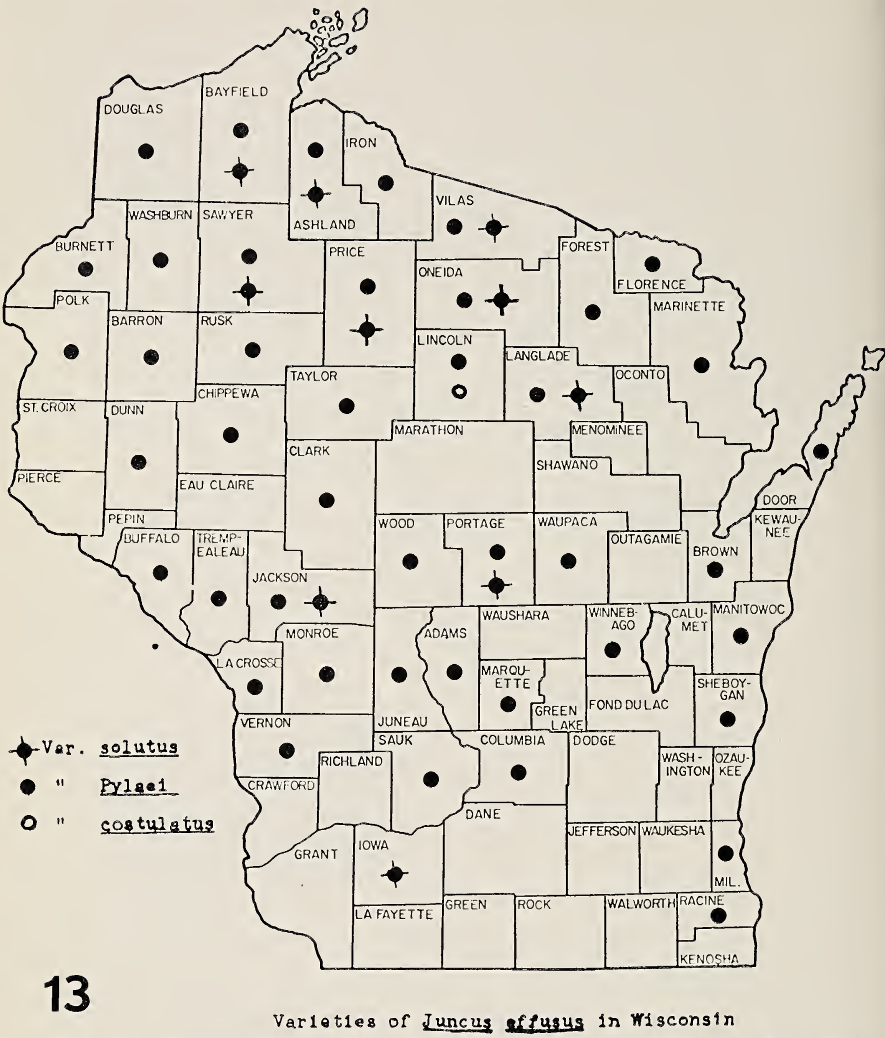



FIGURE 13. Distribution of the varieties recognized in Wisconsin. Each symbol represents at least one report for the variety within a county.

## ACKNOWLEDGEMENTS

The aid of Dr. H. H. Iltis, curator of the Herbarium, University of Wisconsin, Madison, in obtaining specimens for study and his advice are gratefully acknowledged. The monetary aid, in part, of the institutional Studies and Grants Committee of Wisconsin State University, La Crosse, is also gratefully acknowledged here. This aid has permitted the use of student assistance and helped defray the cost of an extensive field trip.

## References Cited

Davidson, Robert A. and Rosalie A. Dunn, 1967. A correlation approach to certain problems of population-environment relations. American Journal of Botany 54(5): 529–538.

Fernald, M. L. and K. M. W|57(&4, 1910. The North American vacations of *Juncus effusus*. Rhodora 12(137): 81–93.

Fernald, M. L., 1922. Expedition to Nova Scotia. Rhodora 23: 239.

Gleason, H. A., 1952. The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. Volume I, page 388 New York Botanical Garden, New York.

Hartley, Thomas G., 1966. The Flora of the "Driftless" Area. The University of Iowa Studies in Natural History 21(1): 1–174.

Iltis, Hugh H., 1968. Personal communication regarding the possible movements of certain plants after the last glaciation.

Snogerup, Sven, 1963. Studies in the genus *Juncus* III. Observations on the diversity of chromosome numbers. Botanisk Notiser 116(2): 142–145.

St. John, Harold, 1931. New and noteworthy Northwestern plants, part 5. Research Studies, State College of Washington.

Weimarck, H. 1946. Studies in Juncaceae. With special reference to the species in Ethiopia and the Cape, Svensk Botanisk Tidskrift 40(2): 141–178.

# GROWTH POTENTIAL OF WISCONSIN NATIVE PINES ON WEED-INVADED SOILS[1]

*S. A. Wilde*

*"No knowledge can be rated as science unless it is anchored in mathematics."*—René Descartes

A reasonably reliable prediction of the outcome of tree planting can seldom be made without an appraisal of the growth-depressing effect of competing ground vegetation. In most cases, the amount of water and nutrients taken away from trees by ground cover plants is closely related to their biomass, the oven-dry weight of tops and roots. Knowledge of this factor is essential for determination of the expected yield of trees to be planted, for establishment of suitable tree spacing, and for estimate of the cost of either chemical or mechanical eradication of weeds.

This paper reports a method for determination of the biomass of weed cover and the expected yield of plantations of Wisconsin native pines, *Pinus banksiana, P. resinosa,* and *P. strobus.*

## Determination of Expected Site Index

The expected site index of the proposed plantation is established on the basis of determination of four soil constituents (Wilde *et al.,* 1964): fine earth (F), organic matter (H), available phosphorus ($P_2O_5$), and available potassium ($K_2O$). The site index of the stand or the average height of a stand at 50 years (I) is obtained by solution of the following simplified regression equation, adjusted to meet requirements of the three native pines of Wisconsin.

$$I = (8.1 + 0.2\ F\% + 2.3\ H\% + 0.03\ P_2O_5\ \text{lbs/a} + 0.01\ K_2O\ \text{lbs/a}) \times 3.4$$

An application of this equation may be illustrated by an appraisal of Plainfield sand, a widely distributed non-podzolic soil of Wisconsin glacial outwash. Let us assume that this soil of the proposed planting site has the following composition: fine earth (silt and clay particles)—9%, organic matter—2%, available $P_2O_5$

---

[1] Contribution from Soil Science Department, University of Wisconsin, in cooperation with and supported in part by the Wis. Dept. of Natural Resources. Publication approved by the Director of the Wis. Agr. Exp. Sta., Madison, Wis.

—40 pounds per acre, and available potassium—100 pounds per acre. Consequently:

$$I = (8.1 + 0.2 \times 9 + 2.3 \times 2 + 0.03 \times 40 + 0.01 \times 100) \times 3.4 = 56.8 \text{ feet}$$

The site index corresponds to definite yields of timber produced at various ages by different tree species. Thus, for the calculated site index of about 57, the volumes expected at the end of a short, 40-year rotation would be 30 cords for jack pine, 34 cords for red pine, and at best 20 cords per acre for white pine. Because 0.7 cords per acre is the minimum average annual increment, promising under Wisconsin conditions a reasonable financial return, the calculation indicates that the analysed soil has a too low productive potential for planting white pine.

The equation under discussion was derived from analyses of nonphreatic sandy soils of Wisconsin supporting about 300 plantations of jack pine, red pine, and white pine of different site indices and of age range from 15 to 37 years (Wilde *et al.*, 1965). The disclosure of an intimate correlation between growth of forest stands and physico-chemical properties of soils, rendered by this equation, presents a remarkable by-product of recent progress in soil analysis, forest mensuration, and statistics.

The degree of the equation's reliability can be inferred from Tables 1 and 2, incorporating the average results of soil and timber analyses published in 1965 (Lit. cit.). A substitution of these results into the equation and subsequent comparison of calculated site indices with those reported in yield tables (Wackerman *et al.*, 1929, for jack pine; Wilde *et al.*, 1964 for red pine; Gevorkiantz

TABLE 1. AVERAGE STATE OF SOIL FERTILITY FACTORS OF SOILS SUPPORTING JACK PINE, RED PINE, AND WHITE PINE OF DIFFERENT SITE INDICES (AFTER WILDE *et al.*, 1965).

| Tree Species and Site Index | Reaction pH | Silt + Clay Percent | Org. Matter Percent | Avail. $P_2O_5$ Lbs./Acre | Avail. $K_2O$ Lbs./Acre |
|---|---|---|---|---|---|
| Jack pine, low | 4.9 | 6.9 | 0.86 | 21.0 | 54.8 |
| Jack pine, medium | 5.1 | 9.4 | 1.80 | 62.8 | 80.0 |
| Jack pine, high | 5.0 | 10.0 | 2.10 | 72.0 | 91.4 |
| Red pine, low | 5.0 | 7.3 | 1.22 | 47.2 | 77.8 |
| Red pine, medium | 5.1 | 8.5 | 1.37 | 59.0 | 87.5 |
| Red pine, high | 5.1 | 12.5 | 2.11 | 85.2 | 134.2 |
| White pine, medium | 5.1 | 13.7 | 2.90 | 51.0 | 70.0 |
| White pine, high | 4.8 | 26.7 | 3.20 | 83.0 | 90.0 |

TABLE 2. AVERAGE GROWTH OF JACK PINE, RED PINE, AND WHITE PINE PLANTATIONS ON SOIL OF DIFFERENT PRODUCTIVITY RATINGS; AS GIVEN IN TABLE 1 (AFTER WILDE *et al.*, 1965).

| Tree Species and Site Quality | Age Yrs. | Ave. Ht. Ft. | Ht.: Age Ins. | Ave. DBH Ins. | Stems No./A. | Basal Area Sq. Ft./A. | Volume Cu. Ft./A. |
|---|---|---|---|---|---|---|---|
| Jack pine, low........ | 22 | 22.0 | 12 | 3.4 | 1,241 | 74 | 473 |
| Jack pine, medium ... | 24 | 30.5 | 15 | 4.1 | 1,177 | 107 | 1,106 |
| Jack pine, high....... | 23 | 38.6 | 20 | 4.6 | 1,029 | 117 | 1,589 |
| Red pine, low......... | 23 | 21.3 | 11 | 4.0 | 1,282 | 101 | 688 |
| Red pine, medium.... | 21 | 27.5 | 15 | 4.8 | 978 | 117 | 1,300 |
| Red pine, high....... | 20 | 32.9 | 19 | 5.1 | 1,054 | 136 | 1,960 |
| White pine, medium.. | 24 | 28.6 | 14 | 5.7 | 648 | 118 | 1,420 |
| White pine, high..... | 24 | 39.3 | 19 | 6.6 | 627 | 136 | 2,257 |

and Zon, 1930, for white pine) give a picture of a rather astonishing accuracy (Table 3).

Nearly all deviations of calculated values from those given in the yield tables are well within experimental error. The maximum deviation of the calculated site index for jack pine of low site quality (3 feet) is due to the deficiency of organic matter in soils of this group and the presence of a large fraction of nutrients in the form of silicate minerals which are decomposable by mycorrhizal rootlets, but not by weak extracting solutions (Wilde and Iyer, 1962; Spyridakis *et al.*, 1967).

## DETERMINATION OF THE BIOMASS OF WEED COVER

The average weight of tops and roots of weeds is determined by excavating entire plants on several 1/10,000 acre plots (2.1 by 2.1 foot squares). Sampling is done at random, and the number of samples required for obtaining an acceptable standard deviation depends on type of soil and nature of ground cover. In many instances a half dozen sampled quadrats are sufficient for an area as large as 40 acres.

The obtained information facilitates in reaching a decision on tree spacing most advantageous with regard to potential site index, biomass of weeds, species and age of trees to be planted, and other conditions (Wilde *et al.*, 1968).

Next, the tree planter must establish the approximate age of the plantation (n) at which the biomass of weeds (b) will be reduced to the harmless level of less than 2 tons per acre. The total of the

TABLE 3. RELATION BETWEEN THE PREDICTED AND ACTUAL SITE INDICES.

| Tree Species | Site Indices | | Deviation in 50 Year Height Growth Feet |
|---|---|---|---|
| | Calculated from the Equation | Determined from the Yield Tables | |
| Jack pine | 43 | 46 | −3 |
| | 57 | 55 | +2 |
| | 61 | 62 | −1 |
| Red pine | 49 | 48 | +1 |
| | 53 | 55 | −2 |
| | 65 | 65 | 0 |
| White pine* | 67 | 69 | −2 |
| | 82 | 82 | 0 |

*A large number of white pine of low site quality were underplantings suppressed in growth by overhead canopy of aspen and were excluded from statistical analysis. As should be expected, both the calculated and actually determined height growth of white pine plantations on fertile soils by far exceeded the maximum of the yield tables obtained largely on the basis of indigenous stand of this tree (75 feet at the age of 50 years), which undoubtedly lost a fraction of their height increment in the struggle with weeds and volunteer trees.

biomass (G), present in the plantation through the years, is then determined from the formula:

$$G = 0.7\ bn$$

For trees with heavy crowns, such as red pine, growing on fertile soils at a spacing of 4 by 4 feet, the n period is about 15 years. However, at 6 by 6 foot spacing this period is extended to approximately 25 years.

With weed cover of blueberries, sweet fern, and other heath plants weighing 10 metric tons per acre, total biomass of a 4 by 4 foot red pine plantation would be:

$$G = 10{,}000 \times 0.7 \times 15 = 105{,}000\ \text{kg/a}$$

A similar calculation for a red pine plantation, established at a spacing of 6 by 6 feet, gives the active weed biomass of 175,00 kg/a.

## DETERMINATION OF THE LOSS OF TIMBER VOLUME DUE TO COMPETITION OF WEED COVER

Evapotranspiration of weeds consumes under Wisconsin conditions approximately 85 kg of water per kilogram of oven-dry biomass (Wilde *et al.*, 1968). On the other hand, production of one kilogram of merchantable wood, having specific gravity of 0.32–0.35, requires close to 1,200 kg of transpiration water (Wilde, 1967;

Shaw *et al.*, 1968). Therefore, the loss of timber (L) is expressed by the formula:

$$L = \frac{85\ G}{1200} = 0.07\ G$$

Assuming active weed biomass of a 6 by 6 foot red pine plantation to be equal to 175 m.t. per acre, the loss of timber would be:

$$L = 175{,}000 \times 0.07 = 12{,}250 \text{ kg/a}$$

This weight of oven-dry wood of specific gravity 0.35 approaches 14 cords.

In the event calculated site index of the proposed plantation is 60, the expected maximum yield of fully stocked stand at the end of a 40-year rotation should be 40 cords per acre. Actually in our case the volume is likely to be 40 — 14 or 26 cords.

The given calculation, featuring 35% loss of merchantable timber, is based on observations in Wisconsin. In this state tree planting on weed-invaded soils was usually accomplished by plowing deep and wide furrows which greatly reduce adverse effects of weed competition. On the other hand, losses of timber volume exceeding 50% were recorded in our study in plantations established without adequate ground preparation.

Competing vegetation deprives trees not only of water but also of nutrients. However, this loss is of a temporary nature; suppression of weeds by tree crowns in time returns nutrients to the plantations cycle via mineralization of plant remains.

## Summary

The productive potential of planting sites for *Pinus banksiana*, *P. resinosa*, and *P. strobus* is predicted on the basis of soil analysis, simplified regression equation, and biomass of weeds. Under local conditions pine plantations require about 1,200 kg of water to produce 1 kg of merchantable wood of approximate specific gravity of 0.35, whereas evapotranspiration of ground vegetation consumes circa 85 kg of water per kg of oven-dry tissues. In turn, each kg of weed biomass present in the plantation through the years reduces production of merchantable wood by 0.07 kg. At this rate, plantations established on soils with a heavy cover of heath plants may suffer within a 40-year rotation a loss of timber exceeding 15 cords per acre.

## References

Gevorkiantz, S. R., and R. Zon. 1930. Second-Growth White Pine in Wisconsin. Wis. Agr. Exp. Sta., Res. Bull. 98. Madison, Wisconsin.

Shaw, B. H., R. R. Maeglin, and S. A. Wilde. 1968. Soil water supply—its consumption by forest stands and weed cover. Adv. Frontiers of Plant Sci. 21:141–155.

SPYRIDAKIS, D. E., G. CHESTERS, and S. A. WILDE. 1967. Kaolinization of biotite as a result of coniferous and deciduous seedling growth. Soil Sci. Soc. Proc. Amer. 31:203–210.

WACKERMAN, A. E., R. ZON, and F. G. WILSON. 1929. Yield of Jack Pine in the Lake States. Wis. Agr. Exp. Sta., Res. Bull. 90. Madison, Wisconsin.

WILDE, S. A. 1967. Production of energy material by forest stands as related to supply of soil water. Acta for. fenn. 1,2:31–44.

WILDE, S. A., A. GIORDANO, B. H. SHAW, A. W. FEDKENHEUER, and W. T. SEIP. 1968. Tree Spacing in Forest Plantations as Related to Soils and Revenue. Coll. of Agr. and Life Sciences, Univ. of Wis., Bull. 589. Madison, Wisconsin.

WILDE, S. A., and J. G. IYER. 1962. Growth of red pine *(Pinus resinosa)* on scalped soils. Ecology 43:771–774.

WILDE, S. A., J. G. IYER, CH. TANZER, W. L. TRAUTMANN, and K. G. WATTERSTON. 1964. The growth of red pine *(Pinus resinosa,* Ait.) plantations in relation to fertility of non-phreatic sandy soils. For. Science 10:463–470.

WILDE, S. A., J. G. IYER, CH. TANZER, W. L. TRAUTMANN, and K. G. WATTERSTON. 1965. Growth of Wisconsin Coniferous Plantations in Relation to Soils. Univ. of Wisconsin, Res. Bull. 262. Madison, Wisconsin.

WILDE, S. A., B. H. SHAW, and A. W. FEDKENHEUER. 1968. Weeds as a factor depressing forest growth. Weed Res., 8:196–204.

WILDE, S. A., G. K. VOIGT, and J. G. IYER. 1964. Analysis of Soils and Plants for Tree Culture. Oxford Books Co., New Delhi, India.

# CORIXIDAE (WATER BOATMEN) OF WISCONSIN[1]

*William L. Hilsenhoff*[2]

In 1948 H. B. Hungerford published his monumental monograph on the Corixidae of the Western Hemisphere, which included a monograph on the *Trichocorixa* by R. I. Sailer. In it are keys, descriptions and the recorded distribution for all the known species. Numerous collection records were listed from the four states that border Wisconsin, especially from Michigan and Minnesota, but records from Wisconsin were meager, with only 23 species reported from this state.

In November and December of 1965, large aggregates of corixids were collected from the Wisconsin River and its tributaries. These were mixtures of several species, many of which had not previously been reported from Wisconsin. Subsequent sampling showed that these aggregates occurred only in the late fall, when corixids apparently congregate in the larger streams to spend the winter. These aggregates often contained 15 or more species, with one collection from the St. Croix River in Douglas County on November 20, 1968, containing 23 different species.

Since it was obvious that Wisconsin's Corixidae were largely unknown, an effort was made to collect Corixidae from all areas of the state in 1968, with a special emphasis on collecting from larger streams in October and November to take advantage of the large aggregations of wintering individuals. Collections were made in all counties, but some counties were sampled more thoroughly than others, or were sampled at times more advantageous for collecting corixids. From 1962 through 1968, nearly 22,000 corixids were collected and identified, and of the 47 species that were collected, 25 are new records for the state. All specimens were preserved in 70% ethanol and have been deposited in the University of Wisconsin Insect Collection, along with detailed collection data.

Keys to the Wisconsin species, maps of their distribution, comments on their distribution, abundance, and identification, and a

[1] Approved for publication by the Director of the Wisconsin Agricultural Experiment Station. Research supported in part by a grant from the Wisconsin Department of Natural Resources.

[2] Department of Entomology, University of Wisconsin, Madison 53706.

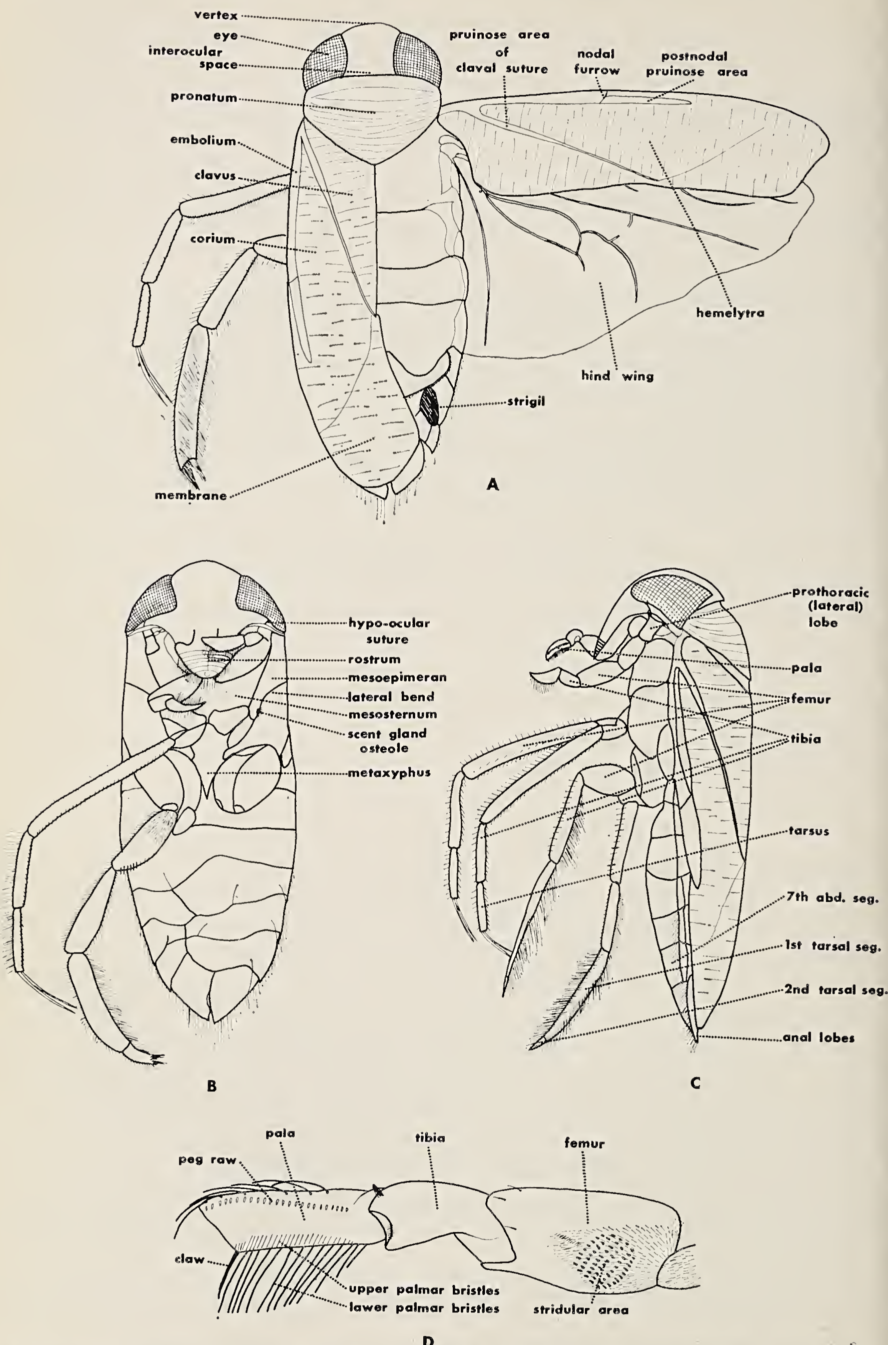



FIGURE 1. *Hesperocorixa obliqua* (modified from Hungerford 1948). A. Dorsal view of male. B. Ventral view of male. C. Lateral view of female. D. Foreleg of male.

summary of the collection records are reported below. The keys are adapted from those of Hungerford (1948), Sailer (1948), and Brooks and Kelton (1967). Figure 1 illustrates the morphological terms used in these keys. Records of previous collections from Wisconsin and from its neighboring states are summarized from Hungerford (1948) and Sailer (1948), since there have been no records published for these states since 1948. Descriptions and illustrations of the various species are not included, because Hungerford and Sailer have thoroughly described and illustrated all of the species.

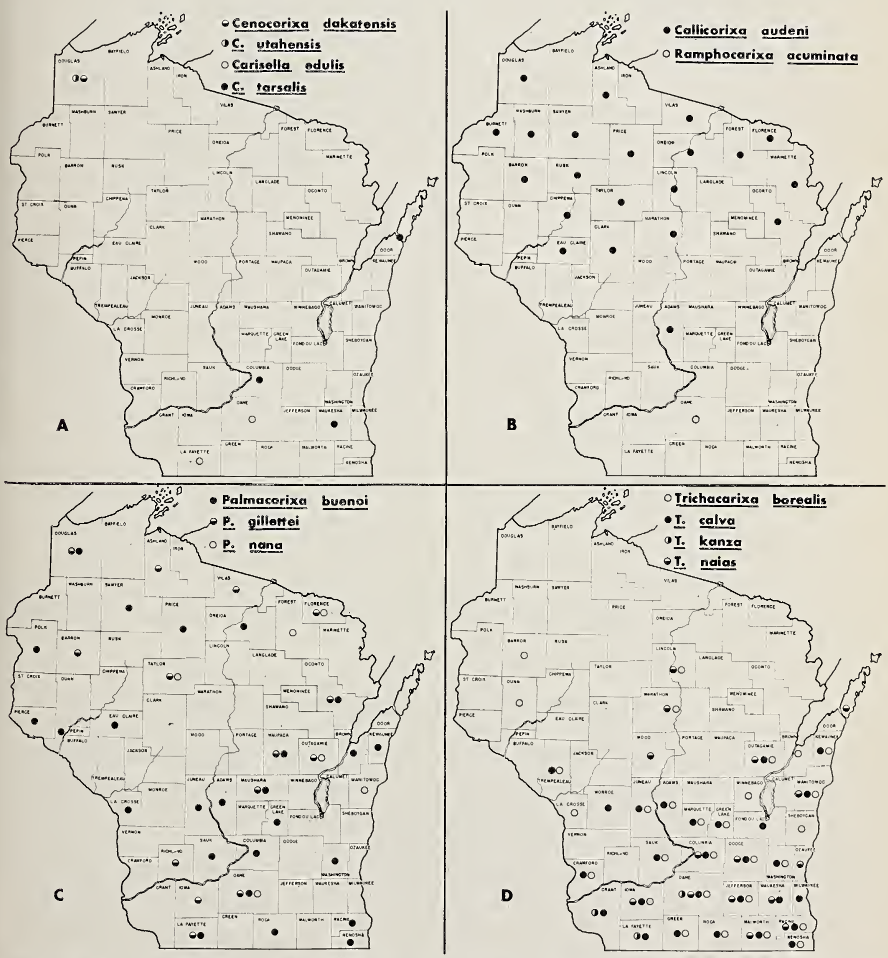



FIGURE 2. Collections of Wisconsin Corixidae, 1962–1968, of the genera *Callicorixa, Cenocorixa, Corisella, Palmacorixa, Ramphocorixa,* and *Trichocorixa.*

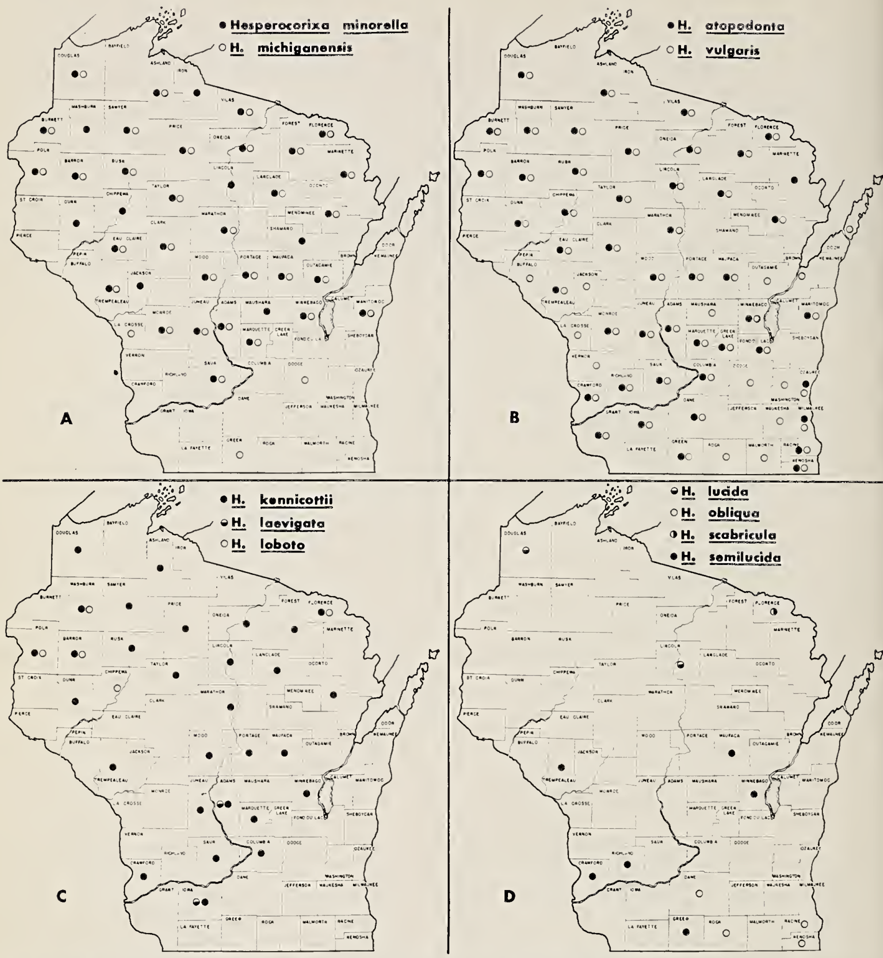



FIGURE 3. Collections of Wisconsin Corixidae, 1962–1968, of the genus *Hesperocorixa.*

## KEY TO WISCONSIN GENERA

1. Rostrum without transverse grooves; pronotum without transverse dark bands ................................ *Cymatia*
   Rostrum with transverse grooves; pronotum with transverse bands although they may be indistinct ................................ 2
2. Entire hemelytral pattern usually effaced; upper surface of male pala deeply incised; vertex of male acuminate; both sexes with palar claw serrate at base; less than 5.5 mm long .. *Ramphocorixa*
   Hemelytral pattern distinct, although limited areas may be effaced in some species ................................ 3

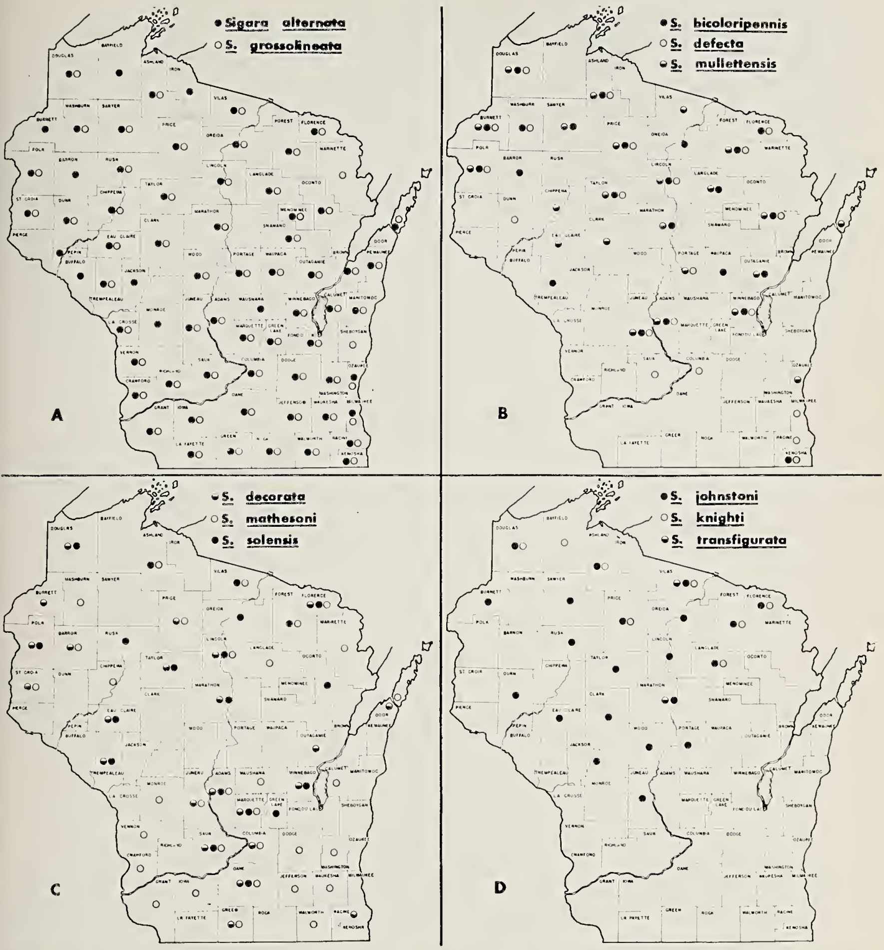



FIGURE 4. Collections of Wisconsin Corixidae, 1962–1968, of the genus *Sigara*.

3. Small shining corixids, the males with sinistral asymmetry; apex of clavus not, or scarcely, exceeding a line drawn through costal margins at nodal furrows ________________________*Trichocorixa*
Male asymmetry dextral; apex of clavus plainly exceeding a line drawn through costal margins at nodal furrows ____________4

4. Pruinose area at base of claval suture short and broadly rounded at apex, usually about ⅔ as long as postnodal pruinose area; prothoracic lobe truncate ____________________*Hesperocorixa*
Pruinose area at base of claval suture narrowly rounded or pointed at apex and almost as long as postnodal pruinose area; prothoracic lobe rounded _______________________________5

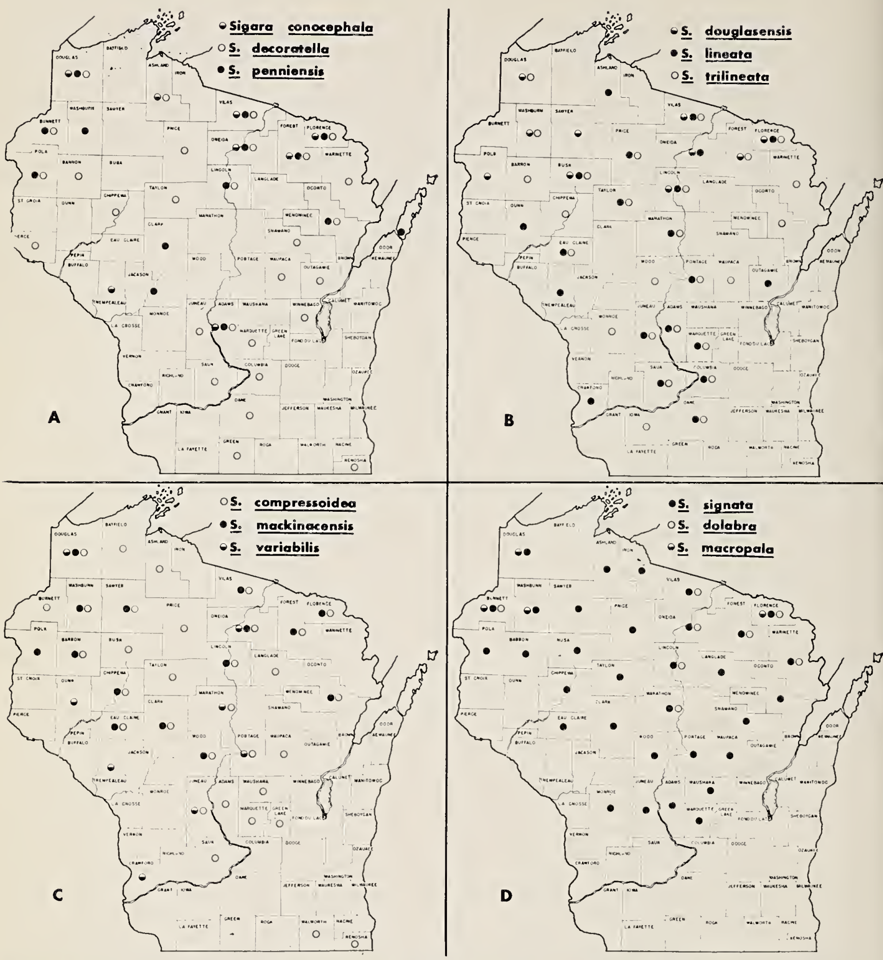



FIGURE 5. Collections of Wisconsin Corixidae, 1962–1968, of the genus *Sigara*.

5. Markings on clavis transverse, those on corium transverse, longitudinal, or reticulate ______________________________6
   Markings on clavus and corium narrow and broken, usually open reticulate with many interconnections ______________7

6. Corial pattern transverse and with little contrast; male strigil absent; male pala with two rows of pegs __________*Callicorixa*
   Corium usually with contrasting pattern, either transverse, longitudinal, or reticulate; male strigil present; male pala with one row of pegs (2 exceptions) ______________________*Sigara*

7. Rear margin of head sharply curved, embracing a very short pronotum; interocular space much narrower than the width of an eye ---------------------------------------- *Palmacorixa*
Rear margin of head gently curved; interocular space about equal to the width of an eye -------------------------------- 8
8. Smooth, shining insects; male pala triangular; prothoracic lobe tapering to a narrowly rounded apex ---------------- *Corisella*
Rastrate, hairy species ------------------------------------ 9
9. Eyes protuberant with inner anterior angles broadly rounded; postocular space broad ------------------------------ *Dasycorixa*
Eyes normal; postocular space narrow ------------ *Cenocorixa*

### *Callicorixa* White 1873

Two species of *Callicorixa* probably occur in Wisconsin, but only *C. audeni* was collected. The second species, *C. alaskensis* Hungerford 1926, has been recorded from Michigan, Pennsylvania, New York, and New Hampshire to the east of Wisconsin, and from Utah, Montana, and Wyoming to the west. It has also been found in most of the Canadian Provinces.

#### Key to Wisconsin species

1. First tarsal segment of hind leg unicolorous -------- *C. audeni*
First tarsal segment of hind leg infuscated on distal third ---- ------------------------------------------ *C. alaskensis*

### *Callicorixa audeni* Hungerford 1928

*Distribution and abundance:* Common in the northern half of the state (Fig. 2B), with three being collected as far south as Adams County.

*Identification:* This species can be separated from other *Callicorixa* that may occur in Wisconsin by the lack of a dark spot on the first tarsal segment of the hind leg. The black prothoracic lobe of almost all Wisconsin specimens serves to separate this species from all other Wisconsin corixids. The females may be most easily confused with female *Sigara alternata* (which may have a smoky prothoracic lobe), but can be distinguished by their longer, more acutely pointed metaxyphus, by a slightly wider mesoepimeron, and by light markings that often extend all the way across the corium.

*Collection Records:* Adams Co. 1 ♂, 2 ♀; Ashland Co. 19 ♂, 12 ♀; Barron Co. 1 ♀; Burnett Co. 1 ♂; Chippewa Co. 1 ♀; Clark Co. 1 ♂, 1 ♀; Douglas Co. 8 ♂, 7 ♀; Eau Claire Co. 1 ♂, 2 ♀; Florence Co. 54 ♂, 65 ♀; Forest Co. 17 ♂, 20 ♀; Lincoln Co. 14 ♂, 30 ♀;

Marathon Co. 15 ♂, 22 ♀; Marinette Co. 2 ♀; Oconto Co. 1 ♂; Oneida Co. 5 ♂, 8 ♀; Price Co. 10 ♂, 14 ♀; Rusk Co. 6 ♂, 10 ♀; Sawyer Co. 4 ♂, 4 ♀; Taylor Co. 9 ♂, 9 ♀; Vilas Co. 12 ♂, 9 ♀; Washburn Co. 1 ♀. *Totals: 398* individuals, *71* collections, *21* counties.

*Previous Records:* None. Recorded from Michigan and Minnesota.

### *Cenocorixa* Hungerford 1948

Only two species, *C. dakotensis* and *C. utahensis,* have been collected in Wisconsin, but both are rare. A third species, *C. bifida* (Hungerford) 1926, has been collected nearby in Minnesota and could occur in Wisconsin. Both Wisconsin records were from large lakes in the extreme northwest, and perhaps intensive collecting of such habitats would yield additional specimens and specimens of *C. bifida* as well.

#### Key to Wisconsin species

1. Last tarsal segment of hind leg black or dark brown; hind femur pubescent for about one-third its length ________*C. dakotensis*
   Last tarsal segment pale; hind femur pubescent for at least 40% of its length __________________________________________2
2. Shining costal area just anterior to nodal furrow longer than middle tarsus; male peg row entire ________________*C. bifida*
   Shining costal area just anterior to nodal furrow equal to middle tarsus in length; peg row of male pala divided ____*C. utahensis*

### *Cenocorixa dakotensis* (Hungerford) 1928

*Distribution and Abundance:* Apparently rare in the western part of the state (Fig. 2A).

*Collection Records:* Douglas Co. 1 ♀. *Totals: 1* individual, *1* collection, *1* county.

*Previous Records:* None. Reported from Illinois and Minnesota.

### *Cenocorixa utahensis* (Hungerford) 1925

*Distribution and Abundance:* Apparently rare in the western part of the state (Fig. 2A).

*Collection Records:* Douglas Co. 1 ♂. *Totals: 1* individual, *1* collection, *1* county.

*Previous Records:* None. Reported from Iowa.

### *Corisella* Lundblad

Two species have been collected in Wisconsin, and it is unlikely that any others occur in this state. The members of this genus are rare in Wisconsin.

#### Key to Wisconsin species

1. Less than 6.5 mm long; hind tarsus embrowned ______*C. tarsalis*
   More than 6.5 mm long; hind tarsus pale; pattern of clavis effaced at inner, basal angle __________________________*C. edulis*

### *Corisella edulis* (Champion) 1901

*Distribution and Abundance:* Rare in Wisconsin, it has been collected only in the southwestern part of the state (Fig. 2A).

*Collection Records:* Dane Co. 1 ♀; Lafayette Co. 2 ♂, 6 ♀. *Totals: 9* individuals, *2* collections, *2* counties.

*Previous Records:* None. Reported from Iowa and Minnesota.

### *Corisella tarsalis* (Fieber) 1851

*Distribution and Abundance:* Rare in Wisconsin, this species appears to be confined to the southern two-thirds of the state (Fig. 2A).

*Collection Records:* Columbia Co. 1 ♂, 2 ♀; Door Co. 1 ♂; Waukesha Co. 2 ♀. *Totals: 6* individuals, *4* collections, *3* counties.

*Previous Records:* "Parco" (probably Portage Co.) 1 ♀. No records from adjoining states.

### *Cymatia* Flor 1860

The only described North American species, *C. americana* Hussey 1920, has not been found in Wisconsin but should occur in the northern half of the state. It has been reported in Michigan and Minnesota.

### *Dasycorixa* Hungerford 1948

One species, *D. hybrida* (Hungerford) 1926, has been collected in Minnesota and could occur in the northwestern part of Wisconsin.

### *Hesperocorixa* Kirkaldy 1908

Twelve species of *Hesperocorixa* have been collected in Wisconsin, eleven in this present study. Four of these species are very common. One additional species, *H. nitida* (Fieber) 1851, probably occurs in Wisconsin, since it has been found in all four of the neighboring states. Its distribution is generally southern, and it would most likely be found in the southern counties of the state.

KEY TO WISCONSIN SPECIES

1. Mesoepimeron at level of scent gland osteole as broad or broader than the lateral lobe of the prothorax ---------------------2
   Mesoepimeron plainly narrower than the lateral lobe of the prothorax ---------------------------------------------6
2. Mesoepimeron at level of scent gland osteole about equal in width to the lateral lobe of the prothorax; a conspicuous V-shaped yellow band bordering the apex of the corium ------ ----------------------------------------*H. atopodonta*
   Mesoepimeron plainly broader than the prothoracic lobe ----3
3. 8 mm long or longer; tip of metaxyphus blunt or truncated -- ----------------------------------------*H. kennicottii*
   7.5 mm long or less; tip of metaxyphus pointed ------------4
4. Dorsal surface of hind femur with two stout spines ------ ----------------------------------------*H. minorella*
   Dorsal surface of hind femur armed with many spines ------5
5. Corial pattern crossbanded ---------------*H. michiganensis*
   Corial pattern in longitudinal series ------------*H. semilucida*
6. Pattern of hemelytra reticulate; pronotum nonrastrate ---- ----------------------------------------*H. laevigata*
   Pattern of hemelytra not reticulate; pronotum rastrate ------7
7. Pronotal disc short, less than half as long as wide -------- ----------------------------------------*H. scabricula*
   Pronotal disc more than half as long as wide --------------8
8. Color pattern of corium effaced laterally ------------*H. lucida*
   Color pattern normal ----------------------------------9
9. Pale bands of corium beyond hemelytral suture forming slender transverse series. Membrane not plainly separated from corium ----------------------------------------*H. vulgaris*
   Pala bands of corium beyond hemelytral suture in an interrupted transverse series. Membrane may be distinctly separated from corium --------------------------------------10
10. Hind femur with a row of about 10 spines ventrally on distal portion of rear margin ----------------------------*H. nitida*
    Hind femur with only about 6 spines on rear margin ------11
11. Corium and membrane not separated by a coalescing of the pale figures; upper distal angle of male pala acutely, obliquely produced -------------------------------------*H. obliqua*
    Corium and membrane separated by a coalescing of the pale figures -------------------------------------------12

12. Interocular space almost equal to the width of an eye; metaxyphus as broad as long; male pala rounded at tip; male strigil oval ________________________________________ *H. lobata*
    Interocular space much narrower than width of an eye; metaxyphus longer than broad; male pala truncated at tip; male strigil very long ____________________________ *H. interrupta*

*Hesperocorixa atopodonta* (Hungerford) 1927

*Distribution and Abundance:* This species is found throughout Wisconsin (Fig. 3B) and is very common in the northern two-thirds of the state.

*Identification:* The mesoepimeron that is the same width as the prothoracic lobe and the conspicuous V-shaped yellow band bordering the apex of the corium readily distinguish this species. The male pala with the last peg out of line is also distinctive.

*Collection Records:* Adams Co. 14 ♂, 11 ♀; Ashland Co. 26 ♂, 30 ♀; Barron Co. 1 ♂, 1 ♀; Burnett Co. 9 ♂, 2 ♀; Chippewa Co. 16 ♂, 15 ♀; Clark Co. 5 ♂, 4 ♀; Columbia Co. 1 ♂, 2 ♀; Crawford Co. 2 ♂; Dane Co. 12 ♂, 9 ♀; Douglas Co. 32 ♂, 33 ♀; Dunn Co. 7 ♂, 8 ♀; Eau Claire Co. 29 ♂, 33 ♀; Florence Co. 89 ♂, 92 ♀; Fond du Lac Co. 2 ♂, 4 ♀; Forest Co. 20 ♂, 22 ♀; Grant Co. 1 ♀; Green Co. 1 ♂, 1 ♀; Green Lake Co. 1 ♀; Iowa Co. 5 ♂, 3 ♀; Juneau Co. 65 ♂, 93 ♀; Kenosha Co. 1 ♂; Langlade Co. 1 ♂; Lincoln Co. 77 ♂, 58 ♀; Manitowoc Co. 1 ♀; Marathon Co. 45 ♂, 36 ♀; Marinette Co. 1 ♂, 2 ♀; Marquette Co. 1 ♀; Milwaukee Co. 5 ♂, 5 ♀; Monroe Co. 1 ♂, 4 ♀; Oconto Co. 7 ♂, 12 ♀; Oneida Co. 9 ♂, 10 ♀; Ozaukee Co. 1 ♂; Polk Co. 5 ♂, 8 ♀; Portage Co. 9 ♂, 12 ♀; Price Co. 25 ♂, 39 ♀; Racine Co. 1 ♂; Richland Co. 3 ♂, 5 ♀; Rusk Co. 40 ♂, 45 ♀; Sauk Co. 2 ♂, 4 ♀; Sawyer Co. 8 ♂; Taylor Co. 9 ♂, 9 ♀; Trempealeau Co. 42 ♂, 36 ♀; Vilas Co. 15 ♂, 16 ♀; Washburn Co. 7 ♂, 6 ♀; Waupaca Co. 17 ♂, 9 ♀; Winnebago Co. 22 ♂, 28 ♀; Wood Co. 5 ♂, 4 ♀. *Totals: 1409* individuals, *145* collections, *47* counties.

*Previous Records:* Bayfield Co. 2 ♀; Dane Co. 6 ♂, 7 ♀; Douglas Co. 1 ♂, 1 ♀; Fond du Lac Co. 1 ♂, 1 ♀; Polk Co. 1 ♀; Rusk Co. 1 ♀; Sauk Co. 2 ♀; St. Croix R. 3 ♀; Wisconsin 2 ♂, 2 ♀. Also reported from Michigan and Minnesota.

*Hesperocorixa interrupta* (Say) 1825

*Distribution and Abundance:* The only Wisconsin record is one male collected at Beaver Dam (Dodge Co.) by W. E. Snyder in 1909 (Hungerford 1948). Most of the records for this species are from states south of Wisconsin, indicating that it would most likely occur in the southern part of the state.

*Identification:* A series of specimens from the Snow Collection was examined. This species is similar to *H. lobata,* but can be separated from that species by its narrow interocular space, which is only ⅔ the width of an eye. In *H. lobata* the interocular space is about 12/13 the width of an eye. The metaxyphus is longer and more pointed than that of *H. lobata.* Males have a pala that is truncate at the tip as compared to the rounded pala of *H. lobata,* and they have a very elongate and large strigil. *H. interrupta* can be separated from the smaller *H. nitida* by the characters given in the key.

*Previous Records:* Dodge Co. 1 ♂. Also reported from Illinois and Michigan.

### *Hesperocorixa kennicottii* (Uhler) 1897

*Distribution and Abundance:* This species is common in all but the extreme southeastern corner of the state, where it was not collected but probably occurs (Fig. 3C).

*Identification:* This species is very distinctive. It has a very wide, pale mesoepimeron, a metaxyphus that is truncate or broadly rounded at the tip, and a golden-brown membrane that is almost devoid of markings and is separated from the corium by the wide, yellow, V-shaped border of the corium.

*Collection Records:* Adams Co. 1 ♂, 2 ♀; Ashland Co. 1 ♀; Barron Co. 1 ♂; Columbia Co. 2 ♂; Crawford Co. 4 ♂, 2 ♀; Douglas Co. 23 ♂, 34 ♀; Dunn Co. 1 ♂, 3 ♀; Florence Co. 2 ♂, 5 ♀; Forest Co. 3 ♀; Iowa Co. 1 ♂; Juneau Co. 1 ♂; Langlade Co. 1 ♂; Lincoln Co. 20 ♂, 11 ♀; Marathon Co. 18 ♂, 28 ♀; Marquette Co. 1 ♂; Oconto Co. 1 ♂, 1 ♀; Oneida Co. 2 ♂, 1 ♀; Polk Co. 1 ♀; Portage Co. 1 ♂, 2 ♀; Price Co. 1 ♀; Rusk Co. 2 ♂, 1 ♀; Sauk Co. 2 ♀; Sawyer Co. 1 ♂, 2 ♀; Taylor Co. 1 ♂, 2 ♀; Trempealeau Co. 3 ♂; Washburn Co. 8 ♂, 3 ♀; Waupaca Co. 1 ♂, 8 ♀; Winnebago Co. 47 ♂, 50 ♀; Wood Co. 1 ♂, 2 ♀. *Totals: 309* individuals, *51* collections, *29* counties.

*Previous Records:* Dane Co. 44 ♂, 75 ♀; Douglas Co. 1 ♂. Also reported from Illinois, Michigan and Minnesota.

### *Hesperocorixa laevigata* (Uhler) 1893

*Distribution and Abundance:* Although apparently rare in Wisconsin, having been collected from only two sites (Fig. 3C), at one of these sites it was abundant and thousands could have been collected. This is a common western corixid, and Wisconsin is east of its principal range.

*Identification:* The reticulate pattern and non-rastrate pronotum set this species apart from all other *Hesperocorixa.*

*Collection Records:* Adams Co. 1 ♂; Iowa Co. 24 ♂, 36 ♀. *Totals: 61* individuals, *2* collections, *2* counties.

*Previous Records:* St. Croix R. 1 ♂ (Hungerford 1948). Also reported from Illinois and Minnesota.

### *Hesperocorixa lobata* (Hungerford) 1925

*Distribution and Abundance:* Although collected in only five northern counties in this study (Fig. 3C), its distribution in the United States (Hungerford 1948) and a previous collection from Dane County indicate that it probably occurs throughout the state.

*Identification:* The separation of this species from *H. interrupta* was discussed under *H. interrupta.* The male pala is rounded at the tip, and is not as illustrated by Hungerford (1948). A series of specimens from the Snow Collection was studied, as well as those collected in Wisconsin.

*Collection Records:* Barron Co. 3 ♀; Chippewa Co. 1 ♂; Florence Co. 4 ♂, 3 ♀; Polk Co. 1 ♂, 1 ♀; Washburn Co. 2 ♀. *Totals: 15* individuals, *5* collections, *5* counties.

*Previous Records:* Dane Co. 1 ♂, 1 ♀. Also reported from Michigan and Minnesota.

### *Hesperocorixa lucida* (Abbott) 1916

*Distribution and Abundance:* A distinct rarity in Wisconsin, *H. lucida* was collected from only two counties in northern Wisconsin (Fig. 3D). Its distribution to the south of Wisconsin indicates that it may be found in all parts of the state.

*Identification:* The lack of markings on the clavis and the effaced markings of the corium separate this species from other *Hesperocorixa.*

*Collection Records:* Douglas Co. 1 ♂, 1 ♀; Lincoln Co. 1 ♂. *Totals: 3* individuals, *2* collections, *2* counties.

*Previous Records:* None. Reported from Illinois and Michigan.

### *Hesperocorixa michiganensis* (Hungerford) 1926

*Distribution and Abundance:* Although it was also collected in the extreme south, the distribution is mostly throughout the northern two-thirds of the state (Fig. 3A). In the north this is a very common species.

*Identification:* The mesoepimeron is pale, much lighter than either *H. minorella* or *H. semilucida,* the other two small *Hespero-*

*corixa* with a wide mesoepimeron. The pale markings on the membrane are also more distinct than in either of these two species.

*Collection Records:* Adams Co. 6 ♂, 5 ♀; Ashland Co. 45 ♂, 20 ♀; Barron Co. 4 ♂, 10 ♀; Burnett Co. 31 ♂, 15 ♀; Clark Co. 7 ♂, 5 ♀; Dodge Co. 1 ♂; Douglas Co. 10 ♂, 8 ♀; Eau Claire Co. 2 ♂, 9 ♀; Florence Co. 203 ♂, 197 ♀; Forest Co. 82 ♂, 99 ♀; Green Co. 1 ♂, 2 ♀; Juneau Co. 1 ♀; La Crosse Co. 1 ♂; Langlade Co. 3 ♀; Lincoln Co. 72 ♂, 84 ♀; Manitowoc Co. 2 ♀; Marathon Co. 42 ♂, 29 ♀; Marinette Co. 2 ♂, 1 ♀; Marquette Co. 3 ♂, 1 ♀; Monroe Co. 1 ♀; Oconto Co. 30 ♂, 12 ♀; Oneida Co. 22 ♂, 17 ♀; Outagamie Co. 1 ♀; Polk Co. 3 ♂, 6 ♀; Portage Co. 4 ♂, 2 ♀; Price Co. 53 ♂, 60 ♀; Rusk Co. 33 ♂, 5 ♀; Sauk Co. 1 ♂; Sawyer Co. 7 ♂, 12 ♀; Taylor Co. 14 ♂, 7 ♀; Trempealeau Co. 10 ♂, 22 ♀; Vilas Co. 26 ♂, 44 ♀; Waupaca Co. 4 ♂, 2 ♀; Winnebago Co. 3 ♂, 4 ♀; Wood Co. 7 ♂, 7 ♀. *Totals: 1422* individuals, *120* collections, *35* counties.

*Previous Records:* Dane Co. 1 ♂, 3 ♀; Douglas Co. 3 ♂, 7 ♀; Wisconsin 2 ♀. Also reported from Michigan and Minnesota.

### *Hesperocorixa minorella* (Hungerford) 1926

*Distribution and Abundance:* A very common species of *Hesperocorixa* that is widely distributed throughout the northern two-thirds of the state (Fig. 3A). It is most abundant in the far north.

*Identification:* This very dark species can be distinguished by the two spines on the dorsal surface of the hind femur.

*Collection Records:* Adams Co. 1 ♂, 10 ♀; Ashland Co. 18 ♂, 18 ♀; Barron Co. 1 ♂; Burnett Co. 3 ♂, 7 ♀; Chippewa Co. 2 ♂, 2 ♀; Clark Co. 2 ♂, 5 ♀; Douglas Co. 17 ♂, 39 ♀; Dunn Co. 2 ♂, 3 ♀; Eau Claire Co. 36 ♂, 54 ♀; Florence Co. 434 ♂, 458 ♀; Forest Co. 195 ♂, 260 ♀; Iron Co. 8 ♂, 20 ♀; Jackson Co. 3 ♂, 4 ♀; Juneau Co. 18 ♂, 14 ♀; Langlade Co. 1 ♀; Lincoln Co. 44 ♂, 78 ♀; Manitowoc Co. 1 ♀; Marathon Co. 14 ♂, 30 ♀; Marinette Co. 4 ♂, 3 ♀; Marquette Co. 1♂; Monroe Co. 1 ♂, 1 ♀; Oconto Co. 38 ♂, 66 ♀; Oneida Co. 62 ♂, 119 ♀; Outagamie Co. 1 ♀; Polk Co. 1 ♂; Portage Co. 7 ♂, 6 ♀; Price Co. 29 ♂, 52 ♀; Rusk Co. 62 ♂, 58 ♀; Sauk Co. 1 ♀; Sawyer Co. 25 ♂, 34 ♀; Shawano Co. 1 ♂, 1 ♀; Taylor Co. 12 ♂, 12 ♀; Trepealeau Co. 1 ♀; Vilas Co. 198 ♂, 231 ♀; Washburn Co. 11 ♂, 21 ♀; Waupaca Co. 3 ♀; Waushara Co. 2 ♂, 1 ♀; Winnebago Co. 5 ♂, 6 ♀; Wood Co. 4 ♂, 7 ♀. *Totals: 2889* individuals, *125* collections, *39* counties.

*Previous Records:* Douglas Co. 1 ♂; Wisconsin (no sex or number). Also reported from Michigan and Minnesota.

### *Hesperocorixa obliqua* (Hungerford) 1925

*Distribution and Abundance:* This species was collected only in the extreme southern part of the state, where it is uncommon (Fig. 3D).

*Identification:* The acute and obliquely produced upper distal angle of the male pala is distinctive, but the females closely resemble those of the much more abundant *H. vulgaris.* The pale transverse lines of the corium are shorter in *H. obliqua,* and seldom traverse the entire corium, while the longer lines of *H. vulgaris* extend entirely across the corium in the basal third.

*Collection Records:* Dane Co. 5 ♂, 4 ♀; Kenosha Co. 5 ♂, 9 ♀; Racine Co. 1 ♂; Rock Co. 1 ♂, 1 ♀. *Totals: 26* individuals, *6* collections, *4* counties.

*Previous Records:* None. Reported from Illinois, Iowa, Michigan and Minnesota.

### *Hesperocorixa scabricula* (Walley) 1936

*Distribution and Abundance:* Apparently rare in Wisconsin, this species was collected only from one site in Florence County (Fig. 3D). Its occurrence in Illinois, Michigan, and Minnesota suggests that it may occur throughout Wisconsin.

*Identification:* Readily distinguished by its large size and the very short pronotal disc.

*Collection Records:* Florence Co. 5 ♀. *Totals: 5* individuals, *1* collection, *1* county.

*Previous Records:* None. Reported from Illinois, Michigan, and Minnesota.

### *Hesperocorixa semilucida* (Walley) 1930

*Distribution and Abundance:* This uncommon species is apparently distributed throughout the southern half of the state (Fig. 3D), although it has not been collected in the extreme southeastern counties.

*Identification:* The small size and wide mesoepimeron distinguish this species, *H. minorella,* and *H. michiganensis.* The mesoepimeron is dusky, as in *H. minorella,* but the arrangement of the corial pattern into a definite longitudinal series separates it from both *H. minorella* and *H. michiganensis.*

*Collection Records:* Crawford Co. 3 ♂, 7 ♀; Green Co. 1 ♂; Richland Co. 6 ♂, 4 ♀; Trempealeau Co. 1 ♂, 1 ♀; Waupaca Co. 3 ♂; Winnebago Co. 1 ♂, 1 ♀. *Totals: 28* individuals, *9* collections, *6* counties.

*Previous Records:* None. Reported from Illinois and Michigan.

### *Hesperocorixa vulgaris* (Hungerford) 1925

*Distribution and Abundance:* This species is very common throughout the state (Fig. 3B).

*Identification:* The narrow metaxyphus, the lack of any pale figures separating the corium from the membrane, and the long, narrow, transverse pale markings of the corium distinguish this species. The truncated tip of the male pala is slightly indented at the middle.

*Collection Records:* Adams Co. 10 ♂, 10 ♀; Ashland Co. 1 ♂, 4 ♀; Barron Co. 21 ♂, 29 ♀; Brown Co. 1 ♂; Buffalo Co. 1 ♂; Burnett Co. 5 ♂, 5 ♀; Chippewa Co. 3 ♂, 11 ♀; Clark Co. 1 ♂, 6 ♀; Columbia Co. 10 ♂, 10 ♀; Crawford Co. 1 ♀; Dane Co. 39 ♂, 22 ♀; Dodge Co. 7 ♂, 11 ♀; Door Co. 1 ♂; Douglas Co. 16 ♂, 17 ♀; Eau Claire Co. 34 ♂, 42 ♀; Dunn Co. 3 ♂; Florence Co. 12 ♂, 11 ♀; Forest Co. 5 ♂, 5 ♀; Fond du Lac Co. 1 ♀; Grant Co. 2 ♂, 2 ♀; Green Co. 16 ♂, 13 ♀; Green Lake Co. 3 ♂, 4 ♀; Iowa Co. 8 ♂, 12 ♀; Jackson Co. 4 ♂, 1 ♀; Juneau Co. 5 ♂, 11 ♀; Kenosha Co. 24 ♂, 13 ♀; La Crosse Co. 1 ♂, 1 ♀; Langlade Co. 2 ♂, 3 ♀; Lincoln Co. 6 ♂, 7 ♀; Manitowoc Co. 1 ♂, 2 ♀; Marathon Co. 12 ♂, 6 ♀; Marquette Co. 5 ♂, 1 ♀; Milwaukee Co. 30 ♂, 39 ♀; Monroe Co. 3 ♂, 2 ♀; Oconto Co. 2 ♂, 9 ♀; Oneida Co. 1 ♂, 1 ♀; Outagamie Co. 6 ♀; Ozaukee Co. 1 ♂, 2 ♀; Polk Co. 6 ♂, 3 ♀; Portage Co. 2 ♂; Price Co. 6 ♂, 15 ♀; Racine Co. 22 ♂, 12 ♀; Richland Co. 3 ♂, 5 ♀; Rock Co. 2 ♂, 6 ♀; Rusk Co. 6 ♂, 17 ♀; Sauk Co. 24 ♂, 33 ♀; Sawyer Co. 6 ♂, 7 ♀; Taylor Co. 3 ♂, 5 ♀; Trempealeau Co. 25 ♂, 22 ♀; Vernon Co. 2 ♂, 1 ♀; Vilas Co. 2 ♂, 2 ♀; Walworth Co. 28 ♂, 45 ♀; Washburn Co. 1 ♂, 1 ♀; Washington Co. 1 ♂, 1 ♀; Waukesha Co. 4 ♂, 8 ♀; Waupaca Co. 2 ♂, 2 ♀; Waushara Co. 3 ♂, 2 ♀; Winnebago Co. 52 ♂, 78 ♀; Wood Co. 2 ♀. *Totals: 1083* individuals, *160* collections, *59* counties.

*Previous Records:* Dane Co. 1 ♂, 19 ♀; Dodge Co. (no numbers); Douglas Co. 1 ♂, 2 ♀; St. Croix R. 8 ♂, 6 ♀. Also reported from Illinois, Iowa, Michigan and Minnesota.

## *Palmacorixa* Abbott 1912

Three species of *Palmacorixa* occur throughout Wisconsin, but none of them is very common. The males of the three species are easily distinguished, but the females are very difficult to separate, especially those of *P. nana* and *P. buenoi.* The identification of the females collected in this study is based on the following key, and on other criteria listed under each species, but the separation of *P. nana* from *P. buenoi* remains uncertain.

KEY TO WISCONSIN SPECIES

1. The pronotal disc with well marked anterolateral depressions; male pala very broad, almost disc-like, with poorly defined pegs ---------------------------------------------- *P. gillettei*
   Anterolateral depression on pronotum weak or absent; male pala elongate ---------------------------------------------- 2
2. Middle femur of male with a longitudinal row or pegs on its ventral surface; female less than 5.2 mm long -------- *P. nana*
   Middle femur of male without a row of pegs; female 5.4 mm or longer ---------------------------------------------- *P. buenoi*

*Palmacorixa buenoi* Abbott 1913

*Distribution and Abundance:* This is the most common species of *Palmacorixa* in Wisconsin. It has been collected throughout most of the state, being fairly common in the southeastern half and less common in the northwest (Fig. 2C).

*Identification:* The females of this species are difficult to separate from *Palmacorixa nana*. Size is perhaps the most important criteria, with *P. nana* females being less than 5.2 mm long and *P. buenoi* females being 5.4 to 6.5 mm. Also, the dark posterior border of the pronotum is usually wider than in *P. nana*. The pronotum lacks the strong antero-lateral depressions that are found in females of *P. gillettei.*

*Collection Records:* Adams Co. 2 ♀; Brown Co. 2 ♀; Columbia Co. 12 ♂, 19 ♀; Dane Co. 2 ♀; Douglas Co. 1 ♀; Eau Claire Co. 2 ♀; Green Lake Co. 1 ♂, 1 ♀; Juneau Co. 5 ♂, 7 ♀; Kenosha Co. 4 ♂; Kewaunee Co. 12 ♂, 7 ♀; La Crosse Co. 1 ♂; Lafayette Co. 2 ♀; Oconto Co. 1 ♀; Oneida Co. 1 ♀; Pepin Co. 1 ♀; Pierce Co. 1 ♀; Polk Co. 1 ♂; Price Co. 2 ♀; Racine Co. 1 ♂; Rock Co. 3 ♀; Sauk Co. 2 ♂, 2 ♀; Sawyer Co. 1 ♀; Washington Co. 2 ♂, 3 ♀; Waupaca Co. 1 ♀; Waushara Co. 1 ♂, 3 ♀. *Totals: 106* individuals, *30* collections, *25* counties.

*Previous Records:* None. Reported from Iowa, Michigan and Minnesota.

*Palmacorixa gillettei* Abbott 1912

*Distribution and Abundance:* Scattered records from throughout the state indicate a statewide distribution, with the possible exception the extreme southeastern counties (Fig. 2C). This species is fairly common, but less common than *P. buenoi.*

*Identification:* The males are easily distinguished by their dilated and flattened palae. The females can be identified by the strong antero-lateral depressions of the pronotum and the wide, dark, posterior border of the pronotum.

*Collection Records:* Ashland Co. 1 ♀; Barron Co. 1 ♂; Dane Co. 2 ♂, 8 ♀; Douglas Co. 1 ♂; Florence Co. 2 ♀; Iowa Co. 3 ♂, 3 ♀; Lafayette Co. 2 ♀; Oconto Co. 2 ♂, 2 ♀; Outagamie Co. 1 ♀; Richland Co. 1 ♀; Taylor Co. 2 ♂, 6 ♀; Vilas Co. 1 ♂; Waupaca Co. 1 ♂, 2 ♀; Waushara Co. 1 ♀. *Totals: 42* individuals, *19* collections, *14* counties.

*Previous Records:* None. Reported from Michigan, Iowa and Minnesota.

### *Palmacorixa nana* Walley 1930

*Distribution and Abundance:* The scattered records indicate that this uncommon species probably occurs throughout the state (Fig. 2C).

*Identification:* The row of pegs on the middle femur separates the males from those of *P. buenoi*. The females can be distinguished by their small size (less than 5.2 mm) and the very narrow, often interrupted, dark posterior border of the pronotum.

*Collection Records:* Dane Co. 1 ♀; Florence Co. 1 ♂; Forest Co. 1 ♂, 6 ♀; Manitowoc Co. 1 ♂, 1 ♀; Outagamie Co. 1 ♀; Taylor Co. 7 ♂, 9 ♀. *Totals: 28* individuals, *6* collections, *6* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

### *Ramphocorixa* Abbott 1912

Only one species occurs in Wisconsin.

### *Ramphocorixa acuminata* (Uhler) 1897

*Distribution and Abundance:* This species is rare in Wisconsin, with but a single specimen having been collected. This individual was collected with a black-light trap at Madison (Fig. 2B).

*Identification:* The effaced pattern of the clavis and corium of this species serves to separate it from all other small Wisconsin corixids. The male is also recognized by its accuminate vertex.

*Collection Records:* Dane Co. 1 ♂. *Totals: 1* individual, *1* collection, *1* county.

*Previous Records:* None. Reported from Illinois and Minnesota.

### *Sigara* Fabricius 1775

This is the most common corixid genus in Wisconsin, 23 species having been collected in the state. The only species likely to occur in Wisconsin that have not been collected are *S. hubbelli* (Hungerford) 1928 and *S. modesta* (Abbott) 1916. Both are distributed throughout the southeastern United States and have been collected in the neighboring states of Illinois, Iowa and Minnesota. *S. hubbelli* is closely related to *S. defecta* while *S. modesta* resembles *S. grossolineata*. Both can be separated by the characters given in the key.

### Key to Wisconsin species

1. Pronotal disk with median longitudinal pale line ____________ 2
   Pronotal disk without a median pale longitudinal line ______ 7
2. Tip of mesoepimeron as close or closer to scent gland osteole than to mesosternum ____________________________________ 3
   Scent gland osteole remote from tip of mesoepimeron, farther than distance from tip to mesosternum __________________ 5
3. Hemelytra nearly black; pale markings wide but obscure, transverse on clavis and somewhat longitudinal on corium; male pala thickened, with a prominent keel on the outside ____________________________________________ *S. variabilis*
   Markings on hemelytra narrower and more distinct ________ 4
4. Male pala with a single row of pegs; female abdomen with anal lobes not notched on inner ventral margin ______ *S. johnstoni*
   Male pala with two rows of pegs; female with anal lobes notched on inner ventral margin __________________ *S. knighti*
5. Pronotum and hemelytra boldly cross-barred; vertex produced beyond the eye curve in both sexes __________ *S. transfigurata*
   Pattern less striking; vertex not noticeably produced ______ 6
6. Pattern of membrane effaced or indistinct; pale figures on corium and clavis transverse ______________ *S. compressoidea*
   Pattern of membrane usually distinct; pale figures on corium and distal half of clavis arranged more or less longitudinally ______________________________________ *S. mackinacensis*
7. Large species, greater than 7.0 mm long __________________ 8
   Small species, less than 7.0 mm long _____________________ 11
8. Metaxyphus broad, truncated or notched at the tip; claw of pala serrate at base in both sexes ________________ *S. decorata*
   Metaxyphus pointed; palar claw normal __________________ 9
9. Palae of both sexes with only 14 to 16 lower palmar hairs ____________________________________________ *S. decoratella*
   Palae with from 18 to 22 lower palmar hairs ______________ 10
10. Interocular space plainly narrower than width of an eye; hemelytra dark, with the pale markings of the corium and distal half of clavis arranged in definite longitudinal series ____________________________________________ *S. penniensis*
    Interocular space equal to width of an eye; pale markings of corium and clavis bold and transverse; vertex of male produced; palae long and slender ________________ *S. conocephala*

11. Corial pattern in definite longitudinal series ---------------12
    Corial pattern not in definite longitudinal series -----------16
12. Clavus and corium with pale lines in wavy longitudinal series; hypoocular suture ending laterad of middle line of eye ---- ----------------------------------------------*S. douglasensis*
    Claval lineations not in wavy longitudinal series -----------13
13. Small, less than 4.3 mm long; antennae usually 3-segmented -- ------------------------------------------------*S. lineata*
    Larger, greater than 4.5 mm long; antennae 4-segmented --14
14. Scent gland osteole remote from tip of mesoepimeron ------ ---------------------------------------------*S. trilineata*
    Scent gland osteole near tip of mesoepimeron -------------15
15. Corial lineations distinct; male pala with two rows of pegs; female pala short; anal lobes of female only very slightly notched on inner ventral margin --------------*S. mullettensis*
    Corial lineations fairly distinct; male pala with one row of pegs ---------------------------------------------------23
16. Metaxyphus longer than broad -------------------------------17
    Metaxyphus not longer than broad -------------------------19
17. Mesoepimeron at level of scent gland osteole about equal in width to lateral lobe of prothorax -----------------*S. dolabra*
    Mesoepimeron at level of scent gland osteole much broader than width of lateral lobe of prothorax -------------------18
18. Pale bands on base of clavus entire, bands on corium plainly transverse; dorsal surface of hind femur with only 3 or 4 pegs -----------------------------------------*S. solensis*
    Pale bands on base of clavus more or less broken and confused; dorsal surface of hind femur with two or three rows of pegs ----------------------------------------------*S. signata*
19. Scent gland osteole nearer lateral bend of mesoepimeron than tip ---------------------------------------------------20
    Scent gland osteole near tip of mesoepimeron -------------22
20. Head with median longitudinal brown line; mesoepimeron with a deep incision at or near the lateral bend ------*S. mathesoni*
    Head without line; mesoepimeron without incision --------21
21. Osteole almost in lateral bend of mesoepimeron, at least 4/5 from tip; metaxyphus with a truncated point --*S. grossolineata*
    Osteole not so far laterad, 1/2–3/5 from tip; metaxyphus with a rounded point ---------------------------------*S. modesta*
22. Corial pattern in a more or less definite longitudinal series --23
    Corial pattern not in a longitudinal series ----------------24
23. Pronotal disc laterally reduced; 4 to 6 pegs on dorsal surface of hind femur; pattern of membrane obscure ------*S. hubbelli*
    Pronotal disc not reduced laterally; row of at least 12 pegs on

dorsal surface of hind femur; pattern of membrane distinct; distal pegs of male pala becoming widely separated; anal lobes of female notched on inner ventral margin; pala of female long ---------------------------------------------*S. defecta*

24. Metaxyphus small and rounded at tip; male pala with peg row close to palm; anal lobes of female not notched ---------- ---------------------------------------*S. bicoloripennis*
Metaxyphus pointed at an angle of less than 90 degrees ----25

25. Pronotum crossed by 5 or 6 dark bands --------*S. macropala*
Pronotum crossed by 8 or 9 dark bands ----------*S. alternata*

### *Sigara alternata* (Say) 1825

*Distribution and Abundance:* The most common Wisconsin corixid, this species is very common in the northern half of the state and abundant in the southern half. It has been collected in almost every county (Fig. 4A).

*Identification:* The short, pointed metaxyphus forms an angle at the tip of about 70°. This, the alternate dark and pale transverse markings on the clavis, and the vermiform markings of the corium separate this species from others with a narrow mesoepimeron.

*Collection Records:* Adams Co. 78 ♂, 114 ♀; Ashland Co. 4 ♂, 6 ♀; Barron Co. 12♂, 16 ♀; Bayfield Co. 1 ♀; Brown Co. 1 ♂, 9 ♀; Buffalo Co. 10 ♂, 6 ♀; Burnett Co. 14 ♂, 34 ♀; Calumet Co. 2 ♂, 4 ♀; Chippewa Co. 2 ♂, 4 ♀; Clark Co. 2 ♂, 3 ♀; Columbia Co. 104 ♂, 128 ♀; Crawford Co. 46 ♂, 62 ♀; Dane Co. 155 ♂, 203 ♀; Dodge Co. 4 ♀; Door Co. 11 ♂, 3 ♀; Douglas Co. 66 ♂, 93 ♀; Dunn Co. 3 ♂, 6 ♀; Eau Claire Co. 24 ♂, 30 ♀; Florence Co. 68 ♂, 77 ♀; Forest Co. 1 ♂, 5 ♀; Fond du Lac Co. 1 ♂, 6 ♀; Grant Co. 11 ♂, 13 ♀; Green Co. 40 ♂, 49 ♀; Green Lake Co. 7 ♂, 23 ♀; Iowa Co. 31 ♂, 22 ♀; Iron Co. 1 ♂; Jackson Co. 7 ♂, 10 ♀; Jefferson Co. 1 ♀; Juneau Co. 50 ♂, 61 ♀; Kenosha Co. 70 ♂, 93 ♀; Kewaunee Co. 1 ♂, 8 ♀; La Crosse Co. 7 ♂, 14 ♀; Lafayette Co. 3 ♂, 7 ♀; Langlade Co. 2 ♂, 1 ♀; Lincoln Co. 29 ♂, 20 ♀; Manitowoc Co. 3 ♂, 8 ♀; Marathon Co. 48♂, 54♀; Marquette Co. 9 ♂, 17 ♀; Menominee Co. 1 ♂; Milwaukee Co. 61 ♂, 61 ♀; Monroe Co. 3♂, 32 ♀; Oconto Co. 16 ♂, 28 ♀; Oneida Co. 9 ♂, 11 ♀; Outagamie Co. 6 ♂, 7 ♀; Ozaukee Co. 1 ♂, 1 ♀; Pepin Co. 1 ♂; Polk Co. 1 ♀; Portage Co. 28 ♂, 31 ♀; Price Co. 15 ♂, 14 ♀; Racine Co. 30 ♂, 34 ♀; Richland Co. 13 ♂, 9 ♀; Rock Co. 8 ♂, 19♀; Rusk Co. 1 ♂, 1 ♀; St. Croix Co. 3 ♀; Sauk Co. 45 ♂, 39 ♀; Sawyer Co. 4 ♂, 9 ♀; Shawano Co. 2 ♂; Taylor Co. 12 ♂, 10 ♀; Trempealeau Co. 78 ♂, 92 ♀; Vernon Co. 11 ♂, 6 ♀; Vilas Co. 3 ♂, 8 ♀; Walworth Co. 59 ♂, 89 ♀; Washburn Co. 2 ♂; Washington Co. 1 ♂; Waukesha Co. 19 ♂, 16 ♀; Waupaca Co. 6

♂, 9 ♀; Waushara Co. 1 ♂; Winnebago Co. 17 ♂, 28 ♀; Wood Co. 6 ♂, 6 ♀. *Totals: 3168* individuals, *248* collections, *69* counties.

*Previous Records:* Burnett Co. 1 ♀; Dane Co. 2 ♂, 5 ♀; Douglas Co. 1 ♂, 1 ♀; Fond du Lac Co. 1 ♀; Jackson Co. 1 ♀; Lafayette Co. 1 ♀; Sauk Co. 1 ♂, 6 ♀. Also reported from Illinois, Iowa, Michigan and Minnesota.

### *Sigara bicoloripennis* (Walley) 1936

*Distribution and Abundance:* This species is fairly common throughout the northern two-thirds of the state (Fig. 4B). One specimen was collected in Kenosha County in the extreme southeast.

*Identification:* The small, rounded metaxyphus separates this species from *S. alternata*. The females might be confused with *S. defecta,* but the pala is shorter in *S. bicoloripennis* and the anal lobes are not notched on the mesal margin.

*Collection Records:* Adams Co. 8 ♂, 20 ♀; Ashland Co. 1 ♂; Barron Co. 1 ♂, 2 ♀; Burnett Co. 3 ♂, 7 ♀; Douglas Co. 6 ♂, 6 ♀; Florence Co. 39 ♂, 44 ♀; Forest Co. 2 ♀; Juneau Co. 1 ♂; Kenosha Co. 1 ♂; Langlade Co. 1 ♀; Lincoln Co. 1 ♂, 1 ♀; Marathon Co. 1 ♂, 2 ♀; Oconto Co. 2 ♂; Oneida Co. 1 ♂, 1 ♀; Outagamie Co. 6 ♂, 5 ♀; Polk Co. 6 ♂, 3 ♀; Price Co. 1 ♂, 3 ♀; Sawyer Co. 1 ♂; Taylor Co. 11 ♂, 11 ♀; Trempealeau Co. 9 ♂, 10 ♀; Washburn Co. 1 ♂; Waupaca Co. 1 ♀; Winnebago Co. 1 ♀. *Totals: 220* individuals, *34* collections, *23* counties.

*Previous Records:* Dane Co. 3 ♂, 12 ♀. Also reported from Michigan and Minnesota.

### *Sigara compressoidea* (Hungerford) 1928

*Distribution and Abundance:* While common in the northern two-thirds of the state, it also has been collected in two extreme southeastern counties (Fig. 5C).

*Identification:* The pale longitudinal line on the prothorax and the effaced membrane distinguish this species. It might be confused only with *S. mackinacensis,* but the lines on the basal third of the clavis are mostly entire and not zig-zag, and the corial pattern is transverse while that in *S. mackinacensis* is arranged in a longitudinal series.

*Collection Records:* Adams Co. 2 ♂, 1 ♀; Ashland Co. 3 ♂, 1 ♀; Barron Co. 1 ♂; Bayfield Co. 1 ♀; Burnett Co. 1 ♂, 2 ♀; Chippewa Co. 1 ♂, 3 ♀; Clark Co. 9 ♂, 6 ♀; Douglas Co. 2 ♂; Eau Claire Co. 3 ♂, 1 ♀; Florence Co. 69 ♂, 93 ♀; Forest Co. 5 ♀; Green Lake Co. 1 ♀; Juneau Co. 1 ♂; Kenosha Co. 1 ♀; Langlade Co. 3 ♂, 3 ♀; Lincoln Co. 41 ♂, 37 ♀; Marathon Co. 82 ♂, 109 ♀; Marquette Co. 2 ♂, 1 ♀; Oconto Co. 9 ♂, 15 ♀; Oneida Co. 3 ♂, 7 ♀; Polk Co. 6 ♀; Portage Co. 1 ♀; Price Co. 4 ♂, 18 ♀; Rusk Co. 6 ♂, 5 ♀; Sauk Co. 3 ♂, 1 ♀; Sawyer Co. 5 ♀; Taylor Co. 33 ♂, 50 ♀; Vilas Co. 9 ♂, 17 ♀; Walworth Co. 1 ♂, 1 ♀; Washburn Co. 1 ♂, 1 ♀; Waupaca Co. 1 ♂; Waushara Co. 1 ♀; Wood Co. 8 ♂, 1 ♀. *Totals: 692* individuals, *96* collections, *33* counties.

*Previous Records:* Dane Co. 7 ♀. Also reported from Michigan and Minnesota.

### *Sigara conocephala* (Hungerford) 1926

*Distribution and Abundance:* Fairly common in the northeast, this species is apparently confined to the northern two-thirds of the state (Fig. 5A).

*Identification:* The strongly produced vertex identifies the male, while the female can be recognized by her large size and unusually long palae.

*Collection Records:* Adams Co. 1 ♂, 1 ♀; Ashland Co. 1 ♂; Douglas Co. 1 ♂; Florence Co. 34 ♂, 66 ♀; Forest Co. 2 ♂, 5 ♀; Oneida Co. 1 ♂; Trempealeau Co. 1 ♂, 2 ♀; Vilas Co. 1 ♂. *Totals: 116* individuals, *23* collections, *8* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

### *Sigara decorata* (Abbott) 1916

*Distribution and Abundance:* This species is fairly common throughout the state (Fig. 4C).

*Identification: S. decorata* is easily distinguished by its large size and broadly rounded or truncated metaxyphus.

*Collection Records:* Adams Co. 14 ♂, 35 ♀; Barron Co. 2 ♀; Burnett Co. 1 ♀; Columbia Co. 1 ♂, 2 ♀; Dane Co. 5 ♂, 2 ♀; Door Co. 2 ♂, 1 ♀; Douglas Co. 1 ♀; Eau Claire Co. 2 ♂, 1 ♀; Florence Co. 1 ♂; Green Co. 1 ♀; Juneau Co. 3 ♂, 3 ♀; Lincoln Co. 1 ♀; Marathon Co. 3 ♂, 2 ♀; Marquette Co. 2 ♂, 1 ♀; Outagamie Co. 1 ♀; Polk Co. 1 ♀; Price Co. 2 ♀; Racine Co. 2 ♂; St. Croix Co. 1 ♂; Sauk Co. 2 ♂, 6 ♀; Taylor Co. 4 ♂, 2 ♀; Trempealeau Co. 14 ♂, 9 ♀; Vilas Co. 1 ♂; Winnebago Co. 5 ♂, 6 ♀. *Totals: 142* individuals, *39* collections, *24* counties.

*Previous Records:* None. Reported from Illinois and Minnesota.

### *Sigara decoratella* (Hungerford) 1926

*Distribution and Abundance:* This is a common species that is distributed throughout the state (Fig. 5A).

*Identification:* The reduced number of lower palmar hairs is distinctive for this large species.

*Collection Records:* Adams Co. 27 ♂, 47 ♀; Ashland Co. 4 ♂; Barron Co. 1 ♂; Burnett Co. 2 ♂, 5 ♀; Chippewa Co. 1 ♂; Columbia Co. 1 ♂, 1 ♀; Dane Co. 1 ♂, 2 ♀; Douglas Co. 4 ♂, 2 ♀; Florence Co. 21 ♂, 21 ♀; Forest Co. 9 ♂, 4 ♀; Green Co. 1 ♀; Juneau Co. 1 ♂, 1 ♀; Kenosha Co. 1 ♀; Lincoln Co. 3 ♂, 8 ♀; Marinette Co. 1 ♂; Marquette Co. 1 ♀; Oconto Co. 1 ♀; Oneida Co. 2 ♀; Outagamie Co. 2 ♂, 2 ♀; Pierce Co. 1 ♂; Polk Co. 4 ♂; Price Co. 7 ♂, 8 ♀; Sauk Co. 2 ♂, 14 ♀; Shawano Co. 1 ♀; Taylor Co. 1 ♂, 4 ♀; Vilas Co. 1 ♂; Waupaca Co. 1 ♂, 1 ♀; Winnebago Co. 18 ♂, 11 ♀. *Totals: 251* individuals, *60* collections, *28* counties.

*Previous Records:* Dane Co. 1 ♂, 4 ♀; St. Croix R. 8 ♂, 11 ♀. Also reported from Iowa, Michigan and Minnesota.

### *Sigara defecta* Hungerford 1948

*Distribution and Abundance:* Although not collected in the extreme southwestern counties, it probably occurs throughout the state (Fig. 4B). It is fairly common in many parts of the state.

*Identification:* The male pala is distinctive, but the female can be easily confused with *S. bicoloripennis* or *S. mullettensis*. The pala is longer than that of *S. bicoloripennis,* and much longer than that of *S. mullettensis.* The anal lobes are distinctly notched mesally, while those of *S. bicoloripennis* are unnotched and those of *S. mullettensis* are only very slightly notched.

*Collection Records:* Adams Co. 12 ♂, 25 ♀; Ashland Co. 1 ♀; Burnett Co. 3 ♂, 3 ♀; Columbia Co. 1 ♀; Douglas Co. 42 ♂, 40 ♀; Dunn Co. 1 ♂; Florence Co. 7 ♂, 4 ♀; Forest Co. 1 ♂, 1 ♀; Juneau Co. 1 ♂, 1 ♀; Kenosha Co. 1 ♀; Lincoln Co. 1 ♂, 1 ♀; Milwaukee Co. 1 ♀; Oconto Co. 4 ♂, 4 ♀; Polk Co. 5 ♀; Portage Co. 1 ♂; Price Co. 3 ♂, 4 ♀; Racine Co. 3 ♂, 1 ♀; Sauk Co. 1 ♀; Taylor Co. 1 ♂, 1 ♀; Washburn Co. 1 ♀; Winnebago Co. 2 ♀. *Totals: 178* individuals, *30* collections, *21* counties.

*Previous Records:* Dane Co. 1 ♂, 2 ♀; Sauk Co. 1 ♂. Also reported from Illinois, Michigan and Minnesota.

### *Sigara dolabra* Hungerford and Sailer 1942

*Distribution and Abundance: S. dolabra* has been collected only in the northern half of the state and it is uncommon (Fig. 5D).

*Identification:* The very long, pointed metaxyphus and the mesoepimeron equal in width to the prothoracic lobe separate this species.

*Collection Records:* Burnett Co. 1 ♀; Florence Co. 8 ♂, 12 ♀; Forest Co. 1 ♂; Lincoln Co. 1 ♂; Marathon Co. 1 ♂; Marinette Co. 1 ♂; Onedia Co. 1 ♂, 1 ♀; Vilas Co. 2 ♀. *Totals: 29* individuals, *12* collections, *8* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

*Sigara douglasensis* (Hungerford) 1926

*Distribution and Abundance:* The distribution of this fairly common species is confined to the northern third of the state (Fig. 5B).

*Identification:* The wavy longitudinal lines on the clavis and corium separate this species, and the location of the hypo-ocular suture is distinctive.

*Collection Records:* Douglas Co. 2 ♂, 1 ♀; Florence Co. 2 ♂, 4 ♀; Forest Co. 3 ♂; Lincoln Co. 1 ♂, 3 ♀; Oneida Co. 1 ♀; Polk Co. 3 ♂, 2 ♀; Rusk Co. 1 ♂; Sawyer Co. 1 ♂, 1 ♀; Vilas Co. 5 ♂, 6 ♀; Washburn Co. 1 ♀. *Totals: 37* individuals, *17* collections, *10* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

*Sigara grossolineata* Hungerford 1948

*Distribution and Abundance:* An abundant species, it occurs throughout the state (Fig. 4A).

*Identification:* Closely related to *S. modesta,* which has not been collected in Wisconsin but might occur in the south. In *S. modesta* the scent gland osteole is only 1/2 to 3/5 from the tip of the mesoepimeron to the lateral bend, and not close to the lateral bend as in *S. grossolineata.* Also in *S. modesta* the dark pattern of the clavis is effaced along the margin bordering the pronotum, while in *S. grossolineata* the lines may become narrow, but they remain distinct. Several specimens of *S. modesta* from the Snow Collection were examined.

*Collection Records:* Adams Co. 2 ♂, 7 ♀; Ashland Co. 3 ♂, 6 ♀; Brown Co. 12 ♂, 28 ♀; Calumet Co. 7 ♂, 16 ♀; Chippewa Co. 5 ♂, 9 ♀; Clark Co. 1 ♂, 1 ♀; Columbia Co. 3 ♂, 8 ♀; Crawford Co. 28 ♂, 60 ♀; Dane Co. 26 ♂, 39 ♀; Dodge Co. 11 ♂, 15 ♀; Door Co. 10 ♂, 9 ♀; Douglas Co. 1 ♀; Dunn Co. 2 ♂, 8 ♀; Eau Claire Co. 1 ♂, 2 ♀; Florence Co. 11 ♂, 21 ♀; Fond du Lac Co. 5 ♂, 5 ♀; Forest Co. 13 ♂, 19 ♀; Grant Co. 14 ♂, 37 ♀; Green Co. 13 ♂, 17 ♀; Green Lake Co. 5 ♂, 8 ♀; Iowa Co. 77 ♂, 81 ♀; Jefferson Co. 11 ♂, 6 ♀; Juneau Co. 6 ♂, 13 ♀; Kenosha Co. 4 ♂, 13 ♀; Kewaunee Co. 8 ♂, 7 ♀; La Crosse Co. 3 ♀; Lafayette Co. 4 ♂, 14 ♀; Langlade Co. 2 ♂, 5 ♀; Lincoln Co. 10 ♂, 14 ♀; Manitowoc Co. 9 ♂, 21 ♀; Marathon Co. 19 ♂, 27 ♀; Marinette Co. 1 ♂, 3 ♀; Marquette Co. 2 ♂, 3 ♀; Menominee Co. 1 ♀; Milwaukee Co. 2 ♂, 4 ♀; Oconto Co. 15 ♂, 20 ♀; Oneida Co. 2 ♂, 5 ♀; Outagamie Co. 8 ♂, 12 ♀; Ozaukee Co. 3 ♀; Polk Co. 2 ♀; Portage Co. 3 ♂, 6 ♀; Price Co. 8 ♂, 10 ♀; Racine Co. 3 ♂, 10 ♀; Richland Co. 4 ♀; Rock Co. 2 ♂, 2 ♀; Rusk Co. 2 ♂, 1 ♀; St. Croix Co. 3 ♂; Sauk Co. 18 ♂, 21 ♀; Sawyer Co. 2 ♂, 3 ♀; Shawano Co.

1 ♂, 6 ♀; Sheboygan Co. 3 ♂, 8 ♀; Taylor Co. 29 ♂, 59 ♀; Trempealeau Co. 3 ♂, 4 ♀; Vernon Co. 1 ♂, 6 ♀; Vilas Co. 19 ♂, 33 ♀; Walworth Co. 19 ♂, 29 ♀; Washburn Co. 1 ♂; Washington Co. 4 ♂, 6 ♀; Waukesha Co. 3 ♂, 3 ♀; Waupaca Co. 5 ♂, 8 ♀; Winnebago Co. 11 ♂, 17 ♀; Wood Co. 6 ♂, 2 ♀. *Totals: 1309* individuals, *212* collections, *62* counties.

*Previous Records:* Dane Co. 15 ♂, 22 ♀; Douglas Co. 3 ♂, 4 ♀. Also reported from Illinois, Iowa, Michigan and Minnesota.

### *Sigara johnstoni* Hungerford 1948

*Distribution and Abundance:* This species is fairly common in the northwest half of the state (Fig. 4D). The Illinois record suggests that it might occur in the southern part of the state as well.

*Identification:* The females may be confused with those of *S. variabilis* or *S. knighti.* The anal lobes are not notched mesally as they are in *S. knighti;* those of *S. variabilis* are slightly notched. Most distinctive is the metaxyphus, which is very slightly notched at the tip in *S. johnstoni.*

*Collection Records:* Ashland Co. 1 ♀; Burnett Co. 1 ♀; Clark Co. 1 ♂, 2 ♀; Douglas Co. 3 ♂; Dunn Co. 1 ♂; Eau Claire Co. 1 ♂; Florence Co. 1 ♂; Forest Co. 1 ♂, 3 ♀; Jackson Co. 1 ♀; Juneau Co. 2 ♂, 2 ♀; Langlade Co. 6 ♂, 6 ♀; Lincoln Co. 4 ♂, 5 ♀; Marathon Co. 11 ♂, 6 ♀; Oneida Co. 1 ♂; Portage Co. 5 ♀; Price Co. 2 ♀; Rusk Co. 2 ♂; Sawyer Co. 4 ♂, 3 ♀; Taylor Co. 3 ♂, 7 ♀; Vilas Co. 1 ♂; Wood Co. 2 ♂, 2 ♀. *Totals: 90* individuals, *34* collections, *21* counties.

*Previous Records:* None. Reported from Illinois and Minnesota.

### *Sigara knighti* Hungerford 1948

*Distribution and Abundance:* This uncommon species occurs only in the northern third of the state (Fig. 4D).

*Identification:* The females may be separated from *S. johnstoni* and *S. variabilis* by their mesally notched anal lobes.

*Collection Records:* Ashland Co. 1 ♀; Bayfield Co. 2 ♂, 1 ♀; Douglas Co. 1 ♂; Florence Co. 5 ♂, 6 ♀; Forest Co. 8 ♂, 12 ♀; Langlade Co. 4 ♀; Price Co. 4 ♀; Vilas Co. 2 ♂, 3 ♀. *Totals: 49* individuals, *12* collections, *8* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

### *Sigara lineata* (Forster) 1771

*Distribution and Abundance:* Where it occurs, this species may be found in tremendous numbers. It is common throughout much of the state, and has been collected mostly in areas where there is sandy soil (Fig. 5B).

*Identification:* The very small size and striped hemelytra make this species easy to recognize.

*Collection Records:* Adams Co. 76 ♂, 101 ♀; Ashland Co. 93 ♂, 164 ♀; Columbia Co. 335 ♂, 329 ♀; Crawford Co. 7 ♂, 14 ♀; Dane Co. 7 ♂, 13 ♀; Dunn Co. 7 ♂, 3 ♀; Eau Claire Co. 1 ♀; Florence Co. 491 ♂, 515 ♀; Juneau Co. 24 ♂, 19 ♀; Lincoln Co. 2 ♂, 1 ♀; Marathon Co. 91 ♂, 157 ♀; Marquette Co. 1 ♀; Oneida Co. 1 ♂, 2 ♀; Outagamie Co. 3 ♀; Portage Co. 8 ♂, 17 ♀; Price Co. 18 ♂, 20 ♀; Rusk Co. 4 ♂, 4 ♀; Sauk Co. 62 ♂, 59 ♀; Taylor Co. 5 ♂, 4 ♀; Trempealeau Co. 41 ♂, 122 ♀; Vilas Co. 84 ♂, 76 ♀. *Totals: 2981* individuals, *78* collections, *21* counties.

*Previous Records:* None. Reported from Illinois and Minnesota.

### *Sigara mackinacensis* (Hungerford) 1928

*Distribution and Abundance:* The distribution of this species is restricted to the northern half of the state where it is fairly common (Fig. 5C).

*Identification:* The distinctly marked membrane separates it from *S. compressoidea,* the only species with which it might be confused.

*Collection Records:* Barron Co. 1 ♀; Chippewa Co. 1 ♀; Clark Co. 2 ♂, 1 ♀; Douglas Co. 1 ♀; Eau Claire Co. 2 ♂; Florence Co. 5 ♂, 8 ♀; Forest Co. 4 ♂, 5 ♀; Lincoln Co. 4 ♂, 2 ♀; Oconto Co. 1 ♀; Oneida Co. 2 ♂, 3 ♀; Polk Co. 4 ♀; Sawyer Co. 3 ♀; Vilas Co. 4 ♂, 7 ♀; Washburn Co. 25 ♂, 36 ♀; Wood Co. 4 ♂, 4 ♀. *Totals: 129* individuals, *27* collections, *15* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

### *Sigara macropala* (Hungerford) 1926

*Distribution and Abundance:* This species is uncommon in Wisconsin, and has been collected only in the extreme north (Fig. 5D).

*Identification:* The large dorsal extension of the male pala is distinctive. The sharply pointed metaxyphus separates this species from *S. bicoloripennis* and *S. defecta,* and it can be easily separated from the larger *S. alternata* by the pattern on the clavis and the fewer number of black bars on the prothorax.

*Collection Records:* Burnett Co. 1 ♀; Douglas Co. 1 ♀; Florence Co. 21 ♂, 20 ♀; Washburn Co. 11 ♂, 11 ♀. *Totals: 65* individuals, *5* collections, *4* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

### *Sigara mathesoni* Hungerford 1948

*Distribution and Abundance:* A very common species throughout the entire state, it seems to have an affinity for spring ponds (Fig. 4C).

*Identification:* The median brown stripe on the head and the deep incision at the lateral bend of the mesoepimeron are distinctive.

*Collection Records:* Adams Co. 4 ♂, 9 ♀; Ashland Co. 1 ♂, 2 ♀; Barron Co. 1 ♀; Calumet Co. 1 ♂; Chippewa Co. 1 ♂, 2 ♀; Columbia Co. 12 ♂, 28 ♀; Crawford Co. 12 ♂, 16 ♀; Dane Co. 36 ♂, 56 ♀; Dodge Co. 13 ♂, 16 ♀; Door Co. 16 ♂, 51 ♀; Florence Co. 30 ♂, 86 ♀; Forest Co. 1 ♂, 3 ♀; Grant Co. 1 ♂; Green Co. 1 ♂; Iowa Co. 39 ♂, 29 ♀; Jefferson Co. 5 ♂, 13 ♀; Juneau Co. 2 ♂, 4 ♀; Langlade Co. 2 ♀; Lincoln Co. 16 ♂, 22 ♀; Marinette Co. 1 ♀; Marquette Co. 4 ♀; Monroe Co. 29 ♂, 33 ♀; Price Co. 83 ♂, 124 ♀; St. Croix Co. 3 ♀; Sauk Co. 1 ♂; Vernon Co. 1 ♂; Vilas Co. 1 ♂, 3 ♀; Walworth Co. 2 ♂, 5 ♀; Washburn Co. 1 ♂, 2 ♀; Washington Co. 1 ♀; Waukesha Co. 67 ♂, 106 ♀; Waushara Co. 5 ♂, 4 ♀. *Totals : 1007* individuals, *69* collections, *33* counties.

*Previous Records:* Dane Co. 4 ♂, 5 ♀; Douglas Co. 14 ♂, 13 ♀; Sauk Co. 1 ♀. Also reported from Michigan and Minnesota.

### *Sigara mullettensis* (Hungerford) 1928

*Distribution and Abundance:* This species is fairly common throughout the northern two-thirds of the state, with only two scattered records from the southern counties (Fig. 4B).

*Identification:* The females could be confused with those of *S. defecta*, which also tend to have the corial pattern in a longitudinal series. In *S. mullettensis* the female pala is much shorter, and the anal lobes are only slightly notched.

*Collection Records:* Ashland Co. 7 ♂, 6 ♀; Burnett Co. 4 ♂, 4 ♀; Chippewa Co. 1 ♂; Clark Co. 1 ♂; Door Co. 1 ♀; Douglas Co. 1 ♀; Eau Claire Co. 1 ♂; Forest Co. 1 ♀; Juneau Co. 1 ♂; Langlade Co. 2 ♂, 5 ♀; Lincoln Co. 2 ♂, 5 ♀; Marathon Co. 1 ♂, 3 ♀; Oconto Co. 3 ♂, 1 ♀; Outagamie Co. 2 ♂, 3 ♀; Ozaukee Co. 1 ♂; Polk Co. 1 ♀; Portage Co. 1 ♂, 1 ♀; Price Co. 1 ♀; Sawyer Co. 2 ♂; Taylor Co. 16 ♂, 14 ♀; Vilas Co. 3 ♀; Winnebago Co. 11 ♂, 27 ♀. *Totals: 133* individuals, *35* collections, *23* counties.

*Previous Records:* Dane Co. 1 ♀. Also reported from Michigan and Minnesota.

### *Sigara penniensis* (Hungerford) 1928

*Distribution and Abundance:* This species is fairly common in the northern two-thirds of the state (Fig. 5A).

*Identification:* This large, dark colored *Sigara* can be recognized by the narrow interocular space and the pale markings of the corium being arranged in a definite longitudinal series.

*Collection Records:* Adams Co. 1 ♀; Burnett Co. 2 ♂, 3 ♀; Clark Co. 1 ♂; Door Co. 1 ♀; Douglas Co. 4 ♂, 10 ♀; Forest Co. 1 ♀; Florence Co. 3 ♂, 7 ♀; Jackson Co. 2 ♀; Lincoln Co. 7 ♂, 9 ♀; Oconto Co. 3 ♂; Oneida Co. 1 ♂, 3 ♀; Polk Co. 1 ♂; Vilas Co. 6 ♂, 2 ♀; Washington Co. 3 ♂, 1 ♀. *Totals: 71* individuals, *26* collections, *14* counties.

*Previous Records:* None. Reported from Michigan and Minnesota.

### *Sigara signata* (Fieber) 1851

*Distribution and Abundance:* This species is common in the northern two-thirds of the state but has not been collected in the southern counties or the counties bordering Lake Michigan or the Mississippi River (Fig. 5D).

*Identification:* This dark little species looks like a miniature *H. minorella*. It is much darker than *S. solensis*, and can be easily separated by the characters given in the key.

*Collection Records:* Adams Co. 1 ♂, 7 ♀; Ashland Co. 3 ♂, 3 ♀; Barron Co. 1 ♂; Burnett Co. 1 ♂, 6 ♀; Chippewa Co. 1 ♀; Clark Co. 6 ♀; Douglas Co. 3 ♀; Eau Claire Co. 3 ♂, 9 ♀; Florence Co. 34 ♂, 67 ♀; Forest Co. 3 ♂, 8 ♀; Iron Co. 2 ♀; Juneau Co. 5 ♂, 5 ♀; Langlade Co. 2 ♂, 1 ♀; Lincoln Co. 26 ♂, 29 ♀; Marathon Co. 9 ♂, 13 ♀; Marinette Co. 2 ♀; Marquette Co. 1 ♀; Monroe Co. 1 ♂, 1 ♀; Oconto Co. 5 ♂, 7 ♀; Oneida Co. 13 ♂, 17 ♀; Polk Co. 1 ♂, 5 ♀; Portage Co. 2 ♂; Price Co. 3 ♂, 4 ♀; Rusk Co. 5 ♂, 7 ♀; Sawyer Co. 4 ♂, 2 ♀; Shawano Co. 1 ♀; Taylor Co. 4 ♂, 4 ♀; Vilas Co. 19 ♂, 45 ♀; Washburn Co. 2 ♀; Waupaca Co. 1 ♀; Waushara Co. 1 ♂, 1 ♀; Wood Co. 1 ♂, 4 ♀. *Totals: 411* individuals, *96* collections, *31* counties.

*Previous Records:* Douglas Co. 1 ♀. Also reported from Illinois, Michigan and Minnesota.

### *Sigara solensis* (Hungerford) 1926

*Distribution and Abundance:* Except for the extreme southern and eastern counties, this species has been collected throughout the state (Fig. 4C). It is fairly common in many areas.

*Identification:* Readily distinguished by the characters in the key.

*Collection Records:* Adams Co. 5 ♂, 6 ♀; Ashland Co. 1 ♂; Dane Co. 2 ♂, 2 ♀; Douglas Co. 1 ♂; Eau Claire Co. 2 ♂, 1 ♀; Florence Co. 11 ♂, 23 ♀; Forest Co. 1 ♂; Green Lake Co. 2 ♂; Lincoln Co. 5 ♂, 3 ♀; Marathon Co. 2 ♂; Marquette Co. 12 ♂, 10 ♀; Oconto Co. 1 ♂; Oneida Co. 1 ♂; Polk Co. 1 ♂; Rusk Co. 1 ♀; Sauk Co. 1 ♀; Taylor Co. 3 ♂, 2 ♀; Trempealeau Co. 1 ♀;

Vilas Co. 1 ♀; Winnebago Co. 34 ♂, 37 ♀. *Totals: 172* individuals, *40* collections, *20* counties.

*Previous Records:* Dane Co. 24 ♂, 23 ♀. Also reported from Michigan and Minnesota.

*Sigara transfigurata* (Walley) 1930

*Distribution and Abundance:* This rare species was collected at only two sites, one in Vilas Co. in the extreme north and one in Marathon Co. in the central part of the state (Fig. 4D).

*Identification:* The bold cross-bars on the corium separate this species from others with a pale longitudinal line on the pronotum.

*Collection Records:* Marathon Co. 1 ♂; Vilas Co. 2 ♂. *Totals: 3* individuals, *2* collections, *2* counties.

*Previous Records:* None. Reported from Michigan.

*Sigara trilineata* (Provancher) 1872

*Distribution and Abundance:* Collected throughout the state, except in the extreme eastern and western counties (Fig. 5B). Like *S. lineata,* with which it often occurs, it seems most prevalent in sandy areas.

*Identification:* The bold longitudinal stripes on the hemelytra and the wide mesoepimeron separate it from all other species.

*Collection Records:* Adams Co. 129 ♂, 199 ♀; Barron Co. 1 ♂, 1 ♀; Chippewa Co. 1 ♂, 2 ♀; Columbia Co. 3 ♂, 3 ♀; Dane Co. 7 ♂, 7 ♀; Douglas Co. 2 ♂; Eau Claire Co. 1 ♂, 1 ♀; Florence Co. 101 ♂, 159 ♀; Forest Co. 2 ♂; Iowa Co. 50 ♂, 41 ♀; Juneau Co. 56 ♂, 82 ♀; Lincoln Co. 6 ♂, 9 ♀; Marathon Co. 44 ♂, 50 ♀; Marinette Co. 6 ♀; Marquette Co. 2 ♂; Monroe Co. 2 ♀; Oconto Co. 6 ♂, 8 ♀; Portage Co. 1 ♂, 2 ♀; Price Co. 1 ♂; Rusk Co. 13 ♂, 6 ♀; Sauk Co. 22 ♂, 29 ♀; Taylor Co. 2 ♂, 2 ♀; Vilas Co. 78 ♂, 162 ♀; Washburn Co. 1 ♂, 4 ♀; Waupaca Co. 2 ♂, 5 ♀; Wood Co. 1 ♂. *Totals: 1312* individuals, *83* collections, *26* counties.

*Previous Records:* Burnett Co. 1 ♂, 4 ♀. Also reported from Michigan and Minnesota.

*Sigara variabilis* (Hungerford) 1926

*Distribution and Abundance:* Although it was collected only in the northwestern half of the state (Fig. 5C), collections in Illinois and Michigan suggest that this uncommon species should be found in the rest of the state as well.

*Identification:* The pala of the male is distinctive, but the females resemble *S. johnstoni.* They can be separated from that species by the lack of an incision in the metaxyphus, the wider and more widely spaced pale figures on the corium, and the slight mesal indentation of the anal lobes.

*Collection Records:* Crawford Co. 2 ♂, 1 ♀; Douglas Co. 3 ♀; Dunn Co. 1 ♂, 1 ♀; Juneau Co. 1 ♀; Marathon Co. 1 ♂; Oneida Co. 3 ♂, 5 ♀; Portage Co. 1 ♂; Trempealeau Co. 1 ♂, 3 ♀. *Totals: 23* individuals, *10* collections, *8* counties.

*Previous Records:* None. Reported from Illinois and Michigan.

## *Trichocorixa* Kirkaldy

Four species of *Trichocorixa* have been collected in Wisconsin, with all species being most common in the southern third of the state (Fig. 2D). A fifth species, *T. macroceps* (Kirkaldy) 1908, has been found in Illinois and Michigan and may occur in Wisconsin.

### Key to Wisconsin species

#### Males

1. Strigil small and round ____________________________________ 2
   Strigil very elongate ______________________________________ 3
2. Nodal furrow appearing absent or at apex of embolar groove; length of pronotal disc about one-fourth its width __ *T. macroceps*
   Nodal furrow dividing embolar groove; length of pronotal disc one-third or more its width _________________________ *T. naias*
3. Strigil extremely narrow, little more than a heavy dark line and usually curved abruptly upward at the mesal end ______ *T. calva*
   Strigil about 7 times as long as wide _______________________ 4
4. Strigil noticeably widened in region of the bend ____ *T. borealis*
   Strigil about the same width along its entire length, any slight widening occurring near the lateral end ____________ *T. kanza*

#### Females

1. Nodal furrow appearing absent or at apex of embolar groove __ 2
   Nodal furrow dividing embolium ____________________________ 3
2. Length of pronotal disc about one-fourth its width _ *T. macroceps*
   Length of pronotal Disc one-third or more its width ____ *T. naias*
3. Length of apical area of embolar groove exceeding length of middle tarsus ___________________________________ *T. borealis*
   Length of apical area less than that of middle tarsus ________ 4
4. At least 2 patches of bristle-like setae on right side of seventh abdominal sternite _____________________________ *T. kanza*
   Only fine pubescence on right side of seventh abdominal sternite ______________________________________________ *T. calva*

*Trichocorixa borealis* Sailer 1948

*Distribution and Abundance:* This species is common throughout the southern third of the state and has been collected as far north as Barron and Langlade Counties (Fig. 2D).

*Identification:* The strigil of the male, which is widened at the bend, and the long postnodal pruinose area in the female separate this species. In most females there is a distinct outward projection at the anterior end of the polished prenodal area.

*Collection Records:* Adams Co. 13 ♂, 15 ♀; Barron Co. 2 ♀; Brown Co. 12 ♂, 31 ♀; Columbia Co. 16 ♂, 49 ♀; Crawford Co. 1 ♂, 2 ♀; Dane Co. 64 ♂, 100 ♀; Dodge Co. 12 ♂, 25 ♀; Dunn Co. 3 ♂, 2 ♀; Green Co. 1 ♀; Green Lake Co. 84 ♂, 141 ♀; Iowa Co. 5 ♂, 6 ♀; Jefferson Co. 2 ♂, 5 ♀; Juneau Co. 3 ♂; Kenosha Co. 18 ♂, 26 ♀; Kewaunee Co. 2 ♀; La Crosse Co. 1 ♀; Lincoln Co. 2 ♂, 1 ♀; Manitowoc Co. 1 ♀; Marathon Co. 1 ♂, 2 ♀; Marquette Co. 4 ♂, 8 ♀; Outagamie Co. 6 ♂, 7 ♀; Racine Co. 2 ♂; Rock Co. 2 ♀; Sauk Co. 24 ♂, 25 ♀; Sheboygan Co. 1 ♂, 1 ♀; Trempealeau Co. 1 ♀; Walworth Co. 65 ♂, 69 ♀; Washington Co. 1 ♂, 2 ♀; Winnebago Co. 1 ♂. *Totals: 867* individuals, *65* collections, *29* counties.

*Previous Records:* None. Reported from Iowa and Minnesota.

*Trichocorixa calva* (Say) 1832

*Distribution and Abundance:* This species is fairly common in the southern half of the state, and apparently does not occur in the north (Fig. 2D).

*Identification:* The males can be identified by their extremely narrow strigil. The females can be separated from *T. kanza* by the lack of patches of setae on the right side of the seventh abdominal sternite.

*Collection Records:* Adams Co. 1 ♀; Columbia Co. 1 ♀; Crawford Co. 30 ♂, 35 ♀; Dane Co. 2 ♀; Dodge Co. 1 ♂, 1 ♀; Fond du Lac Co. 1 ♂; Grant Co. 6 ♂, 10 ♀; Green Co. 1 ♂, 3 ♀; Green Lake Co. 1 ♀; Iowa Co. 1 ♀; Jefferson Co. 1 ♀; Juneau Co. 2 ♂, 1 ♀; Kenosha Co. 80 ♂, 90 ♀; Kewaunee Co. 1 ♀; Lafayette Co. 1 ♂, 3 ♀; Manitowoc Co. 1 ♂; Marquette Co. 14 ♂, 15 ♀; Milwaukee Co. 2 ♂, 1 ♀; Monroe Co. 1 ♂; Outagamie Co. 1 ♀; Racine Co. 7 ♂, 11 ♀; Rock Co. 1 ♀; Sauk Co. 1 ♀; Trempealeau Co. 2 ♂, 1 ♀; Walworth Co. 1 ♂, 8 ♀; Washington Co. 3 ♂, 2 ♀; Waukesha Co. 1 ♀. *Totals: 346* individuals, *37* collections, *26* counties.

*Previous Records:* Dane Co. (no numbers). Also reported from Illinois, Iowa, Michigan and Minnesota.

## *Trichocorixa kanza* Sailer 1948

*Distribution and Abundance:* Found only in the extreme southwest corner of the state, this species is uncommon (Fig. 2D).

*Identification:* The male strigil is much wider than that of *T. calva,* and slightly narrower than *T. borealis.* The female has three small and distinct patches of setae on the right side of the seventh abdominal sternite.

*Collection Records:* Dane Co. 1 ♂, 2 ♀; Grant Co. 1 ♂, 1 ♀; Lafayette Co. 8 ♂, 4 ♀. *Totals: 17* individuals, *7* collections, *3* counties.

*Previous Records:* Dane Co. (no numbers). Also reported from Illinois and Iowa.

## *Trichocorixa naias* (Kirkaldy) 1908

*Distribution and Abundance:* This species is fairly common in the southern fourth of the state, and has been collected as far north as Door and Lincoln Counties (Fig. 2D).

*Identification:* The absence of a postnodal pruinose area in the female and the small rounded strigil of the male separate this species from other Wisconsin *Trichocorixa,* except *T. macroceps,* which has a very short pronotal disc.

*Collection Records:* Columbia Co. 16 ♂, 22 ♀; Dane Co. 39 ♂, 41 ♀; Dodge Co. 3 ♀; Door Co. 4 ♂, 4 ♀; Iowa Co. 1 ♀; Jefferson Co. 1 ♀; Lincoln Co. 3 ♂, 3 ♀; Manitowoc Co. 4 ♂, 6 ♀; Marathon Co. 1 ♂; Outagamie Co. 2 ♂, 1 ♀; Ozaukee Co. 3 ♂, 1 ♀; Racine Co. 1 ♂; Walworth Co. 2 ♀; Waukesha Co. 1 ♀; Wood Co. 6 ♂, 3 ♀. *Totals: 168* individuals, *30* collections, *15* counties.

*Previous Records:* Dane Co. (no numbers). Also reported from Illinois, Iowa, Michigan and Minnesota.

## Literature Cited

Brooks, A. R. and L. A. Kelton. 1967. Aquatic and semiaquatic Heteroptera of Alberta, Saskatchewan, and Manitoba (Hemiptera). Mem. Entomol. Soc. Canada No. 51. 92 pp.

Hungerford, H. B. 1948. The Corixidae of the Western Hemisphere (Hemiptera) Univ. Kansas Sci. Bull. 32: 1–288, 408–827.

Sailer, R. I. 1948. The genus *Trichocorixa* (Corixidae, Hemiptera). Univ. Kansas Sci. Bull. 32: 289–407.

# TROPHIC NATURE OF SELECTED WISCONSIN LAKES

*Lloyd A. Lueschow, James M. Helm, Donald R. Winter and Gary W. Karl*

Appreciable differences in the biota of Wisconsin lakes are apparent to even the most insensitive eye. Some lakes, such as Geneva (Walworth County) and Crystal (Vilas County), are essentially clear; others, such as Winnebago (Winnebago County) and Delavan (Walworth County), develop nuisance growths of algae, weeds, or both. Limnologists have long recognized these differences in biological composition and productivity to be related to the accumulation of nutrients and have referred to this aging process as "eutrophication." Most lakes when formed are nutrient poor or oligotrophic. They subsequently proceed to a nutrient rich, eutrophic condition. Although the distinction between oligotrophic and eutrophic lakes is, by definition, based on nutrient status, many parameters are often used to reflect the trophic status of a lake.

The object of this study was to evaluate several water quality parameters from well-known lakes where the recreational potential is recognized by the public and where long records of observation and aquatic nuisance control are available. Each of these "trophic parameters" is evaluated in terms of how well it relates to both the trophic status and the observed recreational values of each lake. A better understanding of these relationships should lead to more meaningful interpretation of water quality data, more efficient sampling programs, and better diagnostic and interpretive techniques for evaluating lake problems.

## Lakes Included in the Study

The 12 lakes shown in Table 1 were selected because they are all well known and because they represent a broad range of conditions. Of the lakes selected, three (Pewaukee, Delavan, and Winnebago) have nuisance algae "blooms" during most of the summer months which render the waters less desirable for recreational purposes. A fourth (Mendota) has occasional nuisance algae populations. Rooted weed growths and *Chara sp.* growths also impair recreational potential, and Lakes Middle, Oconomowoc, Pine, and Pewaukee all have had extensive weed control activity. Lakes Mendota and Winnebago have received less weed control effort, but weeds produce local nuisances on both during the summer months.

TABLE 1. GENERAL LAKE INFORMATION

| Lake | Crystal | Geneva | Green | Trout | Middle | Mendota |
|---|---|---|---|---|---|---|
| County | Vilas | Walworth | Green Lake | Vilas | Walworth | Dane |
| Area (Acres) | 90 | 5,104 | 7,325 | 3,870 | 256 | 9,730 |
| Maximum Depth (feet) | 69 | 135 | 229 | 115 | 42 | 82 |
| Development | minor | moderate | moderate | minor | moderate | extensive |
| pH (Nov.) | 6.0 | 8.0 | 8.1 | 7.1 | 8.1 | 8.1 |
| Hardness (Nov.) | 4 | 208 | 200 | 50 | 217 | 180 |
| Alkalinity (Nov.) | 2 | 168 | 162 | 39 | 181 | 149 |
| Plankton Nuisance | none | none | minor | none | minor | moderate |
| Chara Nuisance | none | none | moderate | none | none | none |
| Weed Nuisance | none | minor | minor | minor | moderate | moderate |
| Lake | Round | Oconomowoc | Pine | Pewaukee | Delavan | Winnebago |
| County | Waupaca | Waukesha | Waukesha | Waukesha | Walworth | Winnebago |
| Area (Acres) | 106 | 767 | 703 | 2,359 | 2,072 | 137,708 |
| Maximum Depth (feet) | 67 | 62 | 85 | 45 | 56 | 21 |
| Development | moderate | moderate | moderate | extensive | extensive | extensive |
| pH (Nov.) | 9.3 | 8.3 | 8.2 | 8.3 | 8.2 | 8.15 |
| Hardness (Nov.) | 170 | 233 | 168 | 244 | 200 | 156 |
| Alkalinity (Nov.) | 144 | 186 | 143 | 188 | 160 | 136 |
| Plankton Nuisance | minor | minor | minor | heavy | heavy | heavy |
| Chara Nuisance | none | heavy | moderate | minor | none | none |
| Weed Nuisance | none | moderate | moderate | heavy | minor | minor |

Lakes Oconomowoc and Pine have had extensive *Chara sp.* control programs, and Big Green Lake has had an occasional *Chara sp.* nuisance but no control activity.

## Trophic Parameters and Methods

Parameters selected for this study included the nutrients nitrogen and phosphorus, temperature, dissolved oxygen, water transparency and plankton analysis. Nitrogen was analyzed as organic nitrogen, Ammonia–N, Nitrate–N, Nitrite–N. The $NH_3$–N, $NO_3$–N, and $NO_2$–N concentrations were combined as inorganic nitrogen and considered available for utilization. Phosphorus was analyzed as soluble phosphorus (orthophosphates) and total phosphorus. All nutrient analyses were performed by the Wisconsin Laboratory of Hygiene in accordance with Standard Methods, 12th edition, 1965, and results are expressed in mg/l of nitrogen and phosphorus.

Temperature profiles were determined with an electronic resistance thermometer. Dissolved oxygen concentrations were determined by the modified Winkler technique, Standard Methods, 1965. Water transparency was measured with a Secchi disk and also with a Whitney light meter. Light meter values are expressed in per cent of surface incident light at each depth.

Plankton evaluations were based on net collections using a Clarke–Bumpus plankton sampler. The Clarke–Bumpus apparatus measures a known volume of water passed through the net, and the volume of plankton captured can then be used to evaluate the concentration of plankton in the water. The net used was a No. 20 standard mesh (.007 inch bar). Most plankton samples required a 1–5 minute tow depending on the quantity of plankton in the water. Samples were transferred from the plankton cup to 180 ml. storage jars, and 10 ml. of commercial formaldehyde were added for preservation. The samples were then returned to the laboratory for evaluation at a later date.

The volume of plankton constituents was estimated by visual observation under a dissecting or compound microscope. The samples were then dried and ashed to determine total and volatile solids. Plankton quantity was then reported as total solids and expressed as micrograms of solids per liter of water filtered.

## Results and Discussion

### Dissolved Oxygen and Temperature

The dissolved oxygen concentration in the hypolimnion may be used as a trophic parameter. Organic material produced in the trophogenic zone eventually settles through the thermocline into the tropholytic zone where it consumes oxygen during chemical and

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966

| | Crystal | | Geneva | | Green | | Trout | | Middle | | Mendota | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T* | DO† | T | DO | T | DO | T | DO | T | DO | T | DO |
| January | | | | | | | | | | | | |
| Surface | 32 | 13.2 | No Sample | | 32 | 12.8 | 32 | — | — | 12.8 | 32 | 14.0 |
| Middle of Hypolimnion | — | — | | | 32 | 13.0 | 33 | 12.9 | — | — | 32 | 12.0 |
| 1 M above bottom | 33 | 13.5 | | | — | — | 33 | — | — | 11.8 | 32 | 8.4 |
| February | | | | | | | | | | | | |
| Surface | 32 | 7.3 | 33 | 14.3 | 32 | 13.2 | 32 | 12.1 | 32 | 11.8 | 33 | 12.7 |
| Middle of Hypolimnion | 36 | 12.5 | 34 | 14.2 | 34 | 13.2 | 32 | 12.5 | .. | .. | 34 | 10.1 |
| 1 M above bottom | 37 | 12.6 | 34 | 12.5 | — | — | 32 | 11.1 | 37 | 10.2 | 34 | 4.5 |
| March | | | | | | | | | | | | |
| Surface | 33 | 12.6 | 35 | 12.7 | 32 | 12.6 | 34 | 12.2 | 42 | 11.1 | 34 | 13.9 |
| Middle of Hypolimnion | 36 | 10.0 | 35 | 12.8 | 34 | 12.7 | 34 | 12.3 | 40 | 10.8 | 34 | 13.1 |
| 1 M above bottom | 36 | 12.3 | 35 | 12.5 | — | — | 34 | 12.5 | 40 | 10.0 | 34 | 13.0 |
| April | | | | | | | | | | | | |
| Surface | 40 | 12.4 | 41 | 12.2 | 38 | 12.2 | No Sample | | 52 | 11.3 | 40 | 12.8 |
| Middle of Hypolimnion | 38 | 10.2 | 38 | 12.0 | 38 | 12.0 | | | 42 | 11.8 | 40 | 12.8 |
| 1 M above bottom | 38 | 11.7 | 38 | 12.1 | — | — | | | 42 | 11.4 | 40 | 12.9 |
| May | | | | | | | | | | | | |
| Surface | 46 | 11.45 | 45 | 11.3 | 41 | 12.2 | 42 | 11.95 | 52 | 10.5 | 50 | 10.8 |
| Middle of Hypolimnion | 43 | 11.85 | 45 | 11.4 | 41 | 12.2 | 42 | 11.75 | 50 | 11.2 | 47 | 10.7 |
| 1 M above bottom | 42 | 11.65 | 45 | 11.4 | — | — | 42 | 11.55 | 48 | 8.7 | 47 | 10.7 |
| June | | | | | | | | | | | | |
| Surface | 64 | 9.05 | 61 | 10.0 | 61 | 10.85 | 59 | 10.35 | 68 | 7.5 | 68 | 12.3 |
| Middle of Hypolimnion | 50 | 11.8 | 52 | 9.7 | 52 | 11.85 | 50 | 10.75 | 52 | 8.05 | 57 | 7.6 |
| 1 M above bottom | 48 | 11.9 | 50 | 9.7 | — | — | 49 | 10.15 | 52 | 4.8 | 56 | 5.8 |

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966—*Continued*

| | CRYSTAL | | GENEVA | | GREEN | | TROUT | | MIDDLE | | MENDOTA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T* | DO† | T | DO | T | DO | T | DO | T | DO | T | DO |
| July | | | | | | | | | | | | |
| Surface | 73 | 8.0 | 77 | 8.5 | 73 | 8.4 | 72 | 8.1 | 79 | 8.1 | 77 | 8.5 |
| Middle of Hypolimnion | 51 | 10.8 | 59 | 6.5 | 54 | 11.0 | 50 | 7.0 | 59 | 11.0 | 59 | 0.8 |
| 1 M above bottom | 48 | 8.9 | — | 4.8 | — | — | — | 6.2 | 58 | 0.0 | 57 | 0.0 |
| August | | | | | | | | | | | | |
| Surface | 69 | 8.2 | 70 | 7.6 | No Sample | | 68 | 8.7 | 70 | 7.6 | 70 | 8.2 |
| Middle of Hypolimnion | 51 | 6.8 | 59 | 5.5 | | | 50 | 6.4 | 58 | 1.6 | 55 | 1.9 |
| 1 M above bottom | 50 | 5.0 | — | 3.8 | | | — | 2.1 | 47 | 0.0 | — | 0.0 |
| September | | | | | | | | | | | | |
| Surface | 65 | 8.65 | 69 | 9.0 | 67 | 8.7 | 64 | 8.65 | 67 | 8.8 | 66 | 8.0 |
| Middle of Hypolimnion | 56 | 5.15 | — | 3.5 | 67 | — | 52 | 5.4 | 64 | 1.1 | 54 | 0.0 |
| 1 M above bottom | 52 | 3.15 | — | 2.0 | 67 | 9.9 | — | 3.0 | 51 | 0.0 | — | 0.0 |
| October | | | | | | | | | | | | |
| Surface | 53 | 8.8 | 54 | 8.3 | 54 | 9.6 | 52 | 8.9 | 53 | 8.0 | 50 | 8.5 |
| Middle of Hypolimnion | 53 | 8.6 | 54 | 8.0 | 54 | 9.1 | 52 | 6.1 | 53 | 7.7 | 50 | 8.8 |
| 1 M above bottom | 53 | 8.0 | — | 1.0 | — | — | 52 | 1.9 | 53 | 5.2 | 50 | 8.8 |
| November | | | | | | | | | | | | |
| Surface | 40 | 10.5 | 46 | 9.5 | 42 | 8.1 | 40 | 10.6 | 41 | 11.2 | 44 | 9.6 |
| Middle of Hypolimnion | 40 | 10.5 | 46 | 9.4 | 42 | 8.1 | 40 | 10.5 | 41 | 11.3 | 44 | 9.0 |
| 1 M above bottom | 40 | 10.5 | 46 | 9.3 | — | — | 40 | 10.5 | 41 | 11.3 | 44 | 10.2 |

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966—*Continued*

| | Round | | Oconomowoc | | Pine | | Pewaukee | | Delavan | | Winnebago | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | DO | T | DO | T | DO | T | DO | T | DO | T | DO |
| January | | | | | | | | | | | | |
| Surface | 32 | 11.7 | 32 | — | 32 | 13.4 | 32 | 13.7 | — | 12.7 | 32 | 12.8 |
| Middle of Hypolimnion | 37 | 13.1 | — | — | 34 | 12.5 | — | — | — | 12.4 | — | — |
| 1 M above bottom | 37 | 14.1 | 34 | 12.5 | 34 | 12.4 | 35 | 7.55 | — | 11.6 | 33 | 13.0 |
| February | | | | | | | | | | | | |
| Surface | 32 | 12.1 | — | 13.1 | 34 | 13.3 | 32 | 12.6 | 32 | 12.4 | 32 | 13.4 |
| Middle of Hypolimnion | — | — | — | 12.8 | 34 | 13.5 | 36 | 8.1 | 33 | 12.2 | — | — |
| 1 M above bottom | 37 | 9.5 | — | 11.2 | 34 | 13.3 | 36 | 3.2 | 34 | 10.9 | 33 | 13.0 |
| March | | | | | | | | | | | | |
| Surface | 34 | 12.2 | 38 | 11.2 | 36 | 12.2 | 38 | 10.0 | 39 | 14.6 | 33 | 13.0 |
| Middle of Hypolimnion | — | — | 38 | 11.3 | 36 | 12.1 | — | — | 39 | 14.8 | — | — |
| 1 M above bottom | 38 | 12.4 | 38 | 11.2 | 36 | 12.2 | 38 | 8.9 | 39 | 14.7 | 34 | 13.0 |
| April | | | | | | | | | | | | |
| Surface | 48 | 11.4 | 46 | 12.2 | 46 | 11.7 | 46 | 11.7 | 43 | 11.5 | 47 | 11.9 |
| Middle of Hypolimnion | 41 | 5.9 | 42 | 11.9 | 40 | 11.7 | 42 | 11.0 | 41 | 10.2 | — | — |
| 1 M above bottom | 40 | 4.0 | 41 | 11.6 | — | 11.5 | 42 | 11.1 | 41 | 9.9 | 47 | 11.2 |
| May | | | | | | | | | | | | |
| Surface | 54 | 10.95 | 49 | 11.0 | 46 | 11.4 | 50 | 11.0 | 49 | 10.5 | 45 | 10.2 |
| Middle of Hypolimnion | 45 | 4.5 | 49 | 10.7 | 46 | 11.0 | 50 | 10.8 | 49 | 10.8 | — | — |
| 1 M above bottom | 42 | 3.55 | 49 | 10.2 | 46 | 10.5 | 50 | 10.9 | 49 | 10.6 | 45 | 10.0 |
| June | | | | | | | | | | | | |
| Surface | 70 | 8.95 | 66 | 8.5 | 66 | 9.35 | 66 | 8.65 | 76 | 13.1 | 66 | 11.4 |
| Middle of Hypolimnion | 56 | 8.15 | 54 | 8.0 | 50 | 8.7 | 59 | 2.45 | 58 | 0.1 | — | — |
| 1 M above bottom | 54 | 3.6 | 52 | 6.8 | 50 | 7.85 | 57 | 0.35 | 55 | 0.1 | 65 | 9.0 |

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966—*Continued*

| | Round | | Oconomowoc | | Pine | | Pewaukee | | Delavan | | Winnebago | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | DO | T | DO | T | DO | T | DO | T | DO | T | DO |
| July | | | | | | | | | | | | |
| Surface | 75 | 8.7 | 81 | 8.6 | 77 | 8.9 | 77 | 8.3 | 77 | 7.6 | 76 | 8.0 |
| Middle of Hypolimnion | 52 | 6.9 | 57 | 2.2 | 54 | 2.6 | 64 | 0.0 | 66 | 0.0 | — | — |
| 1 M above bottom | 47 | 1.0 | 57 | 0.4 | 54 | 0.1 | 62 | 0.0 | 63 | 0.0 | 76 | 7.9 |
| August | | | | | | | | | | | | |
| Surface | 74 | 8.2 | 69 | 7.7 | 70 | 8.3 | 70 | 7.2 | 70 | 7.4 | | |
| Middle of Hypolimnion | 52 | 6.0 | 59 | 0.7 | 50 | 2.7 | — | — | 54 | 0.0 | No Sample | |
| 1 M above bottom | 46 | 2.5 | 52 | 0.3 | — | 1.6 | 56 | 0.0 | 54 | 0.0 | | |
| September | | | | | | | | | | | | |
| Surface | 68 | 9.2 | 67 | 8.7 | 66 | 9.0 | 65 | 5.9 | 68 | 6.7 | 68 | 8.1 |
| Middle of Hypolimnion | 48 | 0.4 | 54 | 1.0 | 47 | 0.35 | 65 | 0.0 | 62 | 0.0 | — | — |
| 1 M above bottom | 46 | 2.35 | 50 | 0.0 | — | 0.0 | 57 | — | 58 | 0.0 | — | — |
| October | | | | | | | | | | | | |
| Surface | 53 | 9.0 | 51 | 10.2 | 49 | 9.1 | 49 | 10.1 | 56 | 7.9 | 51 | 8.3 |
| Middle of Hypolimnion | 51 | 5.1 | 51 | 9.4 | 48 | 8.4 | 49 | 10.0 | 56 | 8.2 | — | — |
| 1 M above bottom | 44 | 0.15 | 51 | 9.2 | 48 | 0.0 | 49 | 9.7 | 56 | 8.0 | — | — |
| November | | | | | | | | | | | | |
| Surface | 43 | 9.3 | 44 | 8.2 | 44 | 9.6 | 41 | 11.2 | 42 | 11.0 | 34 | 12.8 |
| Middle of Hypolimnion | 43 | 9.3 | 44 | 8.4 | 44 | 9.6 | 41 | 11.2 | 42 | 11.0 | — | — |
| 1 M above bottom | 43 | 9.2 | 44 | 8.3 | 44 | 9.6 | 41 | 11.2 | 42 | 11.0 | — | — |

*Temperature in degrees Fahrenheit.
†Dissolved oxygen in mg/l.

biological stabilization. One may therefore assume that eutrophic lakes with a high productivity or standing crop would produce the most significant oxygen sag in the hypolimnion. These stabilization effects would of course be tempered by the volume of water in the hypolimnion, but nevertheless the quantity of dissolved oxygen in the hypolimnion is indicative of the trophic nature of a lake. Furthermore, a low dissolved oxygen concentration in the hypolimnion would affect the salmonoid and whitefish populations that might be present in the lakes.

It should be noted that even the most oligotrophic lake sampled (Crystal) revealed some reduction in the dissolved oxygen concentration of the hypolimnion. During August, the 5 mg/l observed at 17 meters was only 45 per cent of saturation. Trout Lake and Lake Geneva also revealed substantial dissolved oxygen reductions in the hypolimnion although zero values were not observed. All of the more productive lakes revealed zero dissolved oxygen values during most of the summer months. These dissolved oxygen observations suggest that Lakes Delavan, Pewaukee, Pine, Oconomowoc, Middle, and Mendota produce more organic matter in the trophogenic zone than can be aerobically assimilated by the hypolimnion. Lakes Geneva, Trout, Crystal, and perhaps Pine have not reached that level of production and consequently retain sufficient dissolved oxygen in the hypolimnion to sustain fish and fish food organism populations intolerant of low dissolved oxygen values. Lake Winnebago is too shallow to stratify, so although it is a productive lake, a deoxygenated hypolimnion does not develop. Observations by Birge on Mendota in 1906 suggest that oxygen depletion in the hypolimnion occurred at that time as well as now.

## Transparency and Light Penetration

The transparency of a lake as measured by the Secchi disk may also be used as a measure of the trophic condition. The basic assumption is that the magnitude of organic production affects the color and turbidity of the water. Beeton, 1965, used the Secchi disk readings in the interpretation of the trophic nature of the Great Lakes and reported Lake Michigan as oligotrophic with a reading of 19½ feet. Values of fifteen to eighteen feet reported for Lakes Erie and Ontario were considered by Beeton to be comparatively eutrophic.

Only Crystal Lake had a mean Secchi disk reading that would be considered oligotrophic when compared with the Great Lakes. However, in all lakes where the mean Secchi disk values were greater than twelve feet, there has been essentially no deterioration of recreational potential due to plankton growths. Lakes

TABLE 3. TRANSPARENCY OF 12 WISCONSIN LAKES BY MONTH—1966
(Meters)

| | March | April | May | June | July | August | September | October | November | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Crystal | 3–15–66 | 4–25–66 | 5–17–66 | 6– 6–66 | 8– 1–66 | 8–30–66 | 9–16–66 | 10–11–66 | 11– 8–66 | Crystal |
| Secchi Disc | ice | 7.62 | 6.10 | 5.79 | 8.23 | 9.75 | 9.14 | 6.71 | 8.53 | 7.74 |
| 5% Light Int. | ice | 14.3 | 14.9 | 14.9 | 14.0 | 15.8 | 15.8 | 12.8 | 15.0 | 14.7 |
| 2. Geneva | 3–22–66 | 4–18–66 | 5–10–66 | 6– 9–66 | 8– 3–66 | 8–25–66 | 9–19–66 | 10–18–66 | 11–44–66 | Geneva |
| Secchi Disc | 4.88 | 5.49 | 4.27 | 5.18 | 3.35 | 2.74 | 3.96 | 5.33 | 6.10 | 4.60 |
| 5% Light Int. | 11.0 | 13.7 | 10.1 | 15.9 | 12.5 | 11.9 | 11.0 | 10.1 | 9.75 | 11.8 |
| 3. Green | 3– 9–66 | 4–21–66 | 5–12–66 | 6–10–66 | 8– 2–66 | — | 9–14–66 | 10–12–66 | 11–15–66 | Green |
| Secchi Disc | ice | 5.49 | 4.57 | 7.62 | 2.74 | — | 5.79 | 5.79 | 5.79 | 5.39 |
| 5% Light Int. | ice | 12.8 | 10.1 | — | 8.53 | — | 11.0 | 7.92 | 17.1 | 11.2 |
| 4. Trout | 3–15–66 | 4–25–66 | 5–17–66 | 6– 6–66 | 8– 1–66 | 8–30–66 | 9–16–66 | 10–11–66 | 11– 8–66 | Trout |
| Secchi Disc | ice | ice | 3.66 | 2.74 | 3.96 | 4.88 | 5.18 | 3.96 | 4.27 | 4.08 |
| 5% Light Int. | ice | ice | 9.14 | 10.1 | 8.99 | 7.92 | 8.84 | 6.40 | 5.49 | 8.11 |
| 5. Middle | 3–22–66 | 4–18–66 | 5–10–66 | 6– 9–66 | 8– 3–66 | 8–25–66 | 9–19–66 | 10–18–66 | 11–14–66 | Middle |
| Secchi Disc | 3.05 | 5.79 | 5.18 | 5.49 | 4.57 | 3.05 | 3.96 | 4.88 | 3.35 | 4.36 |
| 5% Light Int. | 7.01 | 11.9 | 9.14 | 10.4 | 7.01 | 11.9 | 8.84 | 11.9 | 7.32 | 9.48 |
| 6. Mendota | 3–28–66 | 4–20–66 | 5–10–66 | 6– 8–66 | 8– 5–66 | 8–26–66 | 9–21–66 | 10–24–66 | 11–11–66 | Mendota |
| Secchi Disc | 1.98 | 3.81 | 5.49 | 1.83 | 2.13 | 2.13 | 2.44 | 2.74 | 5.49 | 3.11 |
| 5% Light Int. | 3.51 | 7.01 | 7.92 | 2.44 | 3.96 | 3.96 | 4.88 | 4.88 | 8.84 | 5.27 |

TABLE 3. TRANSPARENCY OF 12 WISCONSIN LAKES BY MONTH—1966—*Continued*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 7. Round | 3–15–66 | 4–26–66 | 5–17–66 | 6– 6–66 | 8– 2–66 | 8–29–66 | 9–16–66 | 10–11–66 | 11– 7–66 | Round |
| Secchi Disc | ice | 2.44 | 3.35 | 6.10 | 4.27 | 3.35 | 4.27 | 3.35 | 4.27 | 3.93 |
| 5% Light Int. | ice | 5.94 | 7.92 | 11.0 | 14.3 | 11.0 | 11.3 | 7.92 | — | 9.91 |
| 8. Oconomowoc | 3–18–66 | 4–19–66 | 5– 9–66 | 6– 9–66 | 8– 4–66 | 8–24–66 | 9–20–66 | 10–28–66 | 11–10–66 | Oconomowoc |
| Secchi Disc | 4.88 | 3.35 | 4.27 | 7.32 | 3.35 | 6.10 | 4.57 | 3.05 | 2.74 | 4.39 |
| 5% Light Int. | 11.0 | 7.01 | 7.01 | 10.4 | 11.9 | 8.84 | 8.84 | 4.88 | 5.40 | 8.35 |
| 9. Pine | 3–18–66 | 4–19–66 | 5– 9–66 | 6– 9–66 | 8– 4–66 | 8–24–66 | 9–20–66 | 10–28–66 | 11–10–66 | Pine |
| Secchi Disc | 1.68 | 1.83 | 1.83 | 1.83 | 4.27 | 3.96 | 3.96 | 2.44 | 2.13 | 2.65 |
| 5% Light Int. | — | 5.03 | 4.42 | 4.42 | 8.84 | 8.84 | 9.45 | 3.96 | 3.35 | 6.89 |
| 10. Pewaukee | 3–18–66 | 4–19–66 | 5– 9–66 | 6– 9–66 | 8– 4–66 | 8–24–66 | 9–20–66 | 10–28–66 | 11–10–66 | Pewaukee |
| Secchi Disc | 1.98 | 1.37 | .914 | 1.22 | 1.83 | 1.52 | 1.52 | 1.83 | 1.83 | 1.55 |
| 5% Light Int. | 4.42 | 3.96 | 1.52 | 1.52 | 5.79 | 4.42 | 2.44 | 2.90 | 2.44 | 3.26 |
| 11. Delavan | 3–22–66 | 4–18–66 | 5–10–66 | 6–22–66 | 8– 3–66 | 8–25–66 | 9–19–66 | 10–14–66 | 11–14–66 | Delavan |
| Secchi Disc | .914 | 1.98 | 1.52 | 1.83 | 1.52 | 1.22 | 1.22 | 1.83 | 2.44 | 1.62 |
| 5% Light Int. | 2.29 | 3.84 | 3.44 | 3.51 | 4.42 | 3.96 | 1.98 | 3.05 | 3.35 | 3.29 |
| 12. Winnebago | 3– 9–66 | 4–21–66 | 5–12–66 | 6–15–66 | 7– 8–66 | — | 9–14–66 | 10–12–66 | 11–15–66 | Winnebago |
| Secchi Disc | ice | .305 | .914 | .914 | 1.07 | — | .457 | .305 | .914 | .701 |
| 5% Light Int. | ice | .610 | 1.98 | 1.07 | — | — | — | 1.52 | — | 1.31 |

Mendota, Pine, Pewaukee, and Delavan have all had an extensive history of planktonic nuisance and all have mean seasonal Secchi disk values of ten feet or less. Those lakes that have a history of plankton nuisance conditions also reveal a 5 per cent incident light sesonal mean of twenty-five feet or less. In this respect there is good agreement between Secchi disk and per cent of incident light. However, the absolute correlation between Secchi disk and per cent of incident light on a particular lake is not readily apparent.

## Plankton Population

The plankton populations on the twelve lakes studied are represented in Figure I for the months when no ice cover was present. The evaluations were based on Clarke–Bumpus net tows (No. 20 mesh net) and the results are expressed in $\mu g/l$ total solids.

In the twelve lakes under consideration, Crystal, Trout, Geneva, Big Green and Round Lake revealed less than 200 $\mu g/l$ of solids consistently, and nuisance-producing blue–green varieties were detectable in trace quantities only. The plankton populations in these lakes were most typically composed of zooplankton and diatoms. Middle and Oconomowoc Lakes did not reveal plankton concentrations that would be considered a nuisance, although the solids analyses revealed between 700 and 1,500 $\mu g/l$ on five occasions. The plankton were principally diatoms or zooplankton, which do not have the nuisance-producing capability characteristic of the blue–green algae. Past aquatic nuisance control records of the Department of Natural Resources suggest that Delavan Lake has nuisance algae conditions during the entire summer. The plankton catches from June through October revealed 2,500 $\mu g/l$ on four of five occasions. The plankton populations were dominated by blue–green varieties with *Anacystis sp.*, *Anabaena sp.*, and *Oscillatoria sp.* predominating. The aquatic nuisance control records further reveal that shoreline accumulations are a general problem on Delavan Lake and are treated with copper sulphate weekly to control odors and increase the aesthetic and recreational value of the shoreline areas.

Lake Winnebago had 1,500 $\mu g/l$ of solids in the April through October samples. There is no question that plankton populations produce periodic nuisance conditions on Lake Winnebago, but the species composition estimates reveal the principal constituents of the population are diatoms and zooplankton. On only one occasion (June 15, 1966) did blue–green algae varieties *(Anabaena sp., Aphanizomenon sp.,* and *Anacystis sp.)* thoroughly dominate the plankton populations. This observation was substantiated by the

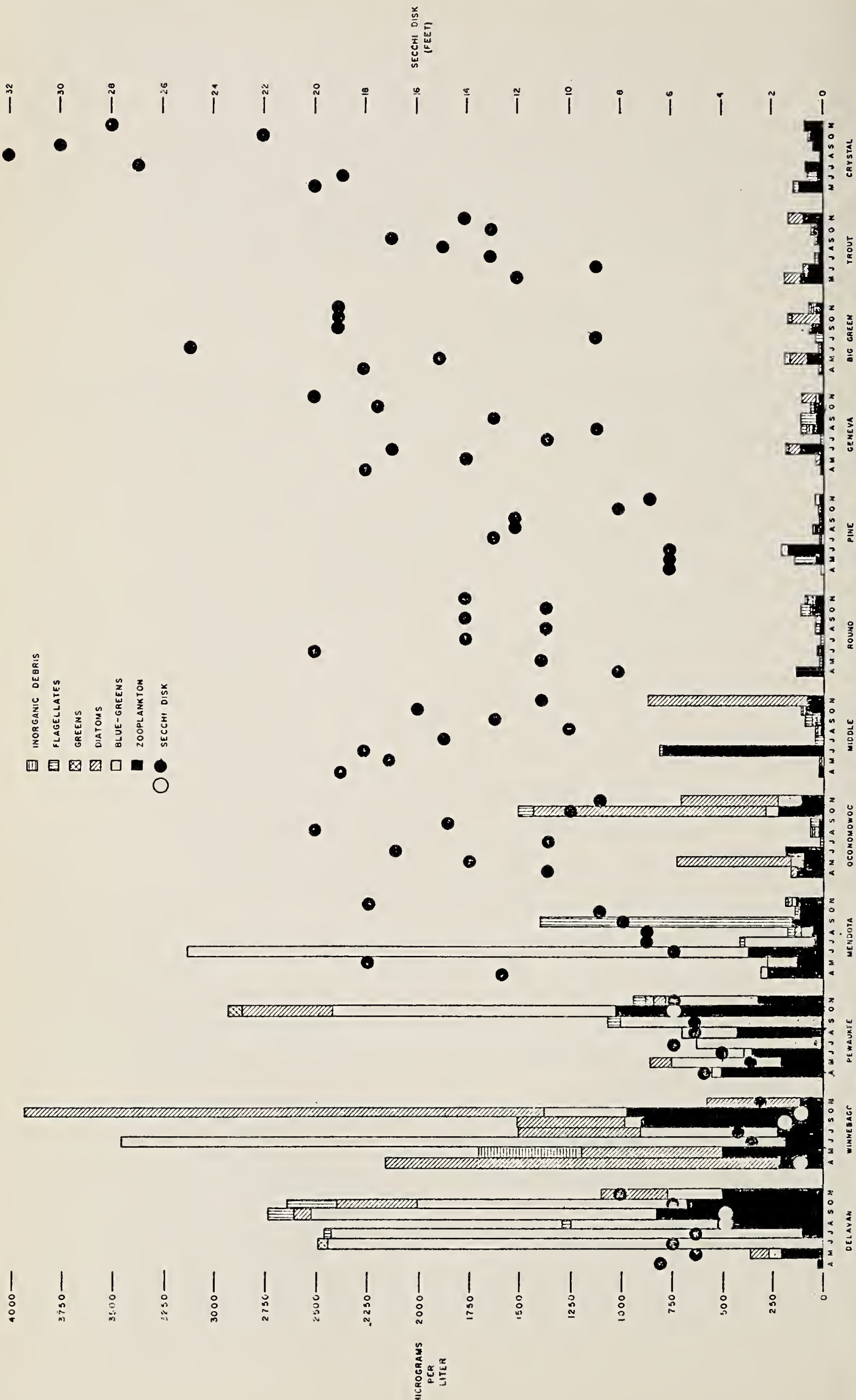



FIGURE 1. Plankton Volumes and Secchi Disks (April through November, 1966).

increased percentage of volatile solids. During the five months when varieties other than blue–green algae dominated the plankton population, the volatile solids averaged approximately 40 per cent. In June, when blue–green algae dominated the plankton volume, the volatile solids represented 90 per cent of the total solids.

Pewaukee Lake has had a long history of algae nuisance control activity, and the blue–green varieties represented a significant portion of the plankton in six of the seven summer–fall collections. A general observation for Pewaukee Lake on June ninth revealed approximately 400 μg/l total solids dominated by zooplankton with no indication of nuisance plankton. On August fourth, 700 μg/l total solids were recorded dominated by *Anabaena flosaquae*. The visual observation of the lake suggested a distinct "bloom" condition. On October twenty-eighth, nearly 2,900 μg/l of solids were recorded as a seasonal high in Pewaukee Lake.

Lake Mendota is a lake that is sporadically plagued by nuisance algae blooms. On June eighth, a visual observation suggested a high algae population, and the Clarke–Bumpus sample recorded over 3,100 μg/l total solids dominated by *Aphanizomenon sp.* Seven other monthly visual observations on Lake Mendota failed to suggest bloom conditions. Total solids were less than 500 μg/l in all other collections except September when a *Ceratium sp.* dominated 1,400 μg/l total solids. This population was not visually noticeable at the time of collection and would not affect recreational potential.

Oconomowoc and Middle Lakes revealed 500 μg/l total solids on five of sixteen occasions, but the populations were dominated by diatoms or zooplankton. At no time were nuisance plankton conditions observed in the lake water.

Round Lake revealed the lowest plankton values of the twelve lakes studied, even though organic nitrogen and Secchi disk observations suggested that there should have been more plankton present. This apparent inconsistency may be partially explained by the fact that small algae cells will not be captured in the No. 20 mesh net. In the case of Round Lake, *Chlorella sp.* was observed in the water samples in sufficient quantities to color the lake water. In this case the plankton analysis techniques were not adequate to represent the actual condition of the lake.

Figure I, which illustrates the plankton population, also shows Secchi disk readings at the time of plankton collection. In general, Delavan, Pewaukee, and Winnebago, which have relatively high plankton populations, have low Secchi disk readings. Lake Mendota, with variable plankton populations, had Secchi disk readings of twelve to sixteen feet in spring and fall but only six to nine feet in midsummer, with no apparent correlation to algae populations.

The lakes with relatively low plankton populations had higher Secchi disk readings, but the cause of variability was not determined. Crystal Lake clarity was obvious both by visual observation and by Secchi disk readings.

## Nutrients

Lake eutrophication, by definition, is an accumulation of nutrients. Many elements and compounds act as nutrients for the development of weeds and algae. However, nitrogen and phosphorus are usually considered the limiting nutrients and as such have received the most emphasis. Sawyer (1947) indicated that lakes containing 0.3 mg/l inorganic nitrogen ($NO_3$-N, $NO_2$-N, and $NH_3$N) and 0.015 mg/l soluble phosphorus at time of spring turnover are capable of producing nuisance algae growths. Gerloff and Skoog (1957) suggested that the nitrogen–phosphorus ratio as it occurred in water was an indication of the ability of that water to produce algae, and their laboratory studies indicated that a ratio of 60 to 1 (nitrogen to phosphorus) was an appropriate ratio for optimum growth. Gerloff and Skoog further suggested that nitrogen was generally the limiting factor in algae production, while other studies (Federal Water Pollution Control Administration, Lake Sebasticook) suggest phosphorus may be the limiting factor since ample nitrogen is available from the atmosphere through nitrification by bacteria and blue–green algae. Whatever the limiting factor in primary production may be, it appears that the concentration of nitrogen and phosphorus is useful in evaluating the trophic condition of a particular lake. Table IV is a summary of monthly nitrogen and phosphorus concentrations from the epilimnion and hypolimnion of the twelve lakes studied.

### Inorganic Nitrogen

The inorganic nitrogen is available for utilization in the production of organic matter. The most obvious source of available nitrogen is nitrate nitrogen ($NO_3$). Nitrite nitrogen ($NO_2$) is an unstable state, and even eutrophic lakes typically have less than 0.01 mg/l. Ammonia nitrogen ($NH_3$) is readily oxidized by nitrifying bacteria in the presence of oxygen to nitrate nitrogen and is therefore essentially available for organic production in the epilimnion.

Five of the twelve lakes studied in this investigation (Round, Mendota, Delavan, Pewaukee, and Winnebago) revealed an eleven-month mean total inorganic nitrogen concentration greater than the 0.3 mg/l regarded as critical by Sawyer. Of these five lakes,

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E* | H† | E | H | E | H | E | H | E | H | E | H |
| PINE | | | | | | | | | | | | |
| TION* | .178 | .206 | .223 | .233 | .213 | .163 | .184 | .184 | .188 | .327 | .082 | .396 |
| $NH_3$ | .11 | .14 | .12 | .11 | .15 | .10 | .10 | .10 | .12 | .26 | .04 | .35 |
| $NO_2$ | .008 | .006 | .003 | .003 | .003 | .003 | .004 | .004 | .008 | .007 | <.002 | .006 |
| $NO_3$ | .06 | .06 | .10 | .12 | .06 | .06 | .08 | .08 | .06 | .06 | .04 | .04 |
| TON* | .92 | .75 | .64 | .72 | .69 | .73 | .46 | .44 | .65 | .59 | .69 | .77 |
| SP* | .26 | .27 | .23 | .22 | .23 | .22 | .20 | .20 | .22 | .22 | .23 | .26 |
| TP* | .26 | .28 | .23 | .22 | .26 | .26 | .20 | .20 | .28 | .28 | .24 | .30 |
| PEWAUKEE | | | | | | | | | | | | |
| TION | .264 | .606 | .829 | 1.097 | .536 | .476 | .376 | .457 | .154 | .353 | .112 | .352 |
| $NH_3$ | .12 | .34 | .80 | .80 | .35 | .29 | .09 | .21 | .06 | .24 | .07 | .31 |
| $NO_2$ | .004 | .006 | .015 | .037 | .006 | .006 | .006 | .007 | .014 | .013 | <.002 | <.002 |
| $NO_3$ | .14 | .26 | .14 | .26 | .18 | .18 | .28 | .24 | .08 | .10 | .04 | .04 |
| TON | 2.16 | .94 | 2.76 | 1.33 | 1.08 | 1.03 | .72 | .61 | 1.00 | 1.27 | .98 | 1.04 |
| SP | .14 | .18 | .05 | .21 | .12 | .13 | .10 | .10 | .088 | .085 | .11 | .10 |
| TP | .26 | .20 | .18 | .26 | .16 | .18 | .14 | .132 | .16 | .16 | .16 | .22 |
| DELAVAN | | | | | | | | | | | | |
| TION | .829 | 1.11 | .842 | .92 | .51 | .48 | .47 | .52 | .372 | .442 | .254 | 1.357 |
| $NH_3$ | .45 | .45 | .43 | .51 | .10 | .11 | .12 | .21 | .04 | .11 | .19 | 1.29 |
| $NO_2$ | .019 | .020 | .012 | .01 | .01 | .01 | .01 | .01 | .012 | .012 | .003 | .006 |
| $NO_3$ | .36 | .64 | .40 | .40 | .40 | .36 | .34 | .30 | .32 | .32 | .061 | .061 |
| TON | 1.43 | 1.08 | .97 | .86 | 1.16 | 1.25 | .82 | .86 | 1.04 | 1.19 | 2.26 | .89 |
| SP | .19 | .22 | .15 | .20 | .08 | .08 | .07 | .072 | .08 | .08 | .02 | .29 |
| TP | .24 | .24 | .16 | .22 | .2 | .18 | .140 | .144 | .16 | .22 | .20 | .34 |
| WINNEBAGO | | | | | | | | | | | | |
| TION | .542 | — | .614 | — | .72 | — | .23 | — | .184 | — | .336 | — |
| $NH_3$ | .11 | — | .12 | — | .14 | — | .06 | — | .06 | — | .09 | — |
| $NO_2$ | <.002 | — | .004 | — | .02 | — | .01 | — | .004 | — | .006 | — |
| $NO_3$ | .43 | — | .49 | — | .56 | — | .16 | — | .12 | — | .24 | — |
| TON | .76 | — | .70 | — | .63 | — | 1.01 | — | .73 | — | 1.04 | — |
| SP | .06 | — | .04 | — | .03 | — | .017 | — | .009 | — | .022 | — |
| TP | .08 | — | .08 | — | .06 | — | .132 | — | .06 | — | .12 | — |

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

| | January | | February | | March | | April | | May | | June | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E | H | E | H | E | H | E | H | E | H | E | H |
| MIDDLE | | | | | | | | | | | | |
| TION | .234 | .448 | .354 | .756 | .529 | .589 | .327 | .397 | .465 | .546 | .145 | .388 |
| $NH_3$ | .15 | .18 | .15 | .27 | .18 | .24 | .12 | .13 | .16 | .16 | .11 | .30 |
| $NO_2$ | .004 | .008 | .004 | .006 | .009 | .009 | .007 | .007 | .005 | .006 | .005 | .008 |
| $NO_3$ | .08 | .26 | .2 | .48 | .34 | .34 | .20 | .26 | .3 | .38 | .04 | .08 |
| TON | .57 | .54 | .33 | .48 | .43 | .45 | .44 | .47 | .42 | .46 | .48 | .50 |
| SP | .06 | .06 | .02 | .04 | .04 | .06 | .012 | .012 | .02 | .02 | .039 | .03 |
| TP | .08 | .06 | .04 | .06 | .18 | .13 | .028 | .028 | .028 | .048 | .10 | .10 |
| MENDOTA | | | | | | | | | | | | |
| TION | 1.009 | .551 | .837 | 1.058 | .652 | .878 | .373 | .362 | .581 | .531 | .192 | .561 |
| $NH_3$ | .72 | .36 | .51 | .73 | .26 | .35 | .12 | .09 | .13 | .10 | .09 | .37 |
| $NO_2$ | .009 | .011 | .017 | .008 | .012 | .008 | .013 | .012 | .011 | .011 | .002 | .011 |
| $NO_3$ | .28 | .18 | .32 | .32 | .38 | .52 | .24 | .26 | .44 | .42 | .10 | .18 |
| TON | .76 | .60 | .85 | .72 | .72 | .64 | .35 | .39 | .53 | .52 | — | .56 |
| SP | .14 | .11 | .48 | .16 | .04 | .05 | .035 | .03 | .04 | .04 | .007 | .137 |
| TP | .16 | .12 | .18 | — | .08 | .08 | .078 | .08 | .066 | .064 | .116 | .184 |
| ROUND | | | | | | | | | | | | |
| TION | .765 | 1.185 | 1.132 | 1.362 | .723 | 1.064 | 1.156 | 1.766 | .956 | 1.532 | .636 | 1.136 |
| $NH_3$ | .22 | .50 | .44 | .38 | .31 | .35 | .10 | .28 | .14 | .33 | .03 | .09 |
| $NO_2$ | < .005 | < .005 | .012 | .022 | .013 | .014 | .016 | .046 | .016 | .042 | .016 | .04 |
| $NO_3$ | .54 | .68 | .68 | .96 | .40 | .70 | 1.04 | 1.44 | .80 | 1.16 | .60 | 1.06 |
| TON | .53 | .37 | .48 | .51 | .62 | .66 | .59 | .56 | .53 | .48 | .36 | .51 |
| SP | .03 | .03 | .02 | > .01 | .04 | .05 | .007 | .003 | .01 | .01 | .015 | .012 |
| TP | .12 | .04 | .04 | .02 | .2 | .26 | .018 | .024 | .072 | .084 | .034 | .068 |
| OCONOMOWOC | | | | | | | | | | | | |
| TION | .428 | .238 | .433 | .483 | .257 | .367 | .376 | .356 | .319 | .543 | .082 | .123 |
| $NH_3$ | .24 | .15 | .15 | .20 | .13 | .14 | .09 | .09 | .13 | .25 | .04 | .08 |
| $NO_2$ | .008 | .008 | .003 | .003 | .007 | .007 | .006 | .006 | .009 | .013 | < .002 | .003 |
| $NO_3$ | .18 | .18 | .28 | .28 | .22 | .22 | .28 | .26 | .18 | .28 | < .04 | < .04 |
| TON | .54 | .52 | .45 | .63 | .54 | .60 | .35 | .34 | .47 | .53 | .39 | .37 |
| SP | .07 | .06 | .07 | .07 | .06 | .07 | .034 | .037 | .039 | .041 | .012 | .01 |
| TP | .08 | .08 | .08 | .08 | .08 | .08 | .06 | .064 | .08 | .08 | .04 | .10 |

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

| | January | | February | | March | | April | | May | | June | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E | H | E | H | E | H | E | H | E | H | E | H |
| CRYSTAL | | | | | | | | | | | | |
| TION | .152 | .082 | .132 | .202 | .132 | .133 | .152 | .20 | .112 | .102 | .102 | .082 |
| $NH_3$ | .07 | .04 | .09 | .16 | .09 | .09 | .07 | .08 | .05 | .04 | .02 | .02 |
| $NO_2$ | .002 | .002 | .002 | .002 | .004 | .003 | <.002 | — | <.002 | <.002 | .002 | <.002 |
| $NO_3$ | .08 | .04 | <.04 | .04 | <.04 | <.04 | .08 | .10 | .06 | .06 | .08 | .04 |
| TON | .16 | .15 | .14 | <.16 | .14 | .18 | .24 | .26 | .17 | .18 | .10 | .10 |
| SP | .04 | .04 | .01 | <.01 | .08 | .05 | .002 | .002 | .012 | .10 | .014 | .018 |
| TP | .04 | .06 | .02 | .04 | .36 | .28 | .012 | .02 | .086 | .088 | .048 | .028 |
| GENEVA | | | | | | | | | | | | |
| TION | — | — | .202 | .182 | .143 | .213 | .092 | .092 | .183 | .233 | .082 | .123 |
| $NH_3$ | — | — | .04 | .04 | .08 | .13 | .05 | .05 | .02 | .07 | .04 | .08 |
| $NO_2$ | — | — | <.002 | <.002 | .003 | .003 | .002 | .002 | .003 | .003 | <.002 | .003 |
| $NO_3$ | — | — | .16 | .14 | .06 | .08 | <.04 | <.04 | .16 | .16 | <.04 | <.04 |
| TON | — | — | .35 | .33 | .42 | .43 | .34 | .38 | .37 | .14 | .39 | .37 |
| SP | — | — | .03 | .03 | .008 | .008 | .006 | .006 | .02 | <.01 | .12 | .01 |
| TP | — | — | .06 | .06 | .03 | .03 | .024 | .024 | .044 | .036 | .04 | .10 |
| BIG GREEN | | | | | | | | | | | | |
| TION | .283 | .392 | .412 | .333 | .286 | .29 | .313 | — | .316 | .291 | .122 | .333 |
| $NH_3$ | .04 | .07 | .04 | .05 | .02 | .03 | .05 | — | .07 | .02 | .06 | .09 |
| $NO_2$ | .003 | .002 | .002 | .003 | .006 | .01 | .003 | — | .006 | .011 | <.002 | .003 |
| $NO_3$ | .24 | .32 | .37 | .28 | .26 | .25 | .26 | — | .24 | .26 | .06 | .24 |
| TON | .51 | .38 | .36 | .36 | .31 | .30 | .28 | — | .31 | .33 | .32 | .38 |
| SP | .06 | .05 | .05 | .04 | .04 | .04 | .029 | — | .03 | .032 | <.002 | .02 |
| TP | .06 | .06 | .10 | .12 | .06 | .06 | .042 | — | <.04 | <.04 | .06 | .06 |
| TROUT | | | | | | | | | | | | |
| TION | .132 | .112 | .092 | .132 | .502 | .102 | — | — | .102 | .082 | .082 | .082 |
| $NH_3$ | .05 | .05 | .05 | .07 | — | .06 | — | — | .06 | .04 | .04 | .04 |
| $NO_2$ | <.002 | <.002 | <.002 | <.002 | .002 | .002 | — | — | <.002 | <.002 | <.002 | .002 |
| $NO_3$ | .08 | .06 | .04 | .06 | <.04 | <.04 | — | — | <.04 | <.04 | <.04 | <.04 |
| TON | .21 | .18 | .16 | .19 | .21 | .21 | — | — | .23 | .25 | .17 | .21 |
| SP | .04 | .04 | <.01 | .01 | .08 | .04 | — | — | .003 | .006 | .01 | .022 |
| TP | .05 | .06 | .02 | .02 | .20 | .2 | — | — | .84 | .096 | .042 | .056 |

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

| | July | | August | | September | | October | | November | | Mean & SD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E | H | E | H | E | H | E | H | E | H | E | H |
| PINE | | | | | | | | | | | | |
| TION | .242 | .962 | .162 | .84 | .142 | .192 | .094 | 1.304 | .505 | .504 | .201 ± .0755 | .480 ± .2554 |
| $NH_3$ | .05 | .79 | .04 | .67 | .06 | .11 | .05 | 1.26 | .08 | .08 | .084 ± .0007 | .361 ± .259 |
| $NO_2$ | .002 | .002 | < .002 | — | .002 | .002 | .004 | .004 | .005 | .004 | .004 ± .0015 | .001 ± .0012 |
| $NO_3$ | .19 | .17 | .12 | .14 | .08 | .08 | .04 | < .04 | .42 | .42 | .114 ± .074 | .115 ± .073 |
| TON | .64 | .66 | .53 | .70 | .71 | .69 | .68 | .67 | .35 | .35 | .633 ± .0992 | .643 ± .0895 |
| SP | .25 | .26 | .26 | .33 | .24 | .25 | .26 | .14 | .26 | .26 | .240 ± .0104 | .239 ± .032 |
| TP | .266 | .36 | .26 | .38 | .24 | .40 | .292 | .42 | .26 | .264 | .253 ± .0105 | .306 ± .156 |
| PEWAUKEE | | | | | | | | | | | | |
| TION | .232 | .843 | .272 | 5.296 | .405 | 2.24 | .446 | .467 | 1.003 | .945 | .421 ± .186 | 1.195 ± .984 |
| $NH_3$ | .07 | .72 | .11 | 5.15 | .30 | 2.13 | .35 | .37 | .29 | .35 | .237 ± .1484 | .992 ± 1.220 |
| $NO_2$ | .002 | .003 | .002 | .006 | .005 | .01 | .016 | .017 | .013 | .015 | .008 ± .0038 | .011 ± .0308 |
| $NO_3$ | .16 | .12 | .16 | .14 | .10 | .10 | .08 | .08 | .70 | .58 | .053 ± .0674 | .043 ± .0074 |
| TON | .95 | .99 | 1.08 | 1.11 | 1.04 | 1.19 | .98 | 1.01 | .53 | .54 | .827 ± .409 | .568 ± .295 |
| SP | .14 | .19 | .13 | .30 | .13 | .33 | .154 | .15 | .128 | .123 | .009 ± .0555 | .020 ± .0882 |
| TP | .196 | .34 | .18 | .44 | .18 | .48 | .218 | .232 | .52 | .166 | .042 ± .079 | .043 ± .0128 |
| DELAVAN | | | | | | | | | | | | |
| TION | .193 | 2.003 | .112 | 3.092 | .233 | .853 | .696 | .728 | .662 | .693 | .470 ± .173 | .625 ± .628 |
| $NH_3$ | .05 | 1.86 | .05 | 3.03 | .13 | .77 | .57 | .64 | .45 | .48 | .040 ± .1569 | .410 ± .662 |
| $NO_2$ | .003 | .003 | < .002 | .002 | .003 | .003 | .006 | .008 | .012 | .013 | .013 ± .0127 | .009 ± .007 |
| $NO_3$ | .14 | .14 | .06 | .06 | .10 | .08 | .12 | .08 | .20 | .20 | .227 ± .0926 | .240 ± .123 |
| TON | 1.17 | .75 | 1.16 | .93 | 1.25 | .81 | 1.02 | 1.02 | .87 | .99 | 1.195 ± .264 | .966 ± .106 |
| SP | .01 | .56 | .012 | .70 | .024 | .71 | .10 | .12 | .09 | .095 | .075 ± .039 | .284 ± .169 |
| TP | .12 | .62 | .126 | .72 | .128 | .78 | .24 | .34 | .158 | .162 | .170 ± .0294 | .361 ± .157 |
| WINNEBAGO | | | | | | | | | | | | |
| TION | .282 | — | — | — | .212 | — | .202 | — | .215 | — | .354 ± .141 | — |
| $NH_3$ | .12 | — | — | — | .07 | — | .06 | — | .05 | — | .088 ± .023 | — |
| $NO_2$ | .002 | — | — | — | < .002 | — | < .002 | — | .005 | — | .006 ± .040 | — |
| $NO_3$ | .16 | — | — | — | .14 | — | .14 | — | .16 | — | .260 ± .119 | — |
| TON | 1.02 | — | — | — | 1.91 | — | 1.22 | — | .80 | — | .982 ± .269 | — |
| SP | .01 | — | — | — | .94 | — | < .03 | — | .017 | — | .031 ± .0678 | — |
| TP | .14 | — | — | — | .248 | — | .24 | — | .128 | — | .129 ± .108 | — |

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

| | July | | August | | September | | October | | November | | Mean & SD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E | H | E | H | E | H | E | H | E | H | E | H |
| MIDDLE | | | | | | | | | | | | |
| TION | .173 | 1.154 | .112 | .882 | .103 | .218 | .193 | .404 | .256 | .336 | .263 ±.0951 | .556 ± .1847 |
| $NH_3$ | .05 | .99 | .05 | .82 | .04 | .13 | .13 | .32 | .05 | .09 | .108 ±.0347 | .330 ± .1990 |
| $NO_2$ | .003 | .004 | <.002 | .002 | .003 | <.008 | .003 | .004 | .006 | .006 | .005 ±.0014 | .006 ± .0014 |
| $NO_3$ | .12 | .16 | .06 | .06 | .06 | .08 | .06 | .08 | .20 | .24 | .151 ±.0699 | .220 ± .0948 |
| TON | .47 | .68 | .51 | .81 | .52 | .65 | .43 | .47 | .49 | .48 | .463 ±.0426 | .545 ± .0787 |
| SP | .05 | .06 | .049 | — | .051 | .05 | .039 | .045 | .028 | .033 | .037 ±.013 | .0410 ± .0142 |
| TP | .08 | .14 | .084 | .124 | .06 | .124 | .116 | .116 | .056 | .124 | .077 ±.0298 | .096 ± .0263 |
| MENDOTA | | | | | | | | | | | | |
| TION | .282 | .192 | .293 | 2.642 | .865 | .183 | .538 | .479 | .752 | .672 | .5794 ±.1818 | .737 ± .459 |
| $NH_3$ | .10 | .13 | .25 | 2.6 | .78 | .06 | .43 | .37 | .38 | .38 | .343 ±.1651 | .504 ± .4849 |
| $NO_2$ | <.002 | <.002 | .003 | <.002 | .005 | .003 | .008 | .009 | .011 | .012 | .008 ±.0033 | .008 ± .0027 |
| $NO_3$ | .18 | .16 | .04 | .04 | .08 | .12 | .10 | .10 | .361 | .28 | .229 ±.0924 | .234 ± .0965 |
| TON | .78 | .56 | .66 | .59 | .64 | .66 | .56 | .62 | .29 | .28 | .6140 ±.1312 | .558 ± .0842 |
| SP | .01 | .48 | .012 | .26 | .08 | <.01 | .119 | .162 | .10 | .10 | .0665 ±.0356 | .140 ± .0902 |
| TP | .066 | .54 | .06 | .58 | .53 | .06 | .152 | .11 | .148 | .152 | .1487 ±.0898 | .1970 ± .1398 |
| ROUND | | | | | | | | | | | | |
| TION | .471 | 1.17 | .639 | 2.40 | .418 | .458 | .884 | 1.382 | .883 | .903 | .788 ±.163 | 1.305 ± .334 |
| $NH_3$ | .07 | .07 | .05 | .45 | .07 | .09 | .11 | .96 | .28 | .29 | .165 ±.088 | .345 ± .168 |
| $NO_2$ | .011 | .10 | .009 | .055 | .008 | .028 | .014 | .102 | .023 | .033 | .011 ±.0042 | .044 ± .021 |
| $NO_3$ | .40 | 1.0 | .58 | 1.90 | .34 | .34 | .76 | .32 | .58 | .58 | .611 ±.137 | .922 ± .317 |
| TON | .45 | .47 | .45 | .74 | .45 | .43 | .49 | .62 | .50 | .51 | .495 ±.048 | .533 ± .071 |
| SP | .005 | .008 | .008 | .009 | <.002 | .005 | .007 | .014 | .006 | .012 | .014 ±.008 | .015 ± .009 |
| TP | .024 | .04 | .024 | .066 | .018 | .034 | .034 | .054 | .044 | .04 | .057 ±.0376 | .066 ± .045 |
| OCONOMOWOC | | | | | | | | | | | | |
| TION | .192 | 1.032 | .193 | .774 | .144 | .564 | .147 | .207 | .464 | .435 | .276 ±.105 | .466 ± .0177 |
| $NH_3$ | .05 | .84 | .05 | .57 | .06 | .46 | .10 | .16 | .06 | .07 | .100 ±.0402 | .274 ± .166 |
| $NO_2$ | .002 | .022 | .003 | .024 | .004 | .004 | .007 | .007 | .004 | .005 | .005 ±.0017 | .009 ± .0082 |
| $NO_3$ | .14 | .17 | .14 | .18 | .08 | .10 | .04 | .04 | .4 | .36 | .156 ±.060 | .192 ± .069 |
| TON | .48 | .61 | .50 | .52 | .50 | .56 | .57 | .55 | .27 | .28 | .460 ±.0607 | .510 ± .0788 |
| SP | .12 | .21 | .09 | .08 | .07 | .11 | .78 | .084 | .072 | .069 | .129 ±.1464 | .076 ± .0347 |
| TP | .128 | .274 | .14 | .12 | .10 | .24 | .158 | .104 | .09 | .086 | .094 ±.0235 | .119 ± .047 |

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | MEAN & SD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E | H | E | H | E | H | E | H | E | H | E | H |
| CRYSTAL | | | | | | | | | | | | |
| TION | .092 | .05 | .183 | .192 | .053 | .073 | .122 | .222 | .136 | .103 | .124 ± .0228 | .131 ± .0413 |
| $NH_3$ | .05 | .008 | .02 | .03 | .01 | .03 | .04 | .08 | .05 | .02 | .051 ± .0184 | .054 ± .0299 |
| $NO_2$ | < .002 | .002 | .003 | .002 | .003 | .003 | .002 | .002 | .006 | .003 | .0027 ± .00085 | .0023 ± .0003 |
| $NO_3$ | .04 | .04 | .16 | .16 | < .04 | < .04 | .08 | .14 | .08 | .08 | .071 ± .0236 | .071 ± .0296 |
| TON | .19 | .25 | .17 | .22 | .17 | .24 | .16 | .21 | .14 | .17 | .162 ± .0236 | .193 ± .0325 |
| SP | .004 | .008 | .008 | .011 | < .002 | .011 | .010 | .022 | .011 | .021 | .018 ± .0156 | .026 ± .0191 |
| TP | .012 | .024 | .022 | .052 | .022 | .042 | .018 | .04 | .028 | .042 | .027 ± .0200 | .065 ± .0495 |
| GENEVA | | | | | | | | | | | | |
| TION | .152 | .253 | .142 | .244 | .103 | .215 | .314 | .176 | .29 | .178 | .170 ± .056 | .191 ± .0372 |
| $NH_3$ | .05 | .05 | .08 | .10 | .02 | .03 | .05 | .07 | .10 | .03 | .053 ± .0188 | .064 ± .0239 |
| $NO_2$ | .002 | .003 | < .002 | .004 | .003 | .005 | .004 | .006 | .01 | .008 | .003 ± .0018 | .004 ± .0014 |
| $NO_3$ | .10 | .20 | .06 | .14 | .08 | .18 | .26 | .10 | .18 | .14 | .114 ± .0523 | .112 ± .0377 |
| TON | .34 | .30 | .40 | .38 | .39 | .37 | .36 | .35 | .43 | .38 | .379 ± .0342 | .343 ± .0567 |
| SP | .02 | .01 | .009 | .024 | .026 | .02 | .04 | .064 | .012 | .012 | .018 ± .0079 | .019 ± .0125 |
| TP | .04 | .04 | .034 | .056 | .032 | .06 | .072 | .104 | .032 | .032 | .041 ± .015 | .054 ± .0202 |
| BIG GREEN | | | | | | | | | | | | |
| TION | .174 | .402 | — | — | .162 | .406 | — | .474 | .273 | .343 | .245 ± .070 | .371 ± .053 |
| $NH_3$ | .07 | .10 | — | — | .06 | .04 | .03 | .05 | < .03 | < .02 | .047 ± .0127 | .052 ± .0224 |
| $NO_2$ | .004 | .002 | — | — | < .002 | .006 | .002 | .004 | .003 | .003 | .003 ± .0011 | .005 ± .0026 |
| $NO_3$ | .10 | .30 | — | — | .10 | .36 | .08 | .42 | .24 | .32 | .195 ± .073 | .306 ± .0444 |
| TON | .42 | .76 | — | — | .34 | .36 | .40 | .36 | .33 | .76 | .358 ± .0489 | .443 ± .139 |
| SP | .008 | .033 | — | — | .019 | .052 | .011 | .012 | .024 | .052 | .027 ± .0133 | .037 ± .0108 |
| TP | .022 | .072 | — | — | .04 | .06 | .028 | .042 | .062 | .09 | .051 ± .016 | .067 ± .0191 |
| TROUT | | | | | | | | | | | | |
| TION | .132 | .122 | .313 | .463 | .083 | .122 | .132 | .243 | .188 | .234 | .176 ± .0957 | .167 ± .079 |
| $NH_3$ | .07 | .04 | < .01 | .02 | .04 | .02 | .05 | .04 | .04 | .05 | .045 ± .0128 | .0430 ± .0112 |
| $NO_2$ | < .002 | < .002 | .003 | .003 | .003 | .002 | .002 | .003 | .008 | .004 | .003 ± .0013 | .002 ± .0005 |
| $NO_3$ | .06 | .08 | .30 | .44 | < .04 | .10 | .08 | .20 | .14 | .18 | .086 ± .0584 | .124 ± .0894 |
| TON | .34 | .33 | .24 | .21 | .52 | .18 | .21 | .23 | .22 | .22 | .251 ± .076 | .221 ± .118 |
| SP | < .002 | .008 | .014 | .026 | .005 | .003 | .007 | .01 | .011 | .12 | .018 ± .143 | .029 ± .158 |
| TP | .024 | .036 | .022 | .06 | .038 | .028 | .024 | .04 | .028 | .032 | .053 ± .038 | .063 ± .045 |

*Epilimnion. †Hypolimnion. *TION—Total Inorganic Nitrogen ($NH_3$+$NO_2$+$NO_3$). *TON—Total Organic N four have a general algae nuisance during much of the summer. Interestingly, the lake with the highest mean inorganic nitrogen concentration (Round) was the lake without an algae nuisance problem. Of the seven lakes with less than 0.3 mg/l inorganic nitrogen, none has a general algae problem, although rare nuisance accumulations have been observed by residents on five of these lakes. Only Crystal and Trout Lakes are essentially free of algae nuisances.

Figure II represents the total inorganic nitrogen by month and suggests that the inorganic nitrogen fluctuates seasonally. The magnitude of the fluctuations apparently depends on the quantity of inorganic nitrogen available and the subsequent algae standing crop. This data suggests that samples of total inorganic nitrogen may be collected at any time of the year from oligotrophic lakes without interfering with interpretation. However, total inorganic nitrogen collections from eutrophic lakes must be interpreted with regard to season. Sawyer realized the seasonal sampling difficulties and suggested spring overturn as the most appropriate sample time. This may very well be, but stratification typically commenced within hours after spring overturn, and a homogeneous spring overturn sample normally could not be collected. The fall overturn (November sample) appeared to be most stable and representative for Round, Mendota, Delavan, and Pewaukee, but was less representative for Lake Winnebago.

## Total Organic Nitrogen

Total organic nitrogen concentrations represent the nitrogen bound by biological processes. As such, it is a useful measure of the trophic condition. The three most eutrophic lakes by this parameter are Delavan, Winnebago, and Pewaukee. Trout, Crystal, and Big Green are the most oligotrophic.

As in the case of inorganic nitrogen, the concentration of organic nitrogen in a relatively oligotrophic lake (Geneva) has no apparent monthly variation (Figure III). Both eutrophic lakes revealed variability, but it was not seasonally oriented as in the case of inorganic nitrogen. The 2.76 mg/l observed on Pewaukee Lake in February was at a time of ice cover and no plankton sample was collected; however, considerable algae were noted in the water samples. The 2.26 mg/l observed on Delavan in June was at a time of high algae population, but the algae population in July, September, and October was just as high with substantially lower organic nitrogen levels.

The range of means was so well distributed on this parameter that it is one parameter in which annual means could offer a


FIGURE 2. Total Inorganic Nitrogen in Surface Samples.

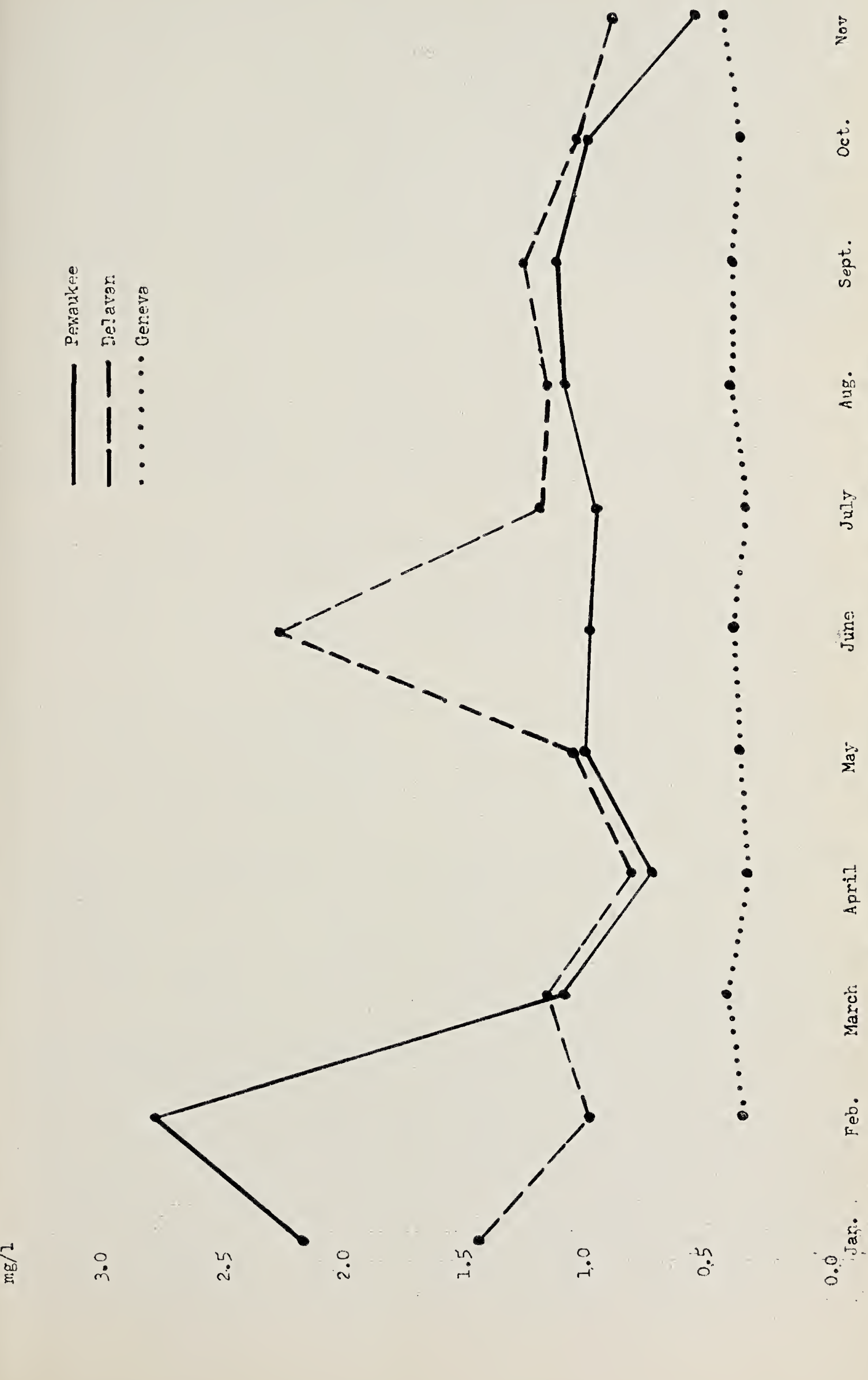



FIGURE 3. Total Organic Nitrogen in Surface Samples.

trophic description. A lake with an annual mean of less than 0.2 mg/l organic nitrogen probably would not have algae or other plankton nuisances. An annual mean of 0.2 mg/l to 0.4 mg/l would have rare algae nuisance conditions dependent on winds but not general nuisance conditions. A lake with an annual mean between 0.4 mg/l and 0.6 mg/l would probably experience periodic algae blooms or have substantial weed growths or both. A lake with an annual total organic nitrogen mean of more than 0.8 mg/l would probably experience numerous blooms during most of the growing season which would present a distinct impairment to recreational potentials.

## Phosphorus

Phosphorus analyses were conducted on all lakes, but the past use of arsenics as an aquatic herbicide on four of the lakes and the subsequent interference of arsenic in the phosphorus test make the interpretation of phosphorus data on the four herbicide-treated lakes impossible.

The eleven-month soluble phosphorus mean on untreated Lakes Crystal, Trout, and Geneva was 0.018 mg/l on all three lakes. The lowest eleven-month phosphorus mean was 0.014 mg/l observed on Round Lake. The plankton catches from these four lakes were all relatively low.

Lakes Delavan and Mendota revealed substantially higher soluble phosphorus levels than the typically oligotrophic lakes. Big Green Lake and Lake Winnebago had remarkably similar soluble phosphorus means (0.027 and 0.026 mg/l). This similarity in phosphorus means and the apparent difference in plankton catches tend to suggest that the concentration of soluble phosphorus is not particularly useful in evaluating water quality and recreational potential of a lake. The soluble phosphorus could be a better indicator parameter if more samples were available. Nine to eleven monthly analyses were simply not adequate to evaluate small differences with the observed analytical variability.

The total phosphorus means for the eight lakes sampled revealed that Lakes Crystal, Geneva, Big Green, and Trout all had relatively low total phosphorus concentrations. This is consistent with plankton observations. Lakes Winnebago, Mendota, and Delavan revealed the highest total phosphorus levels, also consistent with plankton observations. From these monthly total phosphorus means, it appears that lakes with an annual mean total phosphorus of less than 0.03 mg/l would have essentially no aquatic nuisance development. Lakes with an annual mean total phosphorus between 0.03 and 0.05 mg/l experience rare aquatic nuisance development, but recreational potential of the water remains excellent. Lakes with an annual mean total phosphorus of over 0.1 mg/l would experience frequent aquatic nuisances during most of the growing season.

## Summary and Conclusions

1. Table 5 summarizes the ranking of the twelve lakes based on annual means of selected parameters. The relationship between these parameters as indicators of eutrophication is shown by the generally similar placement for each lake in the various columns. A composite rating, based on assignment of a numerical value for position in each column, produces the following ranking. A value of one is given for first place, two for second and so on, so the lowest values represent the most oligotrophic lakes.

Composite Rating Based on Five Parameters

| | |
|---|---|
| Crystal | 8 |
| Big Green | 17 |
| Geneva | 17 |
| Trout | 19 |
| Round | 31 |
| Pine | 33 |
| Middle | 33 |
| Oconomowoc | 34 |
| Mendota | 45 |
| Pewaukee | 49 |
| Delavan | 52 |
| Winnebago | 52 |

Further examination of the table indicates that this composite rating would not be changed greatly if the phosphorus data were included.

2. The presence of dissolved oxygen in the hypolimnion during summer stagnation no doubt has an important effect on fish. However, as a measure of trophic index, it can be misleading since the volume of the hypolimnion tempers the effect of production and decomposition. Even the most oligotrophic lakes such as Crystal, Trout, and Geneva reveal dissolved oxygen levels one meter off the bottom that would be considered critical for fish. Lakes Pine and Oconomowoc, which have essentially no nuisance blooms of plankton, reveal no measurable dissolved oxygen in the hypolimnion in late summer. Classically eutrophic lakes such as Delavan and Pewaukee reveal no measurable dissolved oxygen in the hypolimnion during most of the summer.

## Table 5. Trophic Rank of Twelve Wisconsin Lakes Based on Seven Parameters

| | Dissolved Oxygen Hypolimnion | mg/l 1 M. Off Bottom | Plankton No. 20 Mesh Net | $\mu$g/l Total Solids | Transparency Secchi Disc | Seasonal Mean | Organic Nitrogen | Mo. Mean mg/l | Total Inorganic Nitrogen | Mo. Mean mg/l | Soluble Phosphorus | Mo. Mean mg/l | Total Phosphorus | Mo. Mean mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Most Oligotrophic | Big Green.... | 8.1* | Round...... | 60.3 | Crystal...... | 7.7 | Crystal...... | .162 | Crystal...... | .124 | | | | |
| ↑ | Crystal....... | 3.15 | Pine........ | 64.5 | Big Green... | 5.4 | Trout....... | .251 | Geneva..... | .170 | Round...... | .014 | Crystal...... | .027 |
| | Trout........ | 1.9 | Crystal...... | 68.0 | Geneva..... | 4.6 | Big Green... | .358 | Trout....... | .176 | Crystal...... | .018 | Geneva..... | .041 |
| | Geneva...... | 1.0 | Geneva..... | 77.5 | Middle...... | 4.4 | Geneva..... | .379 | Pine........ | .210 | Geneva..... | .018 | Big Green... | .051 |
| | Round....... | 0.15 | Trout....... | 81.7 | Oconomowoc | 4.4 | Oconomowoc | .460 | Big Green... | .245 | Trout....... | .018 | Trout....... | .053 |
| | | | Big Green... | 83.4 | Trout....... | 4.1 | Round...... | .495 | Middle...... | .263 | Big Green... | .027 | Round...... | .057 |
| | Oconomowoc .<br>Pine......... | 0.0<br>0.0 | Middle...... | 252 | Round...... | 3.9 | Middle...... | .545 | Oconomowoc | .276 | Winnebago.. | .031 | Winnebago.. | .129 |
| | | | Oconomowoc | 426 | Mendota.... | 3.1 | Mendota.... | .614 | Winnebago.. | .354 | Mendota.... | .066 | Mendota.... | .149 |
| ↓ | | | Mendota.... | 751 | Pine........ | 2.7 | Pine........ | .663 | Pewaukee... | .421 | Delavan..... | .075 | Delavan..... | .170 |
| | | | Pewaukee... | 1004 | Delavan..... | 1.6 | Pewaukee... | .827 | Delavan..... | .470 | | | | |
| | Mendota.....<br>Middle....... | 0.0<br>0.0 | Delavan..... | 1637 | Pewaukee... | 1.5 | Winnebago.. | .982 | Mendota.... | .579 | | | | |
| Most Eutrophic | Delavan......<br>Pewaukee.... | 0.0<br>0.0 | Winnebago.. | 2118 | Winnebago.. | .7 | Delavan..... | 1.195 | Round...... | .788 | | | | |

*Middle of hypolimnion.

3. The plankton sample collected with a No. 20 mesh net does not fully measure the standing crop of organic production since it ignores rooted or attached growths, and small algal cells may pass through the net. However, when 1,000 $\mu$g/l of blue–green algae are recorded, there are sufficient algae in the water to be distinctly noticeable. Often a recording of 500 $\mu$g/l in open water will be associated with wind-blown nuisance accumulation on specific shorelines. Diatoms and zooplankton did not develop nuisance conditions on any of the lakes considered, so that absolute nuisance concentrations cannot be established.

4. The monthly analysis for organic nitrogen produced a ranking of the lakes that was reasonably consistent with transparency and plankton recreational potential. Furthermore, it offered an opportunity to translate plankton nuisance conditions into absolute values. The lakes that had a total organic nitrogen annual mean of less than 0.2 mg/l had no algae or plankton nuisance. Lakes that had an organic nitrogen mean between 0.2 and 0.4 mg/l have had rare algae nuisances, and lakes between 0.4 and 0.6 mg/l had periodic algae blooms or substantial weed growths or both. Lakes with an annual total organic nitrogen mean of greater than 0.8 mg/l had nuisance algae during most of the growing season.

5. The monthly analyses for soluble phosphorus had a coefficient of variation which approached 100 per cent, indicating that the eleven monthly samples were insufficient to develop any reliable confidence interval about a mean.

6. The monthly analysis for total phosphorus suggested that lakes with an annual mean of less than .03 mg/l would be free of aquatic nuisances. Lakes with a total phosphorus annual mean between .03 and .05 mg/l would be essentially free of aquatic nuisances. Lakes with an annual mean total phosphorus more than 0.1 mg/l would experience nuisance weed growths or algae blooms during most of the growing season.

7. Eutrophication is not a simple process. It involves complex interrelationships between a variety of water quality parameters and an even greater variety of organisms. Although this study provides some insight into these relationships, a great deal more will need to be learned in order to cope successfully with the demands currently being made for lake management.

## References Cited

Birge, Edward A., Chancy Juday, 1911, The Inland Lakes of Wisconsin, Wisconsin Geological and Natural History Survey, Vol. No. 22.

Beeton, Alfred M., 1965, Eutrophication of the St. Lawrence Great Lakes, Journal of Limnology and Oceanography, Vol. 10, No. 2.

SAWYER, C. N., 1947, Fertilization of Lakes by Agricultural and Urban Drainage, Journal New England Water Works Association, Vol. 61.

GERLOFF, G., and F. SKOOG, 1957, Nitrogen as a Limiting Factor for the Growth of *Microcystis Aeruginosa* in Southern Wisconsin Lakes, Ecology 38, 4 (556).

Federal Water Pollution Control Administration 1966, Fertilization and Algae in Lake Sebasticook, Maine. Technical Services Program, Federal Water Pollution Control Administration, Robert A. Taft, Sanitary Engineer Center, Cincinnati, Ohio.

The authors are all public health biologists employed by the Department of Natural Resources, Division of Environmental Protection.

# ANNOTATED LIST OF THE FISHES OF WISCONSIN

*Marlin Johnson and George C. Becker*

In light of the increasing amount of work being done by state and federal agencies and by various state institutions on systematic and ecological as well as recreational and economic aspects of our fish fauna, the need has arisen for an up-to-date list, briefly noting the status of each species within the State of Wisconsin. Recent local studies on the distribution of fishes in various parts of the state have made possible the preparation of this list. Moreover, in recent years nomenclature for many species has been modified or clarified by national and international agencies; these changes have been incorporated.

Many significant changes in the distribution of certain Wisconsin fish species have occurred in recent years. These range changes have been brought about through fish rescue operations, crossover areas, canals, plantings by federal and state agencies, and the omnipresent fisherman's minnow bucket. Wholesale modification of the landscape, through forestry and agricultural practices as well as dam and industrial construction, has left its mark on streams and lakes and is reflected in widespread alterations in species' composition and numbers. These changes are pointed out in the annotations.

The list includes all the native fishes for Wisconsin and those exotic species planted with the intent that they become a characteristic part of the fish fauna. At the end of the paper, a separate list of problematical species includes those not known to be reproducing in the state and those found in nearby waters but not yet reported from the state. The status of each species is indicated by its general distribution and relative abundance within the state and by occasional reference to specific habitat.

The following scale was used for indicating distribution and abundance:

*Rare*—species which are taken at highly infrequent intervals with one or two specimens per collection.

*Uncommon*—species which are taken infrequently and in very small numbers.

*Common*—species which are taken frequently and in moderate numbers.

*Abundant*—species taken frequently and in large numbers.

The information has been compiled from the following sources: literature on Wisconsin fishes, personal communication with workers now actively engaged in fish research, fish collection records in the University of Wisconsin Zoological Museum and Biology Museum at Wisconsin State University–Stevens Point, and personal observations made by the authors. During the period from 1964–1966 the senior author, in conjunction with Field Zoology classes, has made extensive collections (350 stations) throughout southern Wisconsin. The junior author has made detailed surveys of several large watersheds in the state. Specimens of most species lie in the Zoological Museum, University of Wisconsin, Madison, and in the Museum of Biology, Wisconsin State University, Stevens Point.

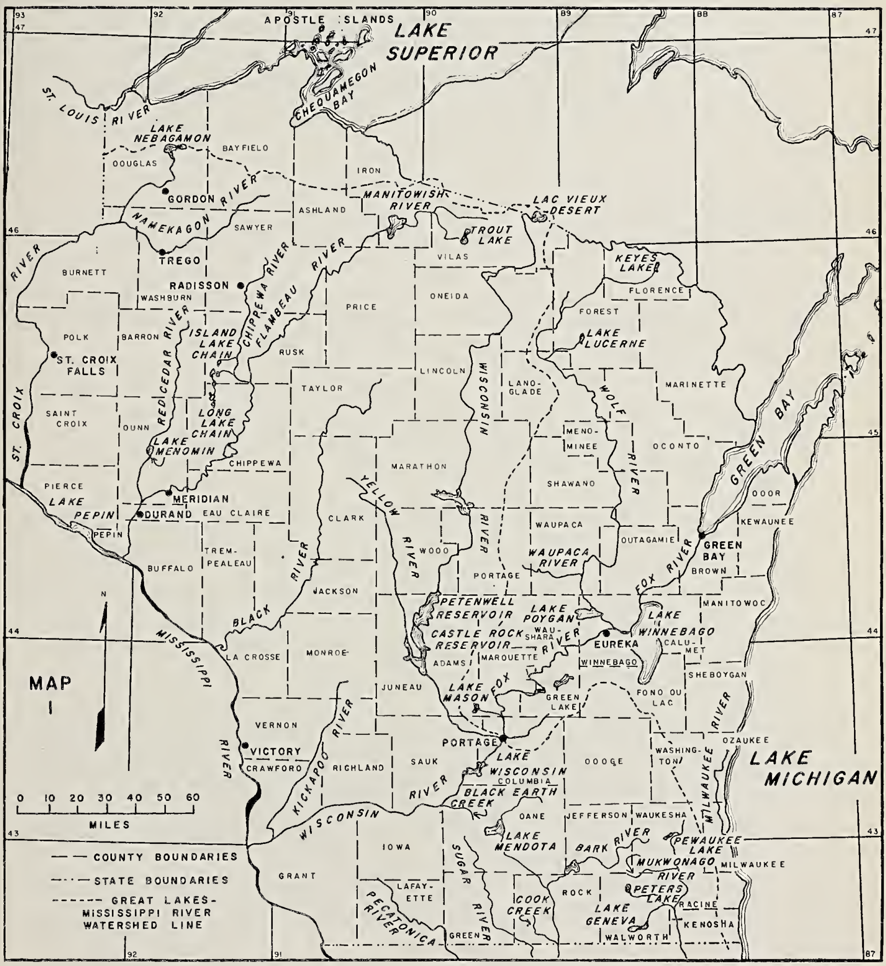
The arrangement of orders and families follows the classification of Greenwood *et al,* 1966. Except where Dr. Bailey (see acknowledgements) has advised recent changes, nomenclature is according to Bailey *et al,* 1960. Certain synonomies have been included to facilitate cross reference to other literature dealing with fishes of our area (particularly Greene 1935, and Forbes and Richardson 1920). Pertinent literature on distribution, ecology, and taxonomy is cited.

Key rivers and lakes mentioned in the text are found on Map 1. The "lower Wisconsin River" refers to that section from the Prairie du Sac dam down to its juncture with the Mississippi River. The "lower Wolf River and its lakes" starts at the Shawano dam and includes Lake Winnebago.

## Acknowledgements

We are grateful to W. Dryer and Stanford Smith of the U. S. Bureau of Fisheries, to Don Mraz, Arthur A. Oehmcke, Clarence Wistrom, John Truog, Cliff Brynildson, Lyle Christenson, John Brasch, Ruth Hine, and C. W. Threinen of the Department of Natural Resources and to Dr. W. G. Reeder of the U. W. Zoology Department for their critical reading of parts of the manuscript and helpful suggestions. The help of E. J. Trimberger, formerly of the Wisconsin Department of Natural Resources, in obtaining distribution data from the Mississippi River area, and of Philip Smith, Illinois Natural History Survey, in checking synonomies is also greatly appreciated. We thank the following commercial fishermen who during 1968 provided specimens from Lakes Michigan and

Superior: Evald Heinonen, Harvey Hadland, Wm. G. Bodin, Howard Weborg, Everett Marks, John Reynen, Bernard Moes, Norbert Swaer, Frederick Topel, and Walter Voight. Special thanks are due Reeve Bailey, Curator of Fishes, Museum of Zoology, University of Michigan, for verification of certain identifications and for help with nomenclatural changes, and Miss Peggy Brogan for drafting the map. Support for publication costs came from University of Wisconsin Center System.




MAP 1. Map of Wisconsin showing major drainage units, counties, key rivers, and lakes and cities.

## ORDER PETROMYZONTIFORMES

### PETROMYZONTIDAE—LAMPREYS

*Ichthyomyzon castaneus* Girard—Chestnut lamprey

Uncommon to common in the lower Wisconsin, Yellow (Wood Co.), Mississippi, St. Croix and Nemakagon Rivers. In Great Lakes drainage present in the upper Fox R. at Eureka (Winnebago Co.) and reported from the lower Wolf R. and its lakes. 16, 65

*Ichthyomyzon fossor* Reighard & Cummins—Northern brook lamprey

Uncommon in Wisconsin R. and its tributaries. Common in small to medium-size streams of central Wisconsin flowing into L. Michigan. Distribution widespread in streams flowing into L. Superior. 7, 16, 25

*Ichthyomyzon unicuspis* Hubbs & Trautman—Silver lamprey
*Ichthyomyzon concolor* (Kirtland) F&R*

Uncommon in Mississippi and lower Wisconsin Rivers, Green Bay, and the large lakes of the lower Wolf R. basin. Common in streams flowing into L. Superior. 9, 13, 15, 16

*Lampetra lamottei* (Lesueur)—American brook lamprey
*Entosphenus appendix* (DeKay) G.†
*Lampetra wilderi* Gage F&R

Common in creeks of the Mississippi basin throughout southern and central Wisconsin. So far not reported from streams of Great Lakes drainage in the state, although reported as common in upper Michigan streams of eastern L. Superior. 7, 13, 16, 58

*Petromyzon marinus* Linnaeus—Sea lamprey

Recently abundant in L. Michigan. Common in L. Superior. Spawning and ammocete development occurring in streams in their watersheds. Exotic, invading L. Michigan in mid-1930's and L. Superior in the late 1940's. Currently subject to control with lampricides and other methods, but in last two years increasing in numbers (Moore, James D. 1969. Lake trout lamprey scarring in North Green Bay. Wis. Dept. Nat. Resources. Oshkosh. 5p. mimeo). 16, 69.

---

* Forbes & Richardson, 1920.
† Greene, 1935.

## ORDER ACIPENSERIFORMES

### ACIPENSERIDAE—STURGEONS

*Acipenser fulvescens* Rafinesque—Lake sturgeon
*Acipenser rubicundus* Lesueur F&R

Common in the Menominee R. (Wis.–Mich. border) and in the lower Wolf R. and its lakes, particularly Poygan and Winnebago. Common in L. Wisconsin (Sauk & Columbia Cos.). Common in St. Croix R. to Gordon Dam and in Namekagon R. below Trego dam. Common in both the Chippewa and Flambeau Rivers. Present in Benson Lake, the widespread of Manitowish R. (Vilas Co.) and in the Clam R. (Burnett Co.). Verified report from Big Cedar L. (Washington Co.) in 1961, resulting from 1936 planting. Rare in Lakes Michigan and Superior. 9, 13, 65, 91.

*Scaphirhynchus platorynchus* (Rafinesque)—Shovelnose sturgeon

Uncommon to common in the main channels of the Mississippi and lower Wisconsin Rivers and in the lower Chippewa and lower Red Cedar Rivers. Presence reported up to St. Croix Falls dam on the St. Croix R. 13

### POLYODONTIDAE—PADDLEFISHES

*Polyodon spathula* (Walbaum)—Paddlefish

Formerly abundant on the Mississippi R., now uncommon in the Mississippi and lower Wisconsin Rivers. 13, 23, 108

## ORDER SEMIONOTIFORMES

### LEPISOSTEIDAE—GARS

*Lepisosteus osseus* (Linnaeus)—Longnose gar

Common in most large lakes and quiet waters of larger rivers over lower two-thirds of Wisconsin. In northwestern Wisconsin common in Big Sissabagama, Big Court Oreilles, Grindstone, and Big Sand Lakes (Sawyer Co.). Common in the St. Croix R. below dam at St. Croix Falls; abundant in the Island Lake Chain (Rusk Co.) and the Long Lake Chain (Chippewa Co.). Uncommon in northeastern Wisconsin. 9, 10, 13, 65

*Lepisosteus platostomus* Rafinesque—Shortnose gar

Uncommon to common in lower Wisconsin and Mississippi Rivers and lower portions of their tributaries; in the St. Croix up to the St. Croix Falls Dam. Formerly reported from Lake Mendota (Dane Co.). Recently appearing in Lake Winnebago (Great Lakes drainage), possibly entering via the Fox–Wisconsin canal at Portage (Columbia Co.). Several specimens taken summer 1968 in southern third of Green Bay (L. Michigan). 9, 13, 67, 87

## ORDER AMIIFORMES

### AMIIDAE—BOWFINS

*Amia calva* Linnaeus—Bowfin

Uncommon to common in quiet waters of large rivers and large lakes. Wider dispersal and less common northward. 9, 10, 13, 65, 69

## ORDER ANGUILLIFORMES

### ANGUILLIDAE—FRESHWATER EELS

*Anguilla rostrata* (Lesueur)—American eel
*Anguilla bostoniensis* (Lesueur) G.
*Anguilla chrysypa* Rafinesque F&R

Rare in the Mississippi R. and its tributaries. Report from L. Neshonic (La Crosse Co.) about 1954 (letter from Lyle Christenson, April 25, 1969). Reports for 1966 from mouth of St. Croix (Burnett Co.) and Chippewa (Buffalo Co.) Rivers, and Lake Nebagamon (Douglas Co.). Taken regularly on Red Cedar R. upstream to L. Menomin (Dunn Co.). Single specimen collected from L. Superior (Beaver Lake Cr., Alger Co., Mich.). Single specimen collected at Red Banks in Green Bay of L. Michigan, summer 1968. Also collected in Lake La Belle, 1959, and Lake Nemahbin (Waukesha Co.), 1951. 46, 67, 69

## ORDER CLUPEIFORMES

### CLUPEIDAE—HERRINGS

*Alosa chrysochloris* (Rafinesque)—Skipjack herring
*Pomolobus chrysochloris* Rafinesque F&R G.

Probably extinct. Formerly found throughout the Wisconsin portion of the Mississippi R. and in the St. Croix up to St. Croix Falls. 23, 46

*Alosa pseudoharengus* (Wilson)—Alewife

Abundant recent (1952) addition to fauna of L. Michigan and has become a nuisance. Appeared in L. Superior in 1954, becoming common. 68, 79, 99

*Dorosoma cepedianum* (Lesueur)—Gizzard shad

Abundant in Mississippi and lower Wisconsin Rivers. Uncommon to common in lower portions of their larger tributaries. Common in

St. Croix R. upstream to St. Croix Falls Dam. Rare, southern L. Michigan. Uncommon in lower third of Green Bay of L. Michigan where collected by commercial fishermen summer 1968. 13, 22, 65, 68

### HIODONTIDAE—MOONEYES

*Hiodon alosoides* (Rafinesque)—Goldeye
*Amphiodon alosoides* Rafinesque G.

Rare in Mississippi R. as far north as Lake Pepin. 23, 46

*Hiodon tergisus* Lesueur—Mooneye

Common in Mississippi, St. Croix R. upstream to St. Croix Dam, lower Wisconsin R., and uncommon in lower portions of their larger tributaries. Common in lower Wolf R. and its lakes (Great Lakes drainage). Rare in Green Bay and L. Michigan. 9, 13, 22, 65

## ORDER SALMONIFORMES

### SALMONIDAE—TROUTS, WHITEFISHES

*Coregonus clupeaformis* (Mitchill)—Lake whitefish

Common in L. Superior (up to 35 fathoms); common in L. Michigan but reduced in recent years by the sea lamprey. Reported from L. Lucerne (Forest Co.), Keyes L. (Florence Co.), and Trout L. (Vilas Co.). 29, 31, 34, 75, 91, 107

*Leucichthys alpenae* (Koelz)—Longjaw cisco

Formerly common in L. Michigan (20 to 60 fathoms), but becoming very rare in recent years. 96

*Leucichthys artedii* Lesueur—Cisco or lake herring
*Argyrosomus artedi* (Lesueur) F&R

Common but declining in Lakes Superior and Michigan. Common in many deeper inland lakes in northern tier of counties; rare to common in lakes of Waukesha Co. and in L. Geneva (Walworth Co.). Nearing extinction in Lake Mendota (Dane Co.). 20, 24, 31, 42, 53, 63, 96

*Leucichthys hoyi* (Gill)—Bloater

Abundant and dominant *Leucichthys* at 20 to 70 fathoms, but some found to greatest depths in both Lakes Superior and Michigan. Increased rapidly in numbers and extended range in L. Michigan during 1950's and early 1960's but declining in recent years as alewives increased. 31, 61, 96, 110, 111

*Leucichthys johannae* (Wagner)—Deepwater cisco

Perhaps now extinct, but formerly common in deeper waters of L. Michigan (30 to 90 fathoms). Last seen and taken in the early 1950's. 96

*Leucichthys kiyi* (Koelz)—Kiyi

Common in deep areas of L. Superior. Have become very rare in recent years in L. Michigan (60 to 100 fathoms). 31, 96

*Leucichthys nigripinnis* (Gill)—Blackfin cisco

Once common but now rare in L. Superior (15 to 100 fathoms). Formerly common in L. Michigan but now probably extinct—last records from the mid-1950's. 31, 96

*Leucichthys reighardi* (Koelz)—Shortnose cisco

Rare in western L. Superior (up to 50 and possibly 65 fathoms). Once common in L. Michigan (20 to 60 fathoms) but very rare in recent years. 31, 96

*Leucichthys zenithicus* (Jordan & Evermann)—Shortjaw cisco

Common in L. Superior (10 to 90 fathoms but most common at 30 to 70 fathoms). Once common in L. Michigan (20 to 70 fathoms) but decreasing to very rare in recent years. 31, 96

*Prosopium coulteri* (Eigenmann and Eigenmann)—Pygmy whitefish

Common in L. Superior (10 to 59 fathoms, but most common at 20 to 50 fathoms). 31, 37

*Prosopium cylindraceum* (Pallas)—Round whitefish
*Prosopium quadrilaterale quadrilaterale* (Richardson) G.

Common in L. Superior (shallows to 19 fathoms; rarer up to 40 fathoms). Uncommon to common in shallower areas of L. Michigan north of Sheboygan. Rare southwards. 31, 73

*Salmo gairdneri* Richardson—Rainbow trout

Introduced in late 1800's. Common locally in streams and lakes over the state. Continuously stocked in L. Superior and its tributaries; spawning successfully in some larger tributaries. Continuously stocked in recent years along Wisconsin shore of L. Michigan; natural reproduction insignificant. 19, 27b

*Salmo trutta* Linnaeus—Brown trout
*Salmo fario* Linnaeus G.

Introduced in late 1800's. Common in cold-water streams of southern and central Wisconsin, and in recent years playing a larger role in stream fishing of northern Wisconsin. Large brown trout are taken frequently in shore areas of Lakes Superior and Michigan, where they are maintained by extensive stocking. 18, 27c, 69

*Salvelinus fontinalis* (Mitchill)—Brook trout

Common in streams of central and northern Wisconsin; rare to uncommon in southern Wisconsin, except Richland, Columbia, Dane and Sauk Cos. where common in some streams. Coasters present along Wisconsin shores of Lakes Superior and Michigan (especially Door and Kewaunee Cos.); these populations sustained by stocking. 15, 17

*Salvelinus namaycush namaycush* (Walbaum)—Common lake trout
*Cristivomer namaycush* (Walbaum) G. & F&R

Common in L. Superior (10 to 39 fathoms). Uncommon in L. Michigan but returning in numbers. Inland waters with spawning trout: Trout and Black Oak L. (Vilas Co.), Big Green L. (Green Lake Co.). Recently introduced in Lac Court Oreilles (Sawyer Co.) 27a, 31, 35, 36, 48

*Salvelinus namaycush siscowet* (Agassiz)—Siscowet

Common in deeper waters (40 to 125 fathoms) of L. Superior. 33

### OSMERIDAE—SMELTS

*Osmerus mordax* (Mitchill)—American smelt

Common in L. Superior and Michigan and occasionally taken in large tributary streams. First taken off Wisconsin shores in L. Michigan in 1928 from 1912 stocking of Crystal R., Benzie Co., Michigan. Reached Wisconsin shores of L. Superior in late 1930's. Populations reproducing in L. Lucerne (Forest Co.); also reported from Sand Bar, Tomahawk and Big Diamond Lakes (Bayfield Co.). 26, 31, 106

### ESOCIDAE—PIKES

*Esox americanus vermiculatus* Lesueur—Grass pickerel
*Esox vermiculatus* Lesueur G. & F&R

Common in scattered localities in lakes and sluggish waters of southern one-third of state. Also found in Fishtrap and High Lakes and headwaters of Manitowish R. (Vilas Co.) and Minocqua Thoroughfare (Oneida Co.), where it was probably accidentally introduced during fish transfer operations in the early 1930's. 10, 64

*Esox lucius* Linnaeus—Northern pike

Common to abundant in lakes throughout state and in slow waters of large streams and rivers. Absent from the Chippewa R. and its lakes above Radisson (Sawyer Co.). 7, 9, 10, 12, 13, 69, 102, 103

*Esox masquinongy* Mitchill—Muskellunge

Common in the lakes and rivers in the headwater regions of the Chippewa, Flambeau, St. Croix (upstream to Trego Dam), and Wisconsin Rivers. Uncommon to rare in the middle one-third of the state. Stocked annually as far south as L. Wisconsin (Columbia Co.). Populations developed from stocking in Little Green L. (Green Lake Co.), Pewaukee L. (Waukesha Co.), and Lenwood L. (Washington Co.). Occasionally caught in L. Superior and in Green Bay (L. Michigan). 9, 10, 43, 64, 69, 81, 83

*Esox masquinongy* female X *Esox lucius* male—Tiger muskellunge

Natural crosses are reported in Lac Vieux Desert (Vilas Co.), Star, Big St. Germaine and Plum Lakes (Vilas Co.), and Tomahawk and Minocqua Lakes (Oneida Co.). Hybrids have been produced in Wisconsin hatcheries in 1940, 1946, 1947, 1963, 1965 and stocked frequently in landlocked bass lakes. This hybrid has a growth rate more rapid than either parent species. Experiments indicate that it will backcross with *Esox lucius*. 14, 65, 69

### UMBRIDAE—MUDMINNOWS

*Umbra limi* (Kirtland)—Central mudminnow

Common to abundant in small streams and marshes throughout state except in southwestern quarter, where uncommon. 7, 9, 12, 13, 65, 69

## ORDER CYPRINIFORMES

### CYPRINIDAE—MINNOWS AND CARP

*Campostoma anomalum pullum* (Agassiz)—Central stoneroller

Abundant in small swift-flowing streams of southern Wisconsin. Occasionally taken in quiet pools. 13, 57, 80

*Campostoma anomalum oligolepis* Hubbs & Greene—Largescale stoneroller

Abundant in medium-size, swift-flowing streams in central and northern Wisconsin. 13, 57, 80

*Carassius auratus* (Linnaeus)—Goldfish

Common in some Milwaukee Co. lagoons. Occasionally found in southeastern Wisconsin streams and in Peters Lake (Walworth Co.). Introduced in part through a fish exchange program with the Nebraska Fish Commission in 1903, 1904, and 1908. 67, 78, 113

*Cyprinus carpio* Linnaeus—Carp

Abundant in large shallow waters of southern and central Wisconsin. Becoming common in some northern Wisconsin waters in recent years. Introduced through plantings by Wis. Commissioners of Fisheries, 1881–1895. 30, 41, 69, 74, 113

*Chrosomus eos* Cope—Northern red-belly dace

Abundant in small streams and in bog lakes of central and northern Wisconsin. 7, 12, 69

*Chrosomus erythrogaster* (Rafinesque)—Southern red-belly dace

Abundant in small to medium-size streams in southern Wisconsin. Rare to uncommon in central Wisconsin, apparently moving into a number of new localities in recent years. 13

*Chrosomus neogaeus* (Cope)—Finescale dace
*Pfrille neogaea* (Cope) G.

Uncommon to common in small streams and ponds in northeastern Wisconsin and in the streams of the L. Superior drainage. Rare in headwater streams of central Wisconsin. 12, 69

*Clinostomus elongatus* (Kirtland)—Redside dace

Uncommon in small to medium-size streams in widely scattered basins of southern, central and eastcentral Wisconsin. 7, 13

*Dionda nubila* (Forbes)—Ozark minnow
*Hybognathus nubila* (Forbes) F&R

Rare in medium-size streams of gentle current Platte R. basin (Grant Co.). Reported from streams in Barron, Lafayette, Iowa, Walworth, Rock, and Waukesha Cos. in late 1920's. 13, 46

*Hybognathus hankinsoni* Hubbs—Brassy minnow

Common in slow-flowing streams over state except northwestern portion where uncommon. Rare in large rivers. 7, 13, 46

*Hybognathus nuchalis* Agassiz—Silver minnow

Uncommon in the lower Wisconsin R. and the Mississippi and in the lower portions of their tributaries. 13, 46

*Hybopsis aestivalis* (Girard)—Speckled chub
*Hybopsis hyostomus* (Gilbert) F&R
*Extrarius aestivalis* (Gilbert) G.

Generally uncommon over shallow sand flats in lower Wisconsin and Mississippi R. and lower portions of their larger tributaries. 13, 46

*Hybopsis biguttata* (Kirtland)—Hornyhead chub
*Hybopsis kentuckiensis* (Rafinesque) F&R
*Nocomis biguttatus* (Kirtland) G.

Common in clear-water, medium-size streams of northern and central Wisconsin. Uncommon in the southwestern quarter of state except in the southern tier of counties where common. 7, 12, 13, 46

*Hybopsis plumbea* (Agassiz)—Lake chub
*Couesius plumbeus* (Agassiz) G.

Uncommon in shoal waters in the vicinity of stream mouths in Green Bay and L. Michigan. Common near mouths of streams in Bayfield and Douglas Cos. (L. Superior drainage). 45, 69

*Hybopsis storeriana* (Kirtland)—Silver chub

Uncommon in flowing sections of the lower Wisconsin R., in the Mississippi R., and in the lower portions of their tributaries. 13, 46

*Hybopsis x-punctata* Hubbs & Crowe—Gravel chub
*Hybopsis dissimilia* (Kirtland) F&R
*Erimystax dissimilis* (Kirtland) G.

Probably extinct in state. Taken only once from the Sugar R. (Green Co.) in the late 1920's. 46

*Notemigonus crysoleucas* (Mitchill)—Golden shiner
*Abramis crysoleucas* (Mitchill) F&R

Common to abundant in lakes, slow-flowing streams and rivers over the entire state. 7, 9, 10, 12, 13, 22, 69

*Notropis amnis* Hubbs & Greene—Pallid shiner

Rare. In recent years this minnow has been collected from the lower Wisconsin and from the Mississippi Rivers in water of moderate flow. 13, 46

*Notropis anogenus* Forbes—Pugnose shiner

Rare. Earlier reports from Burnett, Waupaca, Kewaunee, Marquette, Columbia and Dane Cos. In recent years this minnow has been collected only from Pewaukee Lake (Waukesha Co.) and L. Poygan (Winnebago Co.). 2, 9, 10, 46

*Notropis atherinoides* Rafinesque—Emerald shiner

Common to abundant in L. Michigan, Superior, Winnebago and other large inland lakes of central and southern Wisconsin. Present in Yellow Birch L. (Vilas Co.). A common minnow in the lower Wisconsin and Mississippi R. and lower portions of some of their tributaries. 9, 13, 22, 69

*Notropis blennius* (Girard)—River shiner
*Notropis jejunus* (Forbes) F&R

Common in the lower Wisconsin and the Mississippi R. and lower portions of some tributary streams. An isolated population in L. Winnebago of the Great Lakes Basin. 9, 13, 46

*Notropis buchanani* Meek—Ghost shiner

Rare or nearly extinct in the state. Last collected in 1944 (UW Museum of Zoology—Madison) from the Mississippi R. opposite Crawford Co. 46

*Notropis chalybaeus* (Cope)—Ironcolor shiner

Camm Swift, Dept. of Biological Sciences, Florida State University, Tallahassee, writes that two collections which Greene (46) catalogued originally as *Notropis texanus richardsoni* are *Notropis chalybaeus* (letter November 8, 1968). The two series follow: *From* UMMZ 66537 (7 of 41) Wisc., Collumbia Co., Fox R. opposite Lock 25. VIII:26:1925 Green and Jones. *From* UMMZ 74054 (2 of 75) Wisc., Waupaca Co., Blake Cr., 5 ml. W. Symco. VII:9:1926 Greene and Lo Criccho.

*Notropis cornutus* (Mitchill)—Common shiner

Abundant and one of the commonest of stream and river minnows found under a wide variety of conditions. Occasional in clearwater lakes over clean bottom. 7, 9, 10, 13, 44, 65, 69

*Notropis chrysocephalus* (Refinesque)—Stripped shiner

Common in the Saukville–Grafton sector of the Milwaukee R. (Ozaukee Co.). Single specimen (Museum WSU–Stevens Point) collected from Green Bay near the city of Sturgeon Bay. Older records indicate presence from Kenosha to Dane Cos. 44, 46

*Notropis dorsalis* (Agassiz)—Bigmouth shiner
*Notropis gilberti* Jordan and Meek F&R

Common over sand-bottom, medium-sized streams in the Mississippi drainage. Recently established in the east-central streams within the L. Michigan drainage of Wisconsin. 7, 13

*Notropis heterodon* (Cope)—Blackchin shiner

Uncommon in central and southern Wisconsin. Absent from southwestern quarter. Locally common northward in lakes and bog ponds. 9, 10, 12, 46, 65

*Notropis heterolepis* Eigenmann & Eigenmann—Blacknose shiner
*Notropis cayuga* Meek F&R

Rare in southwestern quarter of state. Elsewhere common in widely separated lakes and slow-moving streams, often in heavily-silted habitats. 7, 9, 10, 12, 46, 65

*Notropis hudsonius* (Clinton)—Spottail shiner

Common locally in very large inland lakes, in Lakes Michigan and Superior, and in large slow-moving rivers as the lower Wisconsin and Mississippi, and in the St. Croix R. upstream to St. Croix Falls Dam. 9, 10, 12, 13, 22, 46, 65, 69

*Notropis rubellus* (Agassiz)—Rosyface shiner
*Notropis rubrifrons* (Cope) F&R

Common in medium-sized, swift-flowing streams of central and southern Wisconsin. Uncommon northward—apparently absent from the extreme northwest corner of the state. 7, 12, 13, 46, 69

*Notropis spilopterus* (Cope)—Spotfin shiner
*Notropis whipplii* (Girard) F&R G.

Abundant in medium to large-sized streams and rivers. A common minnow in large lakes. Absent from the northern tier of counties. 7, 9, 10, 12, 13, 65, 69

*Notropis stramineus* (Cope)—Sand shiner
*Notropis blennius* (Girard) F&R
*Notropis phenacobius* Forbes F&R
*Notropis deliciosus* (Cope) G.

Abundant in medium to large-sized streams and rivers of central and southwestern Wisconsin. Elsewhere uncommon to common. 7, 9, 12, 13, 69

*Notropis texanus* (Girard)—Weed shiner
*Notropis nux* Hubbs & Greene G.

Uncommon in the lower Wisconsin and in the Mississippi Rivers and in the lower portions of their tributaries. Older records indicate presence from east-central Wisconsin (Great Lakes drainage). 13, 22, 46

*Notropis umbratilis* (Girard)—Redfin shiner

Locally common in slow-moving, turbid waters of southeastern Wisconsin. Older records show presence in widely isolated streams throughout the southern half of the state. 46, 54

*Notropis volucellus volucellus* (Cope)—Northern mimic shiner
*Notropis blennius* (Girard) F&R

Locally common in medium-sized streams and in lakes over the state except in the southwestern quarter, where rare. Distribution sites widely isolated. 7, 22, 65, 69

*Notropis volucellus wickliffi* Trautman—Channel mimic shiner

Rare in the Mississippi R. Seldom taken in recent years. 13, 46

*Opsopoeodus emiliae* Hay—Pugnose minnow

Uncommon in slow-water and sloughs of the Wisconsin R. upstream to Du Bay (Marathon Co.) and in the Mississippi R. In the Great Lakes drainage taken only from the west end of L. Poygan (Waushara Co.). 9, 13, 22, 46

*Phenacobius mirabilis* (Girard)—Suckermouth minnow

Uncommon to common in small and medium-sized tributaries to the lower Wisconsin and Mississippi Rivers. In the southwestern quarter of the state, from Vernon Co. southward. Uncommon in Rock R. drainage in southeastern quarter. 13, 46

*Pimephales notatus* (Rafinesque)—Bluntnose minnow
*Hyborhynchus notatus* (Rafinesque) G.

Abundant in streams and lakes over the entire state. Uncommon in the larger rivers. This species, from the standpoint of distribution and numbers, is perhaps the most successful Wisconsin fish. 6, 7, 9, 10, 12, 13, 22, 65, 69

*Pimephales promelas* Rafinesque—Fathead minnow

Locally common over the entire state. Frequently associated with turbid water. 7, 12, 13, 22, 46, 69

*Pimephales vigilax* (Baird & Girard)—Bullhead minnow
*Cliola vigilax* (Baird and Girard) F&R
*Hypargyrus velox* (Girard) G.

Common to abundant in the lower Wisconsin and the Mississippi. Rarely associated with other large streams in the southwestern quarter of state. A recent collection from the Fox R. (Marquette Co.) near the Portage Canal indicates a late crossover into the Great Lakes drainage basin. 7, 22

*Rhinichthys atratulus* (Hermann)—Blacknose dace
*Rhinichthys atronasus* (Mitchill) F&R. G.

Common to abundant in small cool headwater streams. Uncommon to common in medium-sized streams supporting trout. Distributed throughout the state. 6, 8, 12, 13, 69

*Rhinichthys cataractae* (Valenciennes)—Longnose dace

Common to abundant in fast water of medium-sized streams of the northern half of Wisconsin. Common in small fast-water streams of southwestern Wisconsin. Common in wave-swept shallows of Lakes Michigan and Superior. 6, 8, 12 ,13, 69

*Semotilus atromaculatus* (Mitchill)—Creek chub

Abundant in small and medium-sized streams and rivers over the entire state. Rare in large rivers and in lakes. One of our commonest fishes. 7, 12, 13, 65, 69

*Semotilus margarita* (Cope)—Pearl dace
*Margariscus margarita* (Cox) G.

Common in very small streams of central and northern Wisconsin except in streams of L. Superior drainage where rare. Uncommon in larger streams. 7, 12, 65, 69

## CATOSTOMIDAE—SUCKERS

*Carpiodes carpio* (Rafinesque)—River carpsucker

Common in the lower Wisconsin R. and the Mississippi R., and their larger tributaries. 13, 22, 46

*Carpiodes cyprinus* (Lesueur)—Quillback
*Carpiodes thompsoni* Agassiz F&R
*Carpiodes velifer* (Rafinesque) F&R

Abundant in the lower Wisconsin R. and the Mississippi R. and their larger tributaries. Common Lakes Poygan and Winnebago. 9, 13, 65

*Carpiodes velifer* (Rafinesque)—Highfin carpsucker
*Carpiodes difformis* Cope F&R

Common in the lower Wisconsin R. and the Mississippi R. and in their larger tributaries. 13, 46

*Catostomus catostomus* (Forster)—Longnose sucker

Common in L. Superior and its tributaries during spawning. Formerly common, now rare in L. Michigan. 31, 46, 69

*Catostomus commersoni* (Lacépède)—White sucker

Abundant and generally distributed in lakes and streams over the state. One of the most widely distributed and abundant fish species in the state. 6, 7, 9, 10, 12, 65, 69

*Cycleptus elongatus* (Lesueur)—Blue sucker

Rare. Found only in the lower Wisconsin R., the Mississippi R., and the St. Croix upstream to St. Croix Falls Dam. 13, 46, 65

*Erimyzon oblongus* (Mitchill)—Creek chubsucker
*Erimyzon sucetta oblongus* (Mitchill) F&R

Rare. Taken only twice in the southeastern corner of Wisconsin during the late 1920's from the Des Plaines R. (Kenosha Co.) and a tributary. 46

*Erimyzon sucetta* (Lacépède)—Lake chubsucker
*Erimyzon sucetta oblongus* (Mitchill) F&R

Rare to uncommon locally in the larger rivers and the lower portions of tributaries to them in the southern half of Wisconsin. Report from White Clay L. (Shawano Co.) needs substantiation. Occasionally taken in larger lakes, especially in southeastern Wisconsin. 9, 10, 13, 46

*Hypentelium nigricans* (Lesueur)—Northern hogsucker
*Catostomus nigricans* Lesueur F&R

Common locally in riffle areas of medium to large streams and rivers. Generally distributed throughout the state. 7, 12, 13, 65

*Ictiobus bubalus* (Rafinesque)—Smallmouth buffalo

Uncommon in the lower Wisconsin R. and in the Mississippi. Recent record from Island L. (Vilas Co.), needs verification. 13, 22, 46

*Ictiobus cyprinellus* (Valenciennes)—Bigmouth buffalo
*Megastomatobus cyprinella* (Cuvier & Valenciennes) G.

Uncommon to common in medium to large rivers in southern Wisconsin. Reported from L. Delavan (Waukesha Co.), L. Koshkonong (Jefferson Co.), Beaver Dam L. (Dodge Co.), the Madison Lakes (Dane Co.) and Long Lake (Waupaca Co.). The last is the first Wisconsin record from the L. Michigan drainage. Present in the Mississippi R. and in the St. Croix up to St. Croix Falls Dam. Reports needing substantiation from Manitowish Chain and Big Lake (Vilas Co.). 13, 22, 46, 65, 67

*Ictiobus niger* (Rafinesque)—Black buffalo
*Ictiobus urus* (Agassiz) F&R

Rare on the lower Wisconsin R. Uncommon on the Mississippi R. 13, 45

*Minytrema melanops* (Rafinesque)—Spotted sucker

Common locally in the lower Wisconsin and in the Mississippi Rivers and their larger tributaries. Common in Lake Poygan; occasional in L. Winnebago. It has been reported from the upper Fox R. (Columbia to Winnebago Cos.) and from the lower Wolf downstream from the Shawano Dam (Shawano Co.). Recently collected in Des Plaines R. (Kenosha Co.). 9, 13, 22

*Moxostoma anisurum* (Rafinesque)—Silver redhorse

Common locally in large streams in the western half of Wisconsin and in streams in the L. Superior drainage. Uncommon in east-central Wisconsin (L. Michigan drainage). 7, 65, 68, 69

*Moxostoma carinatum* (Cope)—River redhorse

This species has not been collected by Wisconsin workers but is reported in boundary waters in Lake St. Croix on the St. Croix R. between Minnesota and Wisconsin. 82b

*Moxostoma duquesnei* (Lesueur)—Black redhorse

Probably extinct. Taken only once from Black Earth Creek (Dane Co.) in the late 1920's. 46

*Moxostoma erythrurum* (Rafinesque)—Golden redhorse
*Moxostoma aureolum* (Lesueur) F&R

Uncommon in northern half of state (absent from northern tier of counties). Common in medium to large rivers in the southern half of the state. 7, 9, 12, 13

*Moxostoma macrolepidotum* (Lesueur)—Northern redhorse
*Moxostoma breviceps* (Cope) F&R
*Moxostoma aureolum* (Lesueur) G.

Common statewide in medium to large rivers. A common species in large lakes of central and northern Wisconsin. 7, 9, 12, 13, 22, 65, 69.

*Moxostoma valenciennesi* Jordan—Greater redhorse
*Moxostoma rubreques* Hubbs G.

Rare and probably nearing extinction. Old records indicate general distribution in the state. A purported specimen recently reported from the lower Wisconsin R. misidentified as this species, actually *M. macrolepidotum.* 13, 46

## ORDER SILURIFORMES

### ICTALURIDAE—FRESHWATER CATFISHES

*Ictalurus furcatus* (Lesueur)—Blue catfish

Rare, probably extinct. Only two old records from the Mississippi R. (Crawford and Pepin Cos.). 46

*Ictalurus melas* (Rafinesque)—Black bullhead
*Ameiurus melas* (Rafinesque) F&R G.

Abundant throughout the state in lakes and warm-water streams of all sizes. 7, 9, 10, 12, 13, 22, 65, 68, 69

*Ictalurus natalis* (Lesueur)—Yellow bullhead
*Ameiurus nebulosus* (Lesueur) F&R. G.

Common throughout the state, generally in clear medium-sized streams and occasionally in clear lakes. 7, 9, 10, 12, 13, 22, 65, 69, 89

*Ictalurus nebulosus* (Lesueur)—Brown bullhead
*Ameriurus nebulosus* (Lesueur) F&R. G.

Uncommon in sloughs of rivers and in lakes. Discontinuous distribution throughout state. 7, 9, 12, 13, 22, 69, 89

*Ictalurus punctatus* (Rafinesque)—Channel catfish
*Villarius lacustris* (Walbaum) G.

Uncommon to common in the Mississippi R. and the lower Wisconsin R. (upstream to Castle Rock Dam) and their larger tributaries, and in the St. Croix R. to Gordon Dam and in the Namekagon to Trego Dam. Uncommon to common in the Wolf and Fox River system of the L. Michigan basin. Rare in L. Michigan and Green Bay. In the L. Superior drainage a single recent record from the St. Louis R. (Douglas Co.). 9, 13, 22, 65, 69

*Noturus exilis* Nelson—Slender madtom
*Schilbeodes exilis* (Nelson) F&R. G.

Rare in Bark R. system (Waukesha Co. ). 20, 46

*Noturus flavus* Rafinesque—Stonecat

Uncommon to common in medium-sized streams of moderate current in southern two-thirds of state. Rare northward except in L. Superior tributaries (Bayfield and Douglas Cos.), where common. 7, 12, 13, 65, 69

*Noturus gyrinus* (Mitchill)—Tadpole madtom
*Schilbeodes gyrinus* (Mitchill) F&R. G.

Common statewide in medium to large rivers. Frequently found in lakes over debris-covered bottom. 7, 9, 12, 13, 22, 69

*Pylodictis olivaris* (Rafinesque)—Flathead catfish
*Leptops olivaris* (Rafinesque) F&R

Uncommon to common in Mississippi, lower Wisconsin and Pecatonica Rivers. In recent years reported occasionally from lower Wolf and upper Fox Rivers and their lakes (L. Michigan drainage). 9, 13, 22, 65

### APHREDODERIDAE—PIRATE PERCH

*Aphredoderus sayanus* (Gilliams)—Pirate perch

Uncommon to rare in sloughs of the Mississippi R. and in the Wisconsin R. up to central Wisconsin. Occasionally found in lower portions of tributaries to these waters. Uncommon in Des Plaines R. (Kenosha Co.). 13, 22

## ORDER PERCOPSIFORMES

### Percopsidae—trout-perch

*Percopsis omiscomaycus* (Walbaum)—Trout perch
*Percopsis guttatus* Agassiz F&R

Uncommon in the Mississippi and Wisconsin Rivers. More common northward, in the Chippewa R. and connecting lakes of Sawyer Co., and in L. Superior and tributary streams. Reported from Trout L. (Vilas Co.). Rare to uncommon in L. Michigan drainage except in Lakes Winnebago and Poygan (Winnebago Co.), where abundant. 9, 13, 31, 86

## ORDER GADIFORMES

### Gadidae—codfishes and hakes

*Lota lota* (Linnaeus)—Burbot
*Lota maculosa* (Lesueur) F&R. G.

Rare to uncommon in widely separated large rivers and lakes statewide. Common in dark water streams of the Flambeau R. watershed and tributary streams to L. Superior; common in Lakes Poygan and Winnebago (L. Michigan drainage). Young occasionally taken in small streams opening into large bodies of water. Decreasing in L. Michigan in recent years. 9, 12, 13, 31, 65, 69

## ORDER ATHERINIFORMES

### Cyprinodontidae—killifishes

*Fundulus diaphanus* (Lesueur)—Banded killifish

Common in lakes of southeastern Wisconsin. Uncommon in widely isolated sites in northern half of state and absent from southwestern quarter. 9, 12, 46.

*Fundulus notatus* (Rafinesque)—Blackstripe topminnow

Uncommon in sloughs and lakes of the Mississippi drainage in the southeastern quarter of state. A single recent report from the Wisconsin R. at Woodman (Grant Co.). In L. Michigan drainage, present in the upper Fox R. (Columbia and Marquette Cos.). Recently collected from lower Wisconsin R. 13, 46

*Fundulus notti* (Agassiz)—Starhead topminnow
*Fundulus dispar* (Agassiz) F&R. G.

Rare. Recently collected from quiet water in Coon Creek (Rock Co.) and sloughs of the Wisconsin R. (Iowa Co.). The later is the first for the Wisconsin R. basin. Older records from Walworth and Waukesha Cos. (lower Fox R. system). 46

### ATHERINIDAE—SILVERSIDES

*Labidesthes sicculus* (Cope)—Brook silverside

Common in lakes and quiet waters of rivers and large streams in southern half of the state. Distribution discontinuous northward where uncommon. Absent in L. Superior drainage. 10, 13, 20, 22

## ORDER GASTEROSTEIFORMES

### GASTEROSTEIDAE—STICKLEBACKS

*Culaea inconstans* (Kirtland)—Brook stickleback
*Eucalia inconstans* (Kirtland) F&R. G.

Abundant in dense vegetation of small to medium-size streams throughout state. Although taken most frequently in clear water, this species may be found in highly turbid waters. 4, 7, 12, 13, 69

*Pungitius pungitius* (Linnaeus)—Ninespine stickleback
*Pygosteus pungitius* (Linnaeus) F&R

Common in shoal areas of L. Superior and uncommon in streams of its drainage basin. Rare in shoal areas of L. Michigan. 31, 46, 69

## ORDER SCORPAENIFORMES

### COTTIDAE—SCULPINS

*Cottus bairdi* Girard—Mottled sculpin
*Cottus ictalops* (Rafinesque) F&R
*Uranidea kumlieni* Hay F&R

Common in cold headwater streams throughout the state. Occasionally in large lakes: L. Metonga (Forest Co.), L. Winnebago (Winnebago Co.), shoal areas of L. Michigan. 7, 9, 12, 13, 28, 69

*Cottus cognatus* Richardson—Slimy sculpin

Uncommon to common in streams tributary to and in L. Superior. Uncommon in L. Michigan. Recently taken from Citron Creek (Crawford Co.), Camp Creek (Richland Co.) and Big Green L. (Green Lake Co.). 13, 28, 31

*Cottus ricei* (Nelson)—Spoonhead sculpin

Uncommon in shallow to deep waters of Lakes Michigan (2 to 73 fathoms) and Superior (20 to 60 fathoms). 28, 31, 46

*Myoxocephalus quadricornis* (Linnaeus)—Fourhorn sculpin
*Triglopsis thompsonii* Girard G.

Common in deep water of Lakes Superior (40 to 200 fathoms) and Michigan (25 to 100 fathoms). 28, 31, 46

## ORDER PERCIFORMES

### SERRANIDAE—SEA BASSES

*Roccus chrysops* (Rafinesque)—White bass
*Lepibema chrysops* (Rafinesque) G.

Common in large lakes and rivers of southern half of the state and in the St. Croix upstream to St. Croix Falls Dam. Abundant in L. Winnebago. 9, 10, 13, 22, 117

*Roccus mississippiensis* (Jordan & Eigenmann)—Yellow bass
*Morone interrupta* Gill F&R G.

Uncommon to common in the Mississippi and lower Wisconsin Rivers; common and increasing in Lakes Poygan and Winnebago. Introduced into the Madison lakes (Dane Co.) and into lakes of the lower Wolf R. (L. Michigan basin) during fish transfer operations of the 1930's and 1940's. Abundant in L. Mason, Adams Co. Recently stocked in the Manitowoc, Sheboygan, and Milwaukee R. basins in eastern Wisconsin. 9, 13, 50, 51, 67, 99

### CENTRARCHIDAE—SUNFISHES

*Ambloplites rupestris* (Rafinesque)—Rock bass

Common in clear, medium to large streams and in lakes throughout the state except in southwestern quarter where rare. 7, 9, 10, 22, 53, 65, 69

*Chaenobryttus gulosus* (Cuvier)—Warmouth

Rare to uncommon in southern third of state; in sloughs of rivers and impoundments. Common in the Long Lake Chain (Chippewa Co.). Reported in L. Nebagamon (Douglas Co.). 13, 46

*Lepomis cyanellus* Rafinesque—Green sunfish
*Apomotis cyanellus* (Rafinesque) G.

Common in lakes and medium-sized streams of southern one-third of state. Discontinuous distribution northward. Not reported from the L. Superior drainage. 10, 12, 13, 22, 60

*Lepomis gibbosus* (Linnaeus)—Pumpkinseed
*Eupomotis gibbosus* (Linnaeus) F&R. G.

Common in clear medium-sized rivers and in lakes throughout the state except in the southwestern quarter and in L. Superior drainage where uncommon. 7, 9, 12, 13, 22, 69

*Lepomis humilis* (Girard)—Orangespotted sunfish
*Allotis humilis* (Girard) G.

Uncommon to common in Mississippi R. (Vernon Co. southward) and lower Wisconsin R. Rare to uncommon in sloughs and backwaters of larger streams in Richland, Iowa, Green, and Lafayette Cos. Recently collected from Sugar River (Dane and Green Cos.) and lower Fox R. (Kenosha Co.).

*Lepomis macrochirus* Rafinesque—Bluegill
*Lepomis pallidus* (Mitchill) F&R
*Helioperca macrochirus* (Rafinesque) G.

Most abundant centrarchid in Wisconsin. Found in medium-sized streams to large rivers and in nearly all lakes throughout the state. 7, 9, 10, 12, 13, 22, 65, 69, 97

*Lepomis megalotis* (Rafinesque)—Longear sunfish
*Xenotis megalotis* (Cope) G.

Uncommon in southeastern quarter of state. Recently collected in the Milwaukee R. (Ozaukee Co.) and in the Mukwonago R. (Waukesha Co.). Reported rare from L. Geneva (Walworth Co.). 46

*Micropterus dolomieui* Lacépède—Smallmouth bass

Common in medium to large streams and large clear-water lakes throughout the state. Common in upper Green Bay area of L. Michigan and Chequamegon Bay of L. Superior. 7, 9, 10, 12, 13, 65, 69, 70, 71, 114

*Micropterus salmoides* Lacépède—Largemouth bass
*Aplites salmoides* (Lacépède) G.

Abundant in medium to large rivers and in lakes throughout the state. 7, 9, 10, 12, 13, 22, 65, 69, 71, 75, 76

*Pomoxis annularis* Rafinesque—White crappie

Common in the Mississippi and lower Wisconsin Rivers and their larger tributaries. Reported from L. Mendota (Dane Co.). Recently taken from the upper Fox and lower Wolf River basin in east-central Wisconsin (L. Michigan drainage). 9, 13, 22

*Pomoxis nigromaculatus* (Lesueur)—Black crappie
*Pomoxis sparoides* (Lacépède) F&R. G.

Common in lakes and larger rivers throughout the state. Introduced into many lakes in northern Wisconsin where it has become abundant. 7, 9, 10, 12, 13, 22, 65, 69

PERCIDAE—PERCHES

*Ammocrypta asprella* (Jordan)—Crystal darter
*Crystallaria asprella* (Jordan) F&R. G.

Rare in the Mississippi River. Collected recently on the lower Wisconsin R. near Orion (Richland Co.), on the lower Chippewa R. between Durand (Pepin Co.) and Meridian Ferry Landing (Dunn Co.). 13, 46

*Ammocrypta clara* Jordan & Meek—Western sand darter
*Ammocrypta pellucida* (Baird) F&R. G.

Common locally in shallow riffles over sand flats in the lower Wisconsin R., in the Mississippi R. and in the St. Croix upstream to the St. Croix Falls Dam. Recently collected in the Waupaca R. (Great Lakes drainage near its junction with the Wolf R. in Waupaca Co.). 11, 13, 65

*Etheostoma asprigene* (Forbes)—Mud darter
*Etheostoma jessiae* (Jordan & Brayton) F&R
*Poecilichthys jessiae* Jordan & Brayton G.

Rare to uncommon in sloughs of the lower Wisconsin and Mississippi Rivers and in the lower portions of tributaries to them. 13, 22

*Etheostoma caeruleum* Storer—Rainbow darter
*Poecilichthys coeruleus* (Storer) G.

Common locally in central and southeastern Wisconsin. Uncommon in southwestern Wisconsin. 6, 12, 13, 46

*Etheostoma chlorosomum* (Hay)—Bluntnose darter
*Boleosoma camurum* Forbes F&R

Rare. This southern darter has been collected as far north as the Root R., Houston Co., Minnesota. Records (Zoological Museum UW, Madison; University Museums UM, Ann Arbor, Michigan) from the Mississippi River come from small isolated ponds between New Albin and Minnesota slough on the Iowa–Minnesota border just across from Victory, Vernon Co., Wis. 33, 49

*Etheostoma exile* (Girard)—Iowa darter
*Poecilichthys exilis* (Girard) G.

Uncommon to common locally over the state but found primarily in glaciated areas, where it is taken in small streams and bog lakes. 7, 9, 12, 13, 22, 69

*Etheostoma flabellare* Rafinesque—Fantail darter
*Catonotus flabellaris* Agassiz G.

Abundant over rocks and gravel in the smaller streams of the state. Occasionally taken in medium to large rivers. 7, 12, 13

*Etheostoma microperca* Jordan & Gilbert—Least darter
*Microperca punctulata* Putnam F&R. G.

Uncommon. Although found in widely separated areas over the state, it has been collected most frequently from the southeastern counties. 7, 46

*Etheostoma nigrum* Rafinesque—Johnny darter
*Boleosoma nigrum* (Rafinesque) F&R. G.

Abundant in all waters from the smallest stream and pond to the largest river and lake over a wide variety of bottom types. It is the most successful member of its family. 7, 9, 10, 12, 13, 22, 65, 69, 105

*Etheostoma zonale* (Cope)—Banded darter
*Poecilichthys zonalia* Cope G.

Common locally but of spotty distribution over the lower two-thirds of the state. Rare to uncommon in northeastern Wisconsin. In clear-water streams of medium to large size. 7, 12, 13

*Perca flavescens* (Mitchill)—Yellow perch
Abundant in lakes, ponds, impoundments and large rivers. Common in Chequamegon Bay (L. Superior) and in L. Michigan. 5, 7, 9, 10, 12, 13, 22, 63, 65, 69, 98

*Percina caprodes* (Rafinesque)—Logperch

Common in medium to large streams and rivers and in large lakes. Distribution statewide. 7, 9, 12, 13, 22, 65, 69

*Percina evides* (Jordan & Copeland)—Gilt darter
*Hadropterus evides* (Jordan & Copeland) F&R. G.

Uncommon in the Black R. and in the St. Croix R. in the vicinity of St. Croix Falls. 46, 65

*Percina maculata* (Girard)—Blackside darter
*Hadropterus aspro* (Cope & Jordan) F&R
*Hadropterus maculatus* (Girard) G.

Common in streams and rivers of all sizes in clear to turbid water. Distribution statewide. 7, 9, 12, 13, 69

*Percina phoxocephala* (Nelson)—Slenderhead darter
*Hadropterus phoxocephalus* (Nelson) F&R. G.

Uncommon in the lower Wisconsin R., the Mississippi, and in the larger streams tributary to them. Also in the Pecatonica R. (Lafayette Co.) and Sugar R. (Green Co.). In Great Lakes drainage found in L. Winnebago and in waters of the Upper Fox R. 9, 13, 46

*Percina shumardi* (Girard)—River darter
*Cottogaster shumardi* (Girard) F&R
*Imostoma shumardi* (Girard) G.

Uncommon in the lower Wisconsin and in the Mississippi Rivers. Recently collected in Lakes Winnebago, Poygan, and the lower Waupaca R. (L. Michigan basin). 9, 13, 46

*Stizostedion canadense* (Smith)—Sauger

Common in L. Winnebago and in the lower Wisconsin and Mississippi Rivers. Uncommon to common in St. Croix R. up to St. Croix Dam. Elsewhere in state uncommon, rare or absent. 9, 13, 22, 65, 88

*Stizostedion vitreum vitreum* (Mitchill)—Walleye

Common locally in large rivers and almost all of the large lakes in the state. Introduced in many large lakes, especially in the north. Common in Chequamegon Bay area of L. Superior. 7, 9, 10, 13, 22, 65, 69, 77, 88, 90

### SCIAENIDAE—DRUMS

*Aplodinotus grunniens* Rafinesque—Freshwater drum

Common in the lower Wisconsin R., the Mississippi, the St. Croix upstream to St. Croix Falls Dam. Sporadic in some large lakes of southern one-half of state. Abundant in L. Winnebago. 9, 10, 13, 22, 65

## PROBLEMATICAL FISHES

The following list includes those fishes currently not found in Wisconsin waters but which may be expected in the future. Also listed are those species and hybrids planted by various agencies but which are not known to reproduce naturally.

### SALMONIDAE

*Oncorhynchus gorbuscha* (Walbaum)—Pink salmon

Accidentally introduced in 1955 into L. Superior from the Port Arthur, Ontario fish hatchery. Several successive generations have been reported. Six adults observed in the Cross R. near L. Superior, Cook Co., Minnesota, on Sept. 20, 1963. Although reported to this date only from Ontario and Minnesota waters, on the basis of its past movements we may expect to find it in Wisconsin waters. 14, 69, 93, 95

*Oncorhynchus kisutch* (Walbaum)—Coho salmon

Unsuccessfully introduced into L. Michigan and Riley L. (Chippewa Co.) in 1951. Planted in May, 1966, in State of Michigan tributaries of Lakes Michigan and Superior and apparently spreading throughout these lakes. Large numbers netted by commercial fishermen from L. Michigan off Michigan City, Indiana, during April and May, 1967. In 1968, 25,000 stocked in Ahnapee R. at Algoma. Stockings planned for 1969 include Algoma, Kewaunee, Sheboygan, and Manitowoc. 15, 27c, 104

*Oncorhynchus tshawytscha* (Walbaum)—Chinook salmon

Introduced. Between 1876 and 1879 a number of plantings were made, among them L. Geneva (Walworth Co.), Devils L. (Sauk Co.), Wautoma L. (Waushara Co.), L. Mendota (Dane Co.), Wisconsin R. at Portage (Columbia Co.), tributaries to the Mississippi (Grant Co.). In 1881 a mature female was taken from L. Michigan off Cedar Grove (Sheboygan Co.). Unsuccessfully stocked in Sunset L. (Portage Co.) in 1951. The State of Michigan stocked this species in 1967 in streams tributary to Lakes Superior and Michigan. Merryll Bailey reports capture of a 5-lb. chinook off Ashland (L. Superior) in May, 1969. A 1969 Wisconsin release of 60,000 is anticipated for the Sturgeon Bay ship canal. 15, 33, 113

*Salmo clarki* Richardson—Cutthroat trout

Introduced. In the Report of the Commissioners of Fisheries of Wisconsin for 1895–96 an entry is made of "450 black-spotted trout (full grown) distributed in 1896." A later entry in the same report mentions 500 black-spotted trout having been planted in "Pike's Creek," with no further data. Stocked in Black Earth Cr. (Dane Co.) in 1942 and in Gould Stream (Walworth Co.) in 1943. In 1959 the Twenty-Five Sportsmen's Club of Hubertus planted 500 legal cutthroat trout in Friess L. (Washington Co.). 113

*Salmo salar* Linnaeus—Landlocked salmon

Introduced. In 1875 landlocked salmon were stocked in L. Mendota (Dane Co.), Oconomowoc L. (Waukesha Co.), and Devils L. (Sauk Co.). In 1876, 10,000 were planted in L. Geneva (Walworth Co.). In 1879, plantings were made in "Clear L., Silver L., Geneva

L., Nagawicka L., and Green R." In 1907, 10,000 were planted in Trout L. (Vilas Co.). Two purported specimens of this species were taken Nov. 12, 1937, from a stream entering L. Geneva. Conservation personnel who examined the fish in 1939 believe them to be misidentified brown trout (letter Jan. 6, 1939, from L. A. Woodbury to F. C. Hewitt on file with the Wis. Cons. Dept.). 84, 113

*Salvelinus namaycush* female X *Salvelinus fontinalis* male—Splake

This hybrid was produced in Wisconsin as early as 1884. It has been stocked experimentally in lakes of northern Wisconsin in recent years. According to Canadian workers some backcrossing with the lake trout occurs. 15, 113

*Thymallus arcticus* (Pallas)—Arctic grayling

Introduced. Reports of the Commissioners of Fisheries of Wisconsin from 1878 to 1881 refer to grayling held in the Madison Hatchery, but no stocking occurred. In 1902, 180,000 fry were distributed from the Bayfield Hatchery with no locales indicated. In 1906, 30,000 eggs or fry were distributed at Lake Nebagamon to N. Clay Pierce, who had an estate on the Brule R. (Douglas Co.). These may have been released in the Brule. In 1908, 50,000 fry were planted in the Namekagon R. at Cable (Bayfield Co.). Unsuccessfully introduced in Mosquito Brook (Sawyer Co.) in 1937 and Pine R. (Waushara Co.) in 1938. 113

## Cyprinidae

*Scardinius erythrophthalmus* (Linnaeus)—Rudd

Introduced into Oconomowoc L. (Waukesha Co.) in 1917 by Wisconsin Conservation Department. Reported to have spawned successfully in the lake in 1918, but has not been seen since. 20

*Notropis lutrensis* (Baird and Girard)—Red shiner

Recent records from Menominee Cr., 3 mi. ENE of East Dubuque (Jo Daviess Co.), and from Winnebago Co. in northern Illinois place this minnow almost on the Wisconsin state line (letter from Philip Smith, June 6, 1967).

*Semotilus corporalis* (Mitchill)—Fallfish

Appearance of the fallfish in the Cedar Cr., Thunder Bay District of Ontario, Canada is explained through the use of northern Lake Superior as a migration route. Not yet reported from Wisconsin waters. 1

## ICTALURIDAE

*Noturus insignis* (Richardson)—Margined madtom

Introduced population in Sylvania Tract, Upper Peninsula, Michigan. Since this population is only a few miles from Wisconsin, it may possibly spread into our waters (letter from Reeve Bailey, April 4, 1967).

## PERCIDAE

*Etheostoma spectabile* (Agassiz)—Orangethroat darter

The Illinois Natural History Survey has records of this species from Lake and McHenry Cos. which are adjacent to the Wisconsin state line (letter from Philip Smith, June 6, 1967).

*Etheostoma blennoides* Rafinesque—Greenside darter

A recent record needing substantiation from Lake Co., Illinois (L. Michigan drainage), places this species next to the Wisconsin state line. 95

## REFERENCES


1. ALLIN, A. E. 1951. The Fallfish, *Semotilus corporalis,* from the Lake Superior drainage of Western Ontario. Copeia 1951(4):300.
2. BAILEY, REEVE. 1959. Distribution of the American cyprinid fish *Notropis anogenus.* Copeia 2:119–123.
3. BAILEY, REEVE et al. 1960. A list of common and scientific names of fishes from the United States and Canada. Amer. Fish. Soc. Spec. Publ. No. 2. 102 pp.
4. BAILEY, REEVE and M. O. ALLUM. 1962. Fishes of South Dakota. Univ. of Mich. Misc. Publ. Mus. of Zoology. No. 119. 131 pp.
5. BARDACH, JOHN E. 1949. Contribution to the ecology of the yellow perch *(Perca flavescens* Mitchill) in Lake Mendota, Wisconsin. Ph.D. Thesis, Dept. Zoology, Univ. of Wis., Madison, Wis.
6. BECKER, GEORGE C. 1952. Preliminary survey of Rocky Run Creek, Columbia Co., Wisconsin. Unpub. Manuscript. Wisconsin Cons. Dept., Madison, Wisconsin. 59 pp.
7. ————. 1959. Distribution of central Wisconsin fishes. Trans. Wis. Acad. Sci. Arts & Lett. 48:65–102.
8. ————. 1962. Intraspecific variation in *Rhinichthys c. cataractae* (Valenciennes) and *Rhinichthys atratulus meleagris* (Agassiz) and anatomical and ecological studies of *Rhinichthys c. cataractae.* Ph.D. Thesis. University of Wisconsin, Madison, Wisconsin. 279 pp.
9. ————. 1964. The fishes of Lakes Poygan and Winnebago. Trans. Wis. Acad. Sci. Arts & Lett. 53:29–52.
10. ————. 1964. The fishes of Pewaukee Lake. Trans. Wis. Acad. Sci. Arts & Lett. 53:19–27.
11. ————. 1965. The western sand darter. Ammocrypta clara, in the Great Lakes Basin. Copeia 1965 (2):241.
12. ————. 1966. Fishes of northeastern Wisconsin. Unpubl. data. Dept. of Biology, Wis. State Univ., Stevens Point.

13. ————. 1966. Fishes of southwestern Wisconsin. Trans. Wis. Acad. Sci. Arts & Lett. 55:87–117.
14. BLACK, JOHN and LYMAN O. WILLIAMSON. 1947. Artificial hybrids between muskellunge and northern pike. Trans. Wis. Acad. Sci. Arts & Lett. 38:299–314.
15. BORGESON, DAVID P. and WAYNE H. TODY. 1967. Status report on Great Lakes fisheries. Fish Div., Mich. Dept. of Cons., Lansing. Fish Man. Rep. #2:35.
16. BRASCH, JOHN. 1950. The lampreys of Wisconsin. Wis. Cons. Bull. 15(9): 13–16.
17. BRASCH, JOHN, JAMES MCFADDEN and STANLEY KMIOTEK. 1958. The eastern brook trout, its life history, ecology and management. Wis. Cons. Dept. Publ. 226. 11 pp.
18. BRYNILDSON, OSCAR M., VERNON A. HACKER and THOMAS A. KLICK. 1963. Brown trout, its life history, ecology and management. Wis. Cons. Dept. Publ. 254. 15 pp.
19. BURDICK, MILTON E. and E. L. COOPER. 1956. Growth rate, survival, and harvest of fingerling rainbow trout planted in Weber Lake, Wis. Jour. Wild. Man. 20:233–38.
20. CAHN, ALVIN R. 1927. An ecological study of southern Wisconsin fishes. The brook silverside *(Labidesthes sicculus)* and the cisco *(Leucichthys artedi)* in their relations to the region. Ill. Biol. Monogr., 11(1):151 pp.
21. CARLANDER, HARRIET BELL. 1954. A history of fish and fishing in the upper Mississippi River. Upper Miss. River Conservation Committee. 96 pp.
22. CHRISTENSON, LYLE M. and LLOYD L. SMITH. 1965. Characteristics of fish populations in upper Mississippi River backwater areas. U. S. Dept. Interior. Fish & Wild. Serv. Circ. 212. 53 pp.
23. COKER, ROBERT E. 1930. Studies of common fishes of the Mississippi River at Keokuk. U. S. Govt. Print. Off. Bur. of Fish. Docu. No. 1072:141–225.
24. COOPER, EDWIN L. 1956. What's Happened to the Cisco? Wis. Cons. Bull. 21(3). 4 pp.
25. CHURCHILL, WARREN S. 1945. The brook lamprey in the Brule River. Trans. Wis. Acad. Sci. 37:337–46.
26. CREASER, C. W. 1925. The establishment of the Atlantic smelt in the upper waters of the Great Lakes. Mich. Acad. Sci. Arts & Lett. 5:405–424.
27a. DALY, RUSSELL, VERNON A. HACKER and LAWRENCE WIEGERT. 1962. The lake trout, its life history, ecology and management. Wis. Cons. Dept. Publ. No. 233. 15 pp.
27b. DALY, RUSSELL. 1968. Preliminary notes on management of the rainbow trout in western Lake Michigan. Wis. Dept. Nat. Resources. Oshkosh. 4 p. mimeo.
27c. DALY, RUSSELL. 1968. Progress report of fish management on Lake Michigan. Wis. Dept. Nat. Resources. Oshkosh. 18 p. mimeo.
28. DEASON, HILARY J. 1939. The distribution of cottid fishes in Lake Michigan. Pap. Mich. Acad. Sci. Arts & Lett. 24:105–115.
29. DRUSCHBA, LEONARD. 1959. Are the carp moving north? Wis. Cons. Bull. 24(11):4 pp.
30. DRYER, WILLIAM. 1963. Age and growth of the whitefish in Lake Superior. U.S. Fish and Wildlife Service, Fishery Bulletin, 63(1):77–95.
31. DRYER, WILLIAM R. 1966. Bathymetric distribution of fish in the Apostle Islands region. Lake Superior. Trans. Amer. Fish. Soc. 95(3):248–259.

32. DUCK, HARVEY. 1967. Salmon spawn, new hope for Great Lakes fishing. National wildlife. 5(3):18–19.

33. EDDY, SAMUEL and THADDEUS SURBER. 1947. Northern fishes. Univ. of Minn. Press. 276 pp.

34. EDSALL, THOMAS. 1960. Age and growth of the whitefish, *Coregonus clupeaformis*, of Munising Bay, Lake Superior. Trans. Amer. Fish Soc. 89(4):323–332.

35. ESCHMEYER, PAUL H. 1955. The reproduction of lake trout in southern Lake Superior. Trans. Amer. Fish. Soc. 84:47–74.

36. ESCHMEYER, PAUL H. 1956. The early life history of the lake trout in Lake Superior. Mich. Dept. Cons. Inst. for Fish. Rec. Misc. Pub. 10, 21 pp.

37. ESCHMEYER, P. H. and R. M. BAILEY. 1954. The pygmy whitefish, *Coregonus coulteri*, in Lake Superior. Trans. Amer. Fish. Soc. 84:161–199.

38. FERNHOLZ, WILLIS. 1966. Mississippi River commercial fishing statistics—1965. Wis. Cons. Dept. Fish. Man. Div. Stat. Rep. 31 pp. (Mimeo.)

39. FUKANO, K. G., H. GOWING, M. J. HANSEN, and L. N. ALLISON. Introduction of exotic fish into Michigan. Institute for Fisheries Research, Univ. of Mich. Ann Arbor, Rep. No. 1689. 50 pp.

40. FORBES, STEPHEN A. and ROBERT E. RICHARDSON. 1920. The fishes of Illinois. Ill. Nat. Surv. Bull. 3:357 pp.

41. FREY, DAVID G. 1940. Growth and ecology of the carp *Cyprinus carpio* Linnaeus in four lakes of the Madison region. Wisconsin. Ph.D. Thesis, Dept. Zoology, Univ. of Wis., Madison, Wis. 249 pp.

42. FRANKENBERGER, LUDWIG. 1957. Whitefish and Ciscos—Forgotten Fish. Wis. Cons. Bull. 22(12) 3 pp.

43. GAMMON, JAMES R. 1961. Contributions to the biology of the muskellunge. Ph.D. Thesis, Dept. Zoology, Univ. of Wis., Madison, Wis. 144 pp.

44. GILBERT, CARTER R. 1961. Hybridization versus integradation: an inquiry into the relationship of two cyprinid fishes. Copeia 1961(2):181–192.

45. GREENE, C. W. 1927. An ichthyological survey of Wisconsin. Mich. Acad. Sci. Arts & Lett. 7:299–310.

46. GREENE, C. WILLARD. 1935. Distribution of Wisconsin Fishes. Wis. Cons. Comm., Madison, Wis. 235 pp.

47. GREENWOOD, R. H., D. E. ROSEN, S. H. WEITZMAN, and G. C. MEYERS. 1966. Phyletic studies of teleostean fishes, with a provisional classification of living forms. Bull. Amer. Mus. Nat. Hist. 131(4):344–451.

48. HACKER, VERNON A. 1956. Biology and management of lake trout in Green Lake, Wisconsin. Trans. Amer. Fish. Soc. 86:13 pp.

49. HARLAN, JAMES R. and EVERETT B. SPEAKER. 1956. Iowa fish and fishing. State Cons. Comm. Des Moines, Iowa. 377 pp.

50. HELM, WILLIAM T. 1958. A "new" fish in Wisconsin. Wis. Cons. Bull. 23(7):10–12.

51. HELM, WILLIAM T. 1964. Yellow bass in Wisconsin. Trans. Wis. Acad. Sci. Arts & Lett. 53:109–125.

52. HERMAN, ELMER et al. 1959. The yellow perch, its life history, ecology and management. Wis. Cons. Dept. Publ. No. 228. 14 pp.

53. HILE, RALPH. 1936. Age and growth of the cisco *Leucichthys artedi* (Le Sueur), in the lakes of the northeastern highlands, Wisconsin. Bull. of the U. S. Bureau of Fisheries. 48(19):211–317.

54. HILE, RALPH. 1941. Age and growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wis. Acad. Sci., Arts & Lett. 33:189–337.

55. HORRALL, R. M. 1961. A comparative study of two spawning populations of the white bass *Roccus chrysops* (Raf.), in Lake Mendota, Wisconsin, with special reference to homing behavior. Ph.D. Thesis, Dept. Zoology, Univ. of Wis., Madison, Wisconsin.
56. HOY, P. R. 1883. Catalogue of the cold-blooded vertebrates of Wisconsin. Rep. Geol. Surv. Wis. 1:427–436.
57. HUBBS, CARL L. and C. WILLARD GREENE. 1935. Two new subspecies of fishes from Wisconsin. Trans. Wis. Acad. Sci. Arts & Lett. 20:89–101.
58. HUBBS, CARL L. and KARL F. LAGLER. 1964. Fishes of the Great Lakes region (Revised edit.) Cranbrook Instit. of Sci. Bull. 26:213 pp.
59. HUNT, ROBERT L. 1966. Production and angler harvest of wild brook trout in Lawrence Creek, Wisconsin. Wis. Cons. Dept., Madison. Tech. Bull. 35, 51 pp.
60. HUNTER, JOHN R. and ARTHUR D. HASLER. 1965. Spawning association of the redfin shiner, *Notropis umbratilis*, and the green sunfish, *Lepomis cyanellus*. Copeia 1965 (3):265–281.
61. HUVER, CHARLES W. 1961. Variation and speciation in coregonid fishes. M. S. Thesis, Dept. Zoology, Univ. of Wis., Madison, Wis. 27 pp.
62. JOBES, F. W. 1949. The age, growth and bathymetric distribution of the bloater *Leucichthys hoyi* (Gill) in Lake Michigan. Pap. Mich. Acad. Sci. Arts & Lett. 33 (1947):135–172.
63. JOHN, KENNETH. 1954. An ecological study of the cisco *Leucichthys artedi* (Lesueur) in Lake Mendota, Wis. Ph.D. Thesis. Univ. of Wis., Madison. 121 pp.
64. KLEINERT, STANTON J. and DONALD MRAZ. 1966. Life history of the grass pickerel *(Esox americanus vermiculatus)* in southeastern Wisconsin. Wis. Cons. Dept. Tech. Bull. 37, 40 pp.
65. KUEHN, JEROME H., WALLACE NIEMUTH and ARTHUR R. PETERSEN. 1961. A biological reconnaissance of the Upper St. Croix River. Joint Survey Minnesota Conservation Dept. (St. Paul, Minn.) and Wisconsin Conservation Dept. (Madison, Wis.). 25 pp & 21 appendices.
66. MCCUTCHIN, THAYRE N. 1946. A biological survey of Pewaukee Lake, Waukesha Co., Wisconsin. Wis. Cons. Dept. Madison. Sect. of Fish. Biol. Invest. Rep. No. 573. 28 pp. (Mimeo.)
67. MCNAUGHT, DONALD C. 1963. The fishes of Lake Mendota. Trans. Wis. Acad. Sci. Arts & Lett. 52:37–55.
68. MILLER, ROBERT R. 1957. Origin and dispersal of the alewife, *Alosa pseudoharengus* and *Dorosoma cepedianum* in the Great Lakes. Trans. Amer. Fish. Soc. 86:97–111.
69. MOORE, HARRY H. and ROBERT A. BREAM. 1965. Distribution of fishes in U.S. streams tributary to Lake Superior. U. S. Fish & Wildl. Serv., Wash., D. C. Spec. Sci. Rep. Fisheries No. 516. 61 pp.
70. MRAZ, DONALD. 1960. Prelim. report on the Lake Geneva smallmouth bass studies (1958–1959). Wis. Cons. Dept., Fish. Man. Div., Res. Report No. 1, 22 pp.
71. MRAZ, DONALD. 1964. Observations on large and smallmouth bass nesting and early life history. Wis. Cons. Dept., Res. Report No. 11, 13 pp.
72. MRAZ, DONALD. 1964. Age, growth, sex ratio and maturity of the whitefish in Central Green Bay and adjacent waters of Lake Michigan. U. S. Fish & Wildlife Serv. Fish. Bull. 63 (3):619–634.
73. MRAZ, DONALD. 1964. Age and growth of the round whitefish in Lake Michigan. Trans. Amer. Fish. Soc. 93 (1):46–52.
74. MRAZ, DONALD and EDWIN L. COOPER. 1957. Natural reproduction and survival of carp in small ponds. Jour. Wild. Man. 21:66–69.

75. MRAZ, DONALD, STANLEY KMIOTEK and LUDWIG FRANKENBERGER. 1961. The largemouth bass, its life history, ecology and management. Wis. Cons. Dept. Publ. 232. 13 pp.

76. MRAZ, DONALD and C. W. THREINEN. 1955. Angler's harvest, growth rate and population estimate of the largemouth bass of Brown's Lake, Wisconsin. Trans. Amer. Fish. Soc. 85:241–256.

77. NIEMUTH, WALLACE, WARREN CHURCHILL and THOMAS WIRTH. 1959. The walleye, its life history, ecology and management. Wis. Cons. Dept. Publ. 227. 14 pp.

78. NOLAND, W. E. 1951. The hydrography, fish, and turtle population of Lake Wingra. Trans. Wis. Acad. Sci. Arts & Lett. 40:5–58.

79. NORDEN, CARROLL R. 1967. Age, growth and fecundity of the alewife, *Alosa pseudoharengus* (Wilson), in Lake Michigan. Trans. Amer. Fish. Soc. 96(4):387–393.

80. NYBAKKEN, JAMES W. 1961. Analysis of the sympatric occurrence of two subspecies of the cyprinid fish *Campostoma anomalum* (Rafinesque) in Wisconsin. M. S. Thesis. Univ. of Wis., Madison, Wis. 35 pp.

81. OEHMCKE, ARTHUR A., LEON JOHNSON, JOHN KLINGBEIL and CLARENCE WISTROM. 1965. The Wisconsin Muskellunge, its life history, ecology and management. Wis. Cons. Dept. Publ. 225. 12 pp.

82a. O'DONNELL, D. J. and W. S. CHURCHILL. 1954. Certain physical, chemical, and biological aspects of the Brule River, Douglas County, Wisconsin. Trans. Wis. Acad. Sci. Arts & Lett. 43:201–255.

82b. PHILLIPS, GARY L. and JAMES C. UNDERHILL. 1967. Revised distribution records of some Minnesota fishes, with addition of two species to the faunal list. Jour. Minn. Acad. Sci. 34(2):177–180.

83. POFF, RONALD J. and C. W. THREINEN. 1965. Surface water resources of Columbia County, Wis. Cons. Dept. Lake & Stream Classification Project. 55 pp.

84. POPE, T. E. B. 1938. Landlocked salmon in Wisconsin. Trans. Wis. Acad. Sci. Arts & Lett. 31:559–565.

85. PRIEGEL, GORDON R. 1962. Winnebago winter menu. Wis. Cons. Bull. 27(1):20–21.

86. PRIEGEL, GORDON R. 1962. Plentiful but unknown. Wis. Cons. Bull. 27(3): 13.

87. PRIEGEL, GORDON R. 1963. Dispersal of the shortnose gar, *Lepisosteus platostomus*, into the Great Lakes drainage. Trans. Amer. Fish. Soc. 92(2):178.

88. PRIEGEL, GORDON R. 1963. Food of walleye and sauger in Lake Winnebago, Wisconsin. Trans. Amer. Fish. Soc. 92(3):312–313.

89. PRIEGEL, GORDON R. 1966. Age-length and length-weight relationship of bullheads from Little Lake Butte des Morts, 1959. Wis. Cons. Dept. Res. & Planning Div. Res. Rep. 17:6 pp.

90. PYCHA, RICHARD L. 1961. Recent changes in the walleye fishery of northern Green Bay and history of the 1943 year class. Trans. Amer. Fish. Soc. 90(4):475–88.

91. ROELOFFS, EUGENE W. 1958. Age and growth of whitefish, *Coregonus clupeaformis* (Mitchill), in Big Bay de Noc and northern Lake Michigan. Trans. Amer. Fish. Soc. 87:190–199.

92. SCHNEBERGER, EDWARD and LOWELL A. WOODBURY. 1944. The lake sturgeon, *Acipensor fulvescens* Rafinesque, in Lake Winnebago. Wis. Trans. Wis. Acad. Sci. 36:131–140.

93. SCHUMACHER, R. E. and S. EDDY. 1960. The appearance of pink salmon, *Oncorhynchus gorbuscha* (Walbaum), in Lake Superior. Trans. Amer. Fish. Soc. 8:371–373.
94. SCHUMACHER, ROBERT E. and JOHN G. HALE. 1962. Third generation pink salmon, *Oncorhynchus gorbuscha* (Walbaum), in Lake Superior. Trans. Amer. Fish. Soc. 91(4):421–422.
95. SMITH, PHILIP W. 1965. A preliminary annotated list of the lampreys and fishes of Illinois. Ill. Nat. Hist. Surv. Biol. Notes. No. 54.
96. SMITH, STANFORD H. 1964. Status of the deepwater cisco population of Lake Michigan. Trans. Amer. Fish. Soc. 92(2):155–163.
97. SNOW, HOWARD, ARTHUR ENSIGN and JOHN KLINGBEIL. 1960. The bluegill, its life history, ecology and management. Wis. Cons. Dept. Publ. 230. 14 pp.
98. STONE, RODERICK C. 1961. Preliminary investigations of winter activity and movements of the yellow perch *Perca flavescens* (Mitchill) in Lake Mendota, Wisconsin. M.S. Thesis. Dept. of Zoology, Univ. of Wis., Madison, Wisconsin. 78 pp.
99. TIBBLES, J. J. G. 1956. A study of movements and depth distribution of the pelagic fishes in Lake Mendota. Ph.D. Thesis, Univ. of Wis., Madison, Wisconsin. 193 pp.
100. THREINEN, C. W. 195–. Life history, ecology, and management of the alewife. Wis. Cons. Dept. Publ. 223. 8 pp.
101. THREINEN, C. W. (Co-editor). 1961 to present. Surface water resources publications (a continuing series of each Wis. Co.). Wis. Cons. Dept. Lake & Stream Classification Project.
102. THREINEN, C. W. and ARTHUR OEHMCKE. 1950. The northern invades the musky's domain. Wis. Cons. Bull. 15(9):10–12.
103. THREINEN, C. W., C. WISTROM, B. APELGREN, and H. SNOW. 1966. The northern pike, its life history, ecology, and management. Wis. Cons. Dept. Publ. 235. 16 pp.
104. TODY, WAYNE H. and HOWARD A. TANNER. 1966. Coho Salmon for the Great Lakes. Mich. Dept. of Cons. Fish Div. Fish Management. Report No. 1, 38 pp.
105. UNDERHILL, JAMES C. 1963. Distribution in Minnesota of the subspecies of the percid fish *Etheostoma nigrum*, and of their intergrades. Amer. Wildl. Nat. 70(2):470–478.
106. VAN OOSTEN, JOHN. 1936. The dispersal of smelt *Osmerus mordax* (Mitchill) in the Great Lakes region. Trans. Amer. Fish. Soc. 66:160–171.
107. VAN OOSTEN, J., RALPH HILE and FRANK JOBES. 1946. The whitefish fishery of Lakes Huron and Michigan with special reference to the deep-trap-net fishery. U.S. Fish & Wildlife Serv. Fishery Bull. 40. 50:297–394.
108. WAGNER, G. 1908. Notes on the fish fauna of Lake Pepin. Trans. Wis. Sci. Arts & Lett. 16:230–237.
109. WEED, A. C. 1921. Fishes from southern Wisconsin. Copeia (1921) (99):69.
110. WELLS, LARUE and ALFRED M. BEETON. 1963. Food of the bloater, *Coregonus hoyi* in Lake Michigan. Trans. Amer. Fish. Soc. 92(3):245–255.
111. WELLS, LARUE. 1966. Seasonal and depth distribution of larval bloaters *(Coregonus hoyi)* in southeastern Lake Michigan. Trans. Amer. Fish. Soc. 95(4):388–396.
112. WHITLEY, G. P. 1950. New fish names. Proc. Royal Zool. Soc. New S. Wales, 1948–49:44.

113. Wisconsin Commissioners of Fisheries. 1875–1912. Annual and Biennial Reports of the Commissioners of Fisheries of Wisconsin. Madison, Wisconsin.

114. Wis. Cons. Dept. 1958. Smallmouth bass streams in Wisconsin.

115. Wis. Cons. Dept. 1964. Wisconsin Lakes. Wis. Cons. Dept. Publ. 218–64. 67 pp.

116. Wis. Cons. Dept. 1966. Wisconsin trout streams. Wis. Cons. Dept. Publ. 213–66. 75 pp.

117. WRIGHT, T. D. 1964. Aspects of the early life-history of the white bass *(Roccus chrysops)*. M. S. Thesis, Univ. of Wis., Madison, Wisconsin.

# PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 60 TILIACEAE AND MALVACEAE—BASSWOOD AND MALLOW FAMILIES

*Fred H. Utech*

The woody, mostly tropical Tiliaceae has only one native and two cultivated species in Wisconsin, while the Malvaceae, characterized by monadelphous stamens, is represented not only by several noxious Eurasian weeds as velvet-leaf *(Abutilon theophrasti)*, flower-of-an hour *(Hibiscus trionum)* and cheeses *(Malva neglecta* and *M. rotundifolia)* and showy exotics as hollyhock *(Alcea rosea)* and high mallow *(Malva sylvestris)*, but also by several rare, handsome natives : poppy mallow *(Callirhoë triangulata)*, rose mallow *(Hibiscus militaris)* and glade mallow *(Napaea dioica)*.

The present treatment is a revision of an earlier preliminary report on Tiliaceae and Malvaceae by Hagen (1932) and is based on specimens in the herbaria of the University of Wisconsin (WIS), University of Wisconsin–Milwaukee (UWM), Milwaukee Public Museum (MIL), University of Minnesota (MIN), University of Minnesota–Duluth (DUL), State University of Iowa (IA), Oshkosh State University, La Crosse State University, Northland College (Ashland, Wis.), Beloit College and the private herbarium of Katherine Rill (Clintonville, Wis.—RILL). Grateful acknowledgement is due the curators of these herbaria for the loans of specimens.

Map dots represent exact locations, triangles, county records. Some locations have been added from Thomas Hartley's unpublished "Flora of the Driftless Area" (1962), Paul Sorensen's unpublished range maps from his Glacial Lake Wisconsin studies (1966), Jones and Fuller's *Flora of Illinois* (1955) and stand records for *Tilia americana* from the UW Plant Ecology Laboratory The map inset numbers record Wisconsin flowering and fruiting dates. Plants with vegetative growth only, in bud or with dispersed fruit were not included. For introduced species the year of earliest collection within a county is also recorded. Nomenclature and order of genera and species follows that of Gleason and Cronquist (1963) and Fernald (1950).

---

Field work and preparation of manuscript was supported in part by the Research Committee of the University of Wisconsin, on funds from the Wisconsin Alumni Research Foundation.

Special thanks are due the author's major professor, Dr. Hugh H. Iltis, for his uncanny ability to inspire and stimulate botanical awareness and observation. Numerous people deserve special acknowledgement for their assistance in manuscript preparation: Mrs. Katherine Snell, for encouragement and timely aids; Mr. Brian G. Marcks and Mr. Michael H. Nee, for their advice, comment and criticism; Mr. Eugene G. Coffman, for photographic reproductions; Miss Bethia Brehmer, for artistic work; and Drs. H. H. Iltis and John W. Thomson for critical manuscript reading.

## TILIACEAE A. L. De Jussieu Basswood Family

### 1. TILIA [Tourn.] L. Basswood, Linden, Lime, Bee-tree.

Large deciduous trees with soft white wood, fibrous inner bark, and numerous deep lateral roots. Winter buds large, obtuse, with few scales, *the terminal bud lacking.* Leaves alternate (2-ranked), cordate, palmately veined, serrate, oblique to truncate, acute to acuminate; stipules deciduous. *Flowers fragrant, entomophilous, yellowish-white, in cyme-like clusters each on an axillary peduncle adnate to the middle of a short-petioled, thin, wing-like bract.* Flowers perfect, 5-merous, hypogynous. Stamens many, free or united into 5 bundles and then opposite petals; filaments often forked distally; anthers 2-celled, opening longitudinally. *Staminodes 5, petaloid, opposite petals, always present in native species* (and in some Eurasian cultivars). Drupes globular, dry and woody, indehiscent, l-locular, 1- to 3-seeded; seeds with endosperm; cotyledons broad, 3- to 5-lobed.

About 25 tree species, native to north temperate deciduous forests, from Japan and Siberia to Europe, eastern N. America and Mexico. The chromosome number of *Tilia* (x = 41) is the highest odd basic number known in higher plants (Derman 1932).

*Tilia* as a generic name is of special botanical interest, for it was from these noble trees that Carolus Linnaeus (Linné) acquired his surname.

> His ancestors were peasants. Several of his relatives, who had quitted the plough for the Muses, changed their family name with their profession and borrowed the name of Lindelius or Tiliander (Linden-tree-man) . . . , a custom not unfrequent in Sweden, to take fresh appellations from natural objects. The father of Linnaeus, as the first learned man of his family, could not withstand following the example which his kindred had set before him. He likewise borrowed of the same tree a name which his son rendered afterwards famous and immortal in every quarter of the guobe. (Stoever 1794)

In North America, *Tilia* is called basswood in forestry, linden in horticulture, while in Britain, lime, apparently an altered form of linden or lind. The Anglo–Saxon lind means shield, i.e., of linden wood. The white, light, diffuse-porous wood is used for domestic utensils. Leaves, both fresh and dried, were fed to cattle by the Romans, a contemporary custom in northern Europe. The flowers produce excellent honey, hence the local American "beetree", while the dried steeped flowers serve as linden tea. Ropes, mats, shoes and baskets are made from the tough, fibrous inner bark, morphologically phloem bast fibers or bass, hence basswood.

Leaf pubescence on flowering branchlets usually differs from that on sprout leaves. Most *Tilia* lower leaf surfaces have small tufts of simple trichomes in the principal vein axils; these barbulae, domatia or acaradomatia are supposed to be symbiotic adaptations for mites (Jones 1968).

### Key to Species

A. *Leaves* of flowering branchlets *glabrous beneath,* except for tufts of simple trichomes in lateral vein axils; fruit ribs obscure or lacking.

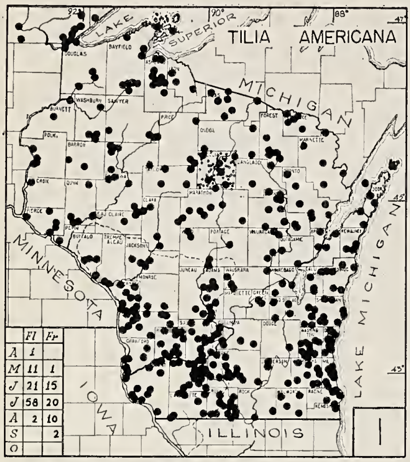
B. Staminodes 5; stamens 45–60; *axillary tufts whitish-gray,* lacking at petiolar leaf insert; cymes 6- to 15-flowered; common native forest tree __________ 1. *T. AMERICANA.*

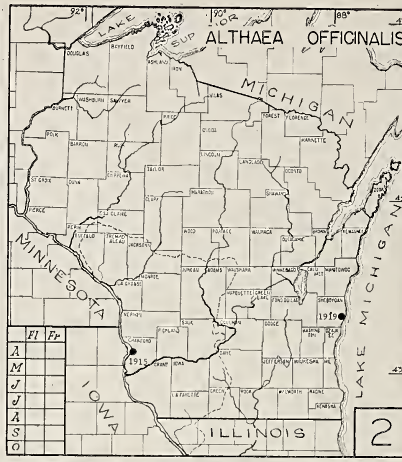
BB. Staminodes lacking; stamens 25–30; *axillary tufts rusty brown,* well developed at petiolar leaf insert; cymes 5- to 7- (11-) flowered; commonly cultivated European tree ____________________________________ 2. *T. CORDATA.*

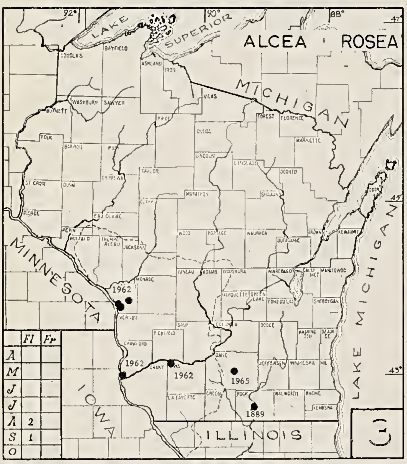
AA. *Leaves* of flowering branchlets *pubescent beneath and often above;* axillary tufts white; fruit strongly 3- to 5-ribbed; stamens 30–40; staminodes lacking; rarely cultivated European tree ______________________ 3. *T. PLATYPHYLLOS.*

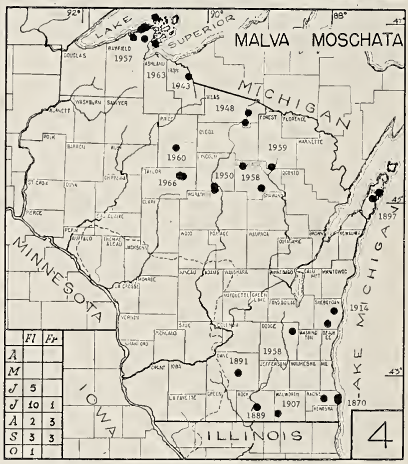
1. Tilia americana L. American Basswood, Linden. Map 1.
*Tilia glabra* Vent.

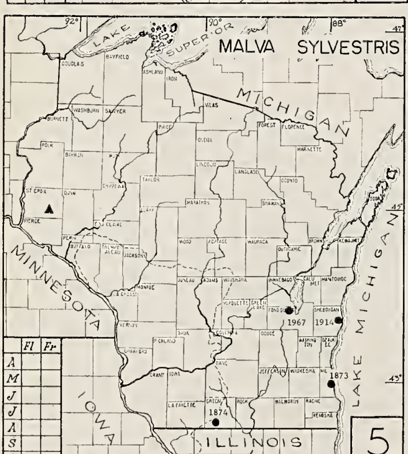
Trees to 35 m tall, 1–1.5 m DBH, often clustered with two or more trunks, often with *several to many basal sprouts.* Bark on old trunks firm, dark gray with longitudinal furrows, young bark smooth, light gray. *Winter buds shiny, dark red,* ellipsoid–ovate, 2-ranked; terminal bud absent. Leaves broadly ovate–cordate, the blades of fertile shoots 8–20 cm long, 6–16 cm wide, cordate to truncate at base, abruptly acuminate, coursely serrate with gland-tipped teeth, glabrous beneath, with *tufts of whitish-gray hairs in vein axils, these lacking at petiolar leaf insert.* Petioles, pedicels and bracts of inflorescence glabrous. Cymes 6- to 15-flowered. Petals 5, yellowish-white, oblong to oblanceolate, 6–9 mm long. *Staminodes 5, oblanceolate, 5–7 mm long, opposite petals.* Stamens

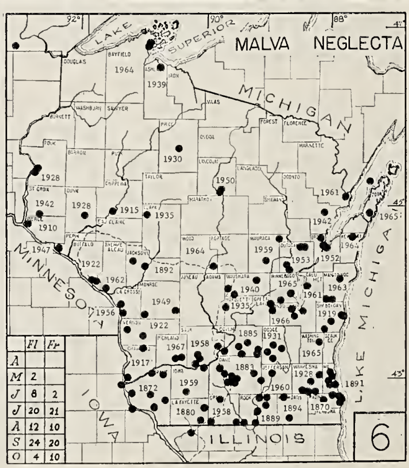

TILIA AMERICANA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A 1
M 11 1
J 21 15
J 58 20
A 2 10
S 2
O
1


ALTHAEA OFFICINALIS
LAKE SUP
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
1919
1915
Fl Fr
A
M
J
J
A
S
O
2


ALCEA ROSEA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
1962
1962
1962
1965
1889
Fl Fr
A
M
J
J
A 2
S 1
O
3


MALVA MOSCHATA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
1957
1963
1943
1948
1960
1966
1950
1958
1959
1897
1914
1958
1891
1907
1889
1870
Fl Fr
A
M
J 5
J 10 1
A 2 3
S 3 3
O 1
4


MALVA SYLVESTRIS
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
1967
1914
1873
1874
Fl Fr
A
M
J
J
A
S
O
5


MALVA NEGLECTA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M 2
J 8 2
J 20 21
A 12 10
S 24 20
O 4 10
6

45–60, free. Floral bracts 7–10 cm long, short stalked or sessile. Drupes globose, 6–12 mm wide, thick-shelled, without ribs. 2N = 82 (Derman 1932).

Native to deciduous forests of eastern North America (New Brunswick to southern Manitoba, southward to Penna. and Oklahoma), in its southeastern range partially sympatric along the glacial maxima with the Appalachian centered *Tilia heterophylla* Vent. (cf. maps Fowells 1965, Jones 1968), whence, Braun (1960) suggests, on vegetative characters, the putative "hybrid swarm" origin of *Tilia neglecta* Spach. However, according to Jones (1968) most specimens labelled *T. neglecta* consist of sprout leaves. The modern distributions suggest survival of *T. americana* in the Ozarks, *T. heterophylla* in the Appalachians, and post-glacial migration, overlap, and hybridization, a clinal pattern similar to that found between *Acer saccharum* ssp. *nigrum* and *A. s.* ssp. *saccharum* (Desmarais 1948, 1952), with *Tilia* the main deciduous forest co-dominant. Flowering from mid-May to late July, fruiting from early June to mid-August.

2. TILIA CORDATA Mill. Small-leaved Linden.

Cultivated trees to 25 m tall. Leaves orbicular-cordate, 2–7 (–10) cm wide, cordate, abruptly acuminate, the margin sharply serrate, *dark green and glaucous above, blue–green and glabrous beneath,* the axillary hair tufts rusty brown. Petioles glabrous, 1.4–3 cm long. *Cymes pendulent or upright, 5- to 7- (11-)flowered.* Stamens equaling petals, ca. 25–30, the filaments connate basally into 5 bundles alternating with petals; staminodes usually lacking. Floral bracts 3–8 cm long, glabrous. Drupes 1-seeded, globose–apiculate, thin-walled, slightly or not ribbed. 2N = 82 (Derman 1932).

Native from Siberia to England, Spain, Italy and the Balkans, commonly planted as lawn, street or park trees in many southern Wisconsin cities. Flowering in late June to early July.

3. TILIA PLATYPHYLLOS Scop. Large-leaved Linden.

Cultivated trees to 30 m tall. Leaves orbicular–ovate, 6–12 cm wide, obliquely cordate, abruptly acuminate, serrate, pubescent beneath and often above; *axillary tufts white.* Petioles densely pubescent, 2–5 cm long. *Cymes pendulent, 3- (rarely 4- to 6-) flowered.* Floral bracts 6–12 cm long, pubescent on lower midrib. Drupes 1-seeded, subglobose to pyriform, apiculate, densely pubescent, strongly 3- to 5-ribbed. 2N = 82 (Derman 1932).

Native in central and southeastern Europe (England to Spain, Asia Minor and Caucasus), rarely cultivated in Wisconsin as a shade tree: Milwaukee Co.: Milwaukee, 20 Sept. 1935, *Goessl s.n.* (WIS). Milwaukee, cultivated, 14 May 1938, *Shinners 12899* (UWM).

## MALVACEAE A. L. De Jussieu Mallow Family

Herbs (shrubs and trees in tropical regions), often *stellate-pubescent,* with simple alternate, mostly *palmately-veined and -lobed leaves.* Flowers solitary or cymose, 5-merous, regular, hypogynous and bisexual (unisexual in *Napaea*). *Calyx gamosepalous, persistent, often subtended by calyx-like bracts (paracalyx, epicalyx, involucre).* Petals separate, but slightly coalescent or frequently adnate to the base of the filament tube. *Stamens numerous, monadelphous* (filaments coalescent into a tube about ovary and style); anthers 1-celled. Ovary superior, bearing as many terminal style branches as there are carpels. Carpels 5-many, either *loosely coherent in a ring* around the base of the single style and then separating at maturity or completely *united into a compound ovary. Fruit a loculicidal capsule (Hibiscus) or carpels splitting ventrally and releasing seeds (Abutilon) or carpels separate, indehiscent, 1-seeded schizocarps (Malva).*

A large, predominately tropical family, only one-third of the Wisconsin species native, the majority naturalized from Eurasia, including obnoxious weeds (Cheeses, Velvet-leaf, Flower-of-an-Hour) and showy Eurasian garden cultivars (Hollyhocks, Mallows), of which some persist after cultivation, becoming locally established (Kearney 1951).

### KEY TO GENERA

A. Carpels 5–20 or more, loosely united in a ring around a central axis, separating at maturity (schizocarps or mericarps); stamen-column antheriferous at summit. (Tribe MALVEAE)
  B. Carpels reniform, indehiscent, but not beaked, 1-ovulate; style-branches stigmatic along the inner face, slender-tipped.
    C. Flowers perfect; involucre usually present.
      D. Involucel of 6–9 distinct bractlets, united at base.
        E. Plants 7–12 dm tall; petals 1.8–3.5 cm long; staminal tube terete, hairy; schizocarps 18–20, rounded on back, not keeled; rare escaped cultivar ---------------------------1. ALTHAEA.
        EE. Plants 12–25 dm (or more) tall; petals 3.6–4.8 cm long; staminal tube 5-angled, glabrous; schizocarps 25–35 (or more), keeled on back; common showy garden escape ------2. ALCEA.

DD. Involucel of 3 bractlets or none.
F. Petals obcordate, white or tinted with blue, purple or red; bractlets 3; common weeds ---------------------------------------- 3. MALVA.
FF. Petals truncate, rose red to purple; bractlets 3 or none; rare, dry prairie species -4. CALLIRHOE
CC. Flowers white, small, dioecious; involucre none; large-leaved robust native prairie herbs ------5. NAPAEA.
BB. Carpels with long divergent beaks (3–3.5 mm), dehiscent, 3–8 seeded; stigmas terminal and capitate; flowers yellow; very common weed ---------------------6. ABUTILON.
AA. Carpels 5, *united,* the fruit a loculicidal capsule without a central column; stamen-column antheriferous along much of its length; flowers 3 cm or more in diam. (Tribe HIBISCEAE) ---------------------------------------------7. HIBISCUS.

## 1. ALTHAEA L. Marsh-mallow.

1. Althaea officinal|. L. Marsh-mallow. Map 2.

*Tomentose erect perennial* 8–12 (–20) dm tall from an enlarged, knotty rootstock. Leaves triangular–ovate to cordate, crenate–serrate, gray to grayish-green, velvet-pubescent, the petioles 1.4–2.8 cm long. *Involucre united at base,* the 6–9 lanceolate bractlets densely stellate and hirsute, 4–5 mm long. *Petals obcordate, 18–28 (–35) mm long, white to pale pink. Staminal tube terete, hairy, commonly 12 mm long, bright violet;* anthers purplish-red. Carpels 18–20, densely short stellate, convex and not keeled on back, the lateral face not radially veined. *Seeds purplish black, 3.6–3.9 mm long.* 2N = 42 (Skovsted 1935).

Facultative salt-marsh plant, native to the drainage systems of the Caspian, Black and Baltic Seas, in North America as an escape along borders of saline or fresh water marshes. Formerly cultivated for the perennial root which yielded the original non-synthetic mucilaginous marshmallow paste; collected twice in Wisconsin: Crawford Co.: Lynxville, 11 Sept. 1915, *Davis s.n.* (WIS). Sheboygan Co.: Sheboygan, Aug. 1919, *Goessl s.n.* (WIS). Flowering in August to October.

## 2. ALCEA [Tourn.] L. Hollyhock.

Linnaeus (Sp. Pl. 1753) followed Tournefort's distinction between *Althaea* (marsh-mallow) and *Alcea* (hollyhock), though Willdenow, De Candolle, Bentham and Hooker and others have fused the two genera into *Althaea*. Recent studies by Zohary (1963a, 1963b) in SW Asia have demonstrated the validity of readoption of this generic segregation: the staminal tubes in *Alcea* are 5-angled and glabrous, in *Althaea,* terete and hairy; the keeled schizocarps of *Alcea* are divided by an internal septum into an upper, empty cell and a lower one with a single seed, in *Althaea,* the schizocarps are rounded (on back), unilocular, one-seeded.

*Alcea,* an Old World genus with 60 species, is an Irano–Turanian element (mainly East Mediterranean, SW & central Asia).

1. ALCEA ROSEA L. Hollyhock. Map 3.
*Althaea rosea* (L.) Cav.

Robust biennial or perennial with *spire-like stems* to 2.5 m tall. Leaves cordate, shallowly 5- to 7- (9-) lobed, rarely dissected, densely stellate-pubescent, crenate; mid-stem leaves 5–11 cm long (blade petiole junction to lobe tip), 6–13 cm wide, the petioles (–3) 5–14 cm long. *Flowers showy, 7–10 cm wide, solitary or 2–4/leaf axil or in a terminal raceme.* Involucral of 6 (–9) lanceolate bractlets, united at base, densely stellate, the lobes 10–13 mm long. Calyx lobes 5, united, densely long-stellate, 11–16 mm long, *the involucre and calyx accrescent at maturity.* Petals 5 or double in horticultural forms, broadly obcordate, 3.6–5 (–6) cm long, white, yellow, pink, carmine-red to purplish-black or brownish-black, the claws bearded. *Staminal tube 5-angled, glabrous.* Peduncle stout, 1.8–2.3 cm long at maturity. Carpels 26–30, pale brown, ribbed, densely stellate–hirsute on tips, the lateral face radially veined. *Seeds light gray, 3–3.4 mm long.* 2N = 42 (Skovsted 1941).

Native to the north-eastern Mediterranean region (Aegean Islands, and adjacent Balkan Peninsula), and not, as customarily ascribed, to China (Linnaeus, *Sp. Pl.* 1753), which is beyond the natural range of the genus (Zohary 1963b); exact European introduction unclear, though long naturalized in SE Europe, Italy and S France; early herbalists Caspar Bauhin and Albertus Magnus noted that, like the tulip, introduction probably came in the 16th century from Turkey (Hegi 1925).

In Wisconsin frequently cultivated and persisting in the vicinity of gardens, dumps and waste places. Flowering from June to August or till frost.

The cultivated hollyhock is undoubtedly polymorphic (Zohary 1963b), consisting at least in part of hybrids of *A. pallida* (Willd.) Waldst. & Kit., *A. rosea* L. and *A. lavateraeflora* (D.C.) Boiss. In recent years its cultivated popularity has decreased due to a wide-spread Chilean fungal leaf infection *(Puccinia malvacearum* Bert.).

A horticultural variety, *ALCEA ROSEA* L. VAR. *SIBTHROPII* Boiss., differs from *A. rosea* in having large fig leaf-like leaves with 7-elongate lobes; carpels 35 or more, densely stellate at tips, deeply keeled; seeds reddish brown, minitely papillose, 3.8–4.2 mm long; in Wisconsin a rare and sporadic escape in dumps and rubbish piles, occasionally cultivated singly or mixed with *A. rosea.* Milwaukee Co.: Milwaukee, C. & N. R.R., on Locust St., one clump near patch of *A. rosea,* all probably sprouting from garden refuse, 3 July 1939, *Shinners 518* (WIS). Winnebago Co.: Oshkosh, dump at end of Oak St., probably escaped from soil scraped off a garden, 2 July 1966, *Harriman 924* (Oshkosh State Univ.). Flowering in July.

### 3. MALVA [Tourn.] L. MALLOW, CHEESES.

Annual, biennial or perennial herbs with *orbicular-reniform, palmately dissected or lobed, crenate leaves.* Flowers solitary or fascicled in leaf axils. Involucral bractlets (2–) 3, free, linear to obovate. Calyx 5-lobed. Petals 5, truncate, notched or obcordate. Anthers terminal on the staminal column. Styles as many as carpels, stigmatic on the inner surface. *Fruit of 8–20 radial carpels surrounding a central depression, these separating at maturity into as many one-seeded, indehiscent, round-reniform, laterally flattened schizocarps.*

Old World genus, native to Eurasia and North Africa, with 30 species, including several world-wide weeds and cultigens, such as the medical herbs *Malva sylvestris* and *M. neglecta,* which provide a leaf concoction (i.e. *Malvae folia*) that serves as an emollient and demulcent. *Malva* is an Old Latin name from the Greek *malache* or *moloche,* referring to the emollient leaves. The fruits are called cheeses since they resemble cheese wheels, and are eaten by children and poultry, and had been served on medieval tables. Reported hybrids (in *Flora Europaea,* Tutin *et al.* 1968) include *M. alcea* X *M. moschata, M. sylvestris* X *M. neglecta,* and *M. neglecta* X *M. rotundifolia.*

#### KEY TO SPECIES

A. Upper leaves deeply 5- to 7-parted to below the middle or nearly to the base; flowers chiefly solitary in the upper axils, showy; petals 2–3 cm long; escaped garden plants (Section BISMALVAE).

B. Pubescence of spreading simple hairs; carpels densely hirsute on back; bractlets linear-lanceolate ---------------------------------------------1. *M. MOSCHATA.*

BB. Pubescence of short stellate hairs; carpels glabrous; bractlets oblong-ovate ---------------------- *M. ALCEA.*

AA. Upper leaves reniform-cordate, with scalloped margins, only rarely lobed to the middle; flowers fascicled in the axils; petals 0.4–2.3 cm long (Section MALVA).

C. Bractlets oblong-ovate; *petals rose-violet, 1.4–2.3 cm long;* erect, escaped garden plant -------- 2. *M. SYLVESTRIS.*

CC. Bractlets linear or narrowly lanceolate; *petals white with pale blue or purple tinged tips, 0.3–1.2 cm long.*

D. *Carpels 12–15, when mature puberulent and not rugose on back;* lateral face of carels not radially veined; petals 6–12 mm long; common prostrate weed ------------------------------------------ 3. *M. NEGLECTA.*

DD. *Carpels 8–11, when mature glabrous and rugose-reticulate on back* (Figs. 1 & 2); lateral face of carpels radially veined; petals 3.2–6 mm long.

E. Stems commonly prostrate to ascending; fruiting pedicels 10–45 mm long; bractlets 2.9–3.8 mm long; petals 3.2–4.5 mm long; common weed ------------------------------------- 4. *M. ROTUNDIFOLIA.*

EE. Stems erect; fruiting pedicels 8–15 mm long; bractlets 3.7–5.4 mm long; petals 4.8–6 mm long; rare garden escape ---------- *M. VERTICILLATA.*

1. MALVA MOSCHATA L. Musk-malow. Map 4.

Erect biennial to perennial, 3–8 dm tall, with knotty root-stocks, *pubescent throughout, chiefly of simple divergent hairs.* Leaves cordate, deeply 3- to 5- (7-) parted, the upper linear bipinnatifid, the lowest broadly 5-lobed, *faintly musk scented* (hence common name). Flowers solitary to 3 in upper axils, the fruiting pedicels 1.6–4 cm long. Bractlets 3, linear to oblanceolate, ciliate, glabrous on back, 5–6 mm long. *Calyx 5-lobed, with simple trichomes, inflated in fruit. Petals 5, triangular-obcordate, pale rose-violet, 2–2.4 cm long. Fruiting carpels 11–15, rounded not keeled and densely hirsute on back.* Seeds reniform, gray brown, glabrous, 1.8–2 mm long. 2N = 42 (Skovsted 1935).

Native of Europe to North Africa, (rail-transported) adventive over most of Europe, often cultivated as a garden plant for its showy flowers, in Wisconsin infrequent, escaping and persisting locally on sandy roadsides, dumps, waste places and beaches. Flowering and fruiting from mid June to mid September.

MALVA ALCEA L. Vervain mallow.

Erect robust perennial, 4–8 (–12) dm high, short stellate pubescent. Similar to *M. moschata,* but upper leaves more broadly divided. *Flowers solitary,* on short pubescent pedicels, these 1.6–2.6 cm long in fruit. Bractlets 3, oblong to ovate, 4.5–6 mm long, densely stellate on back. Calyx 5-lobed, stellate pubescent. *Petals 5, obcordate, notched, pale purple to white, 2–2.8 cm long. Carpels 18–20, when mature keeled and glabrous or sparsely pubescent on back.* Seeds reniform, dark gray brown, glabrous, 2–2.3 mm long. 2N = 82 (Skovsted 1935).

Native of Europe (Sweden to Spain, the Balkans and S Russia), a pontic-Mediterranean element of dry and calcareous sites, in Wisconsin escaping sporadically from gardens but not persisting: Calumet Co.: Roadside n of Stockbridge, 7 Aug. 1907, *Goessl s.n.* (WIS). Milwaukee Co.: Milwaukee, vacant lot on Hopkins St., ½ block s of Villard Ave., flowers light pink, garden escape, 15 July 1942, *Fuller F–42–86* (MIL). Flowering in late summer.

2. MALVA SYLVESTRIS L. High-mallow. Map 5.

Erect biennial to perennial, 4–8 dm tall from a shallow branched taproot, *the stems glabrous or very sparsely hirsute.* Leaf blades round–cordate or reniform, broadly 5-lobed, the terminal lobe obtuse to rounded, 2–9 cm long (petiolar leaf insert to lobe tip), 3–11 cm wide. *Petioles 6.5–9.5 cm long, pubescent in a single line on the upper surface.* Flowers fascicled in upper leaf axils; fruiting pedicels 2–3.5 (–5) cm long. *Bractlets 3, oblong to ovate or obovate, 3.8–4.7 mm long, subglabrous, ciliate.* Calyx 5-lobed, stellate–pubescent. Petals obcordate, notched, rose–violet, 1.4–2.3 cm long. *Mature carpels commonly 10, rugose–reticulate on the back,* glabrous. Seeds round–reniform, 1.9–2.1 mm long, blackish brown, subglabrous.

Native Euro–siberian element (Europe, N. Africa, Asia Minor to Siberia), world-wide adventive, in Wisconsin grown in old gardens, locally persisting as an escape: Green Co.: Monroe, 7 Aug. 1894, *Stuntz s.n.* (WIS). Fond du Lac Co.: Pea field near old homestead, 1 mi. w from hwy 175 on Cemetery Rd., 1 Oct. 1967, *Jeffers s.n.* (WIS). Ozaukee Co.: Port Washington, growing wild, 17 Aug. 1887, *Runge 137* (MIL). Sheboygan Co.: Sheboygan, July 1914, *Goessl s.n.* (WIS). St. Croix Co.: Baldwin, *Anderson s.n.* (WIS). Milwaukee Co.: Milwaukee, 1873, *Sherman 673* (IA). The Wisconsin specimens have glabrous or sparsely hirsute stems, obtuse-lobed leaves and dark flower color, thus belong to var. *mauritiana* (L.)

Boiss. (Fernald and Wiegand 1910). This is the common type grown in European farm gardens (Hegi 1925). Flowering from mid-July to early October.

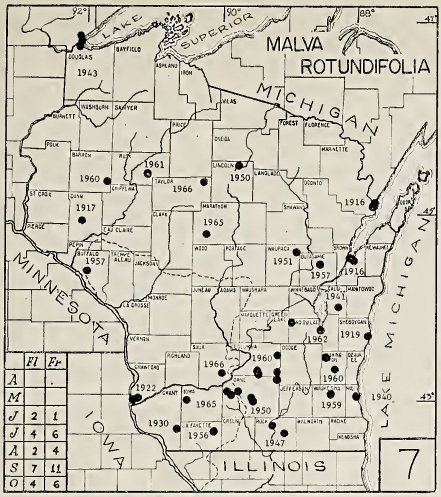
3. MALVA NEGLECTA Wallr. Common mallow, Cheeses. Fig. 1 & 2.
*Malva rotundifolia* of some American authors, not L. Map 6.

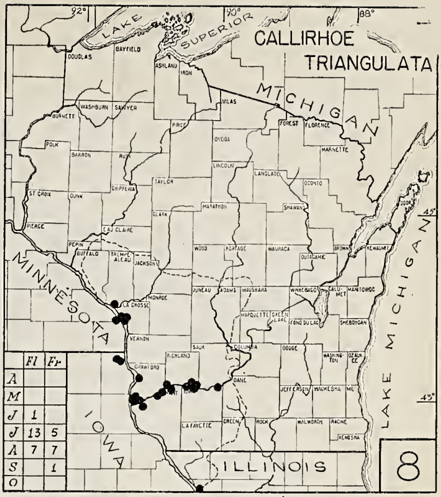
Biennial or perennial with prostrate to ascending stems, 1–7 dm tall, from a deep branching taproot. Leaves round–cordate, shallowly 5–9 lobed, crenate, 2–4 (5.5) cm long (petiolar leaf insert to lobe tip), 3–6 (–9) cm wide, long petiolate. Flowers 1–5 in leaf axils, pedicels slender, 1–5 cm long. Calyx 5-lobed, stellate–pubescent at anthesis. Bractlets 3, linear, ciliate, 3.6–4.6 mm long. Petals 5, triangular–obcordate, 6–12 mm long, white with pale blue or purplish tips, the claws bearded. Staminal tube ca. 6 mm long. Styles and stigmas purple. *Outline of carpel ring scalloped,* the depressed center ca. 1/3 the diameter of the head (Figs. 1 & 2). *Mature carpels 12–15, commonly 14, densely puberulent, not reticulate on back,* the lateral faces smooth. Seeds round–reniform, 1.7–1.9 mm long, laterally depressed, blackish brown, glabrous. 2N = 42 (Mulligan 1961).

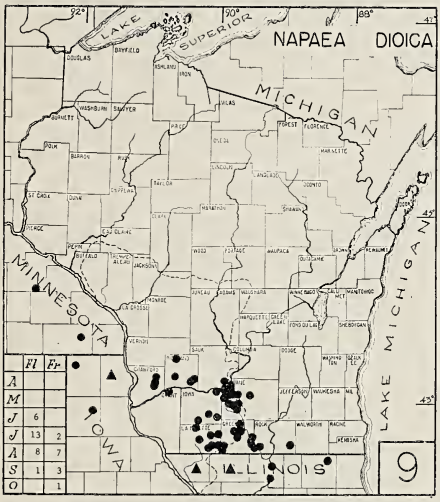
Native to temperate Eurasia (from England to L. Baikal) and N. Africa, widely adventive in Wisconsin mostly about dwellings, fields, lawns, roadsides, gardens and especially in highly nitrogenous waste places, becoming a noxious pest, most common south of the northern highlands, being limited by the colder climate, e.g. earlier frost, shorter growing season—cf. map of *Galium aparine* (Urban & Iltis 1957). Flowering continually from April to November, fruiting May to November.

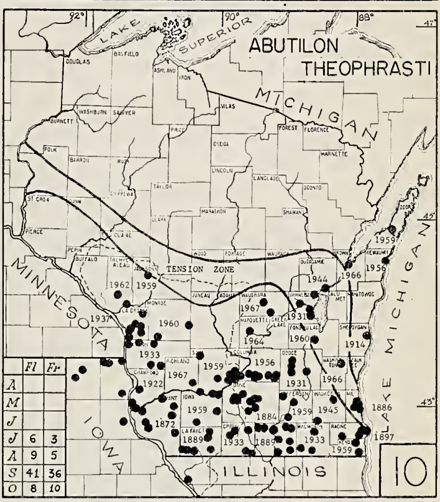
4. MALVA ROTUNDIFOLIA L. Cheeses. Map 7, Figs. 1 & 2.
*Malva borealis* Wallm.
*Malva pusilla* Smith ex Withering

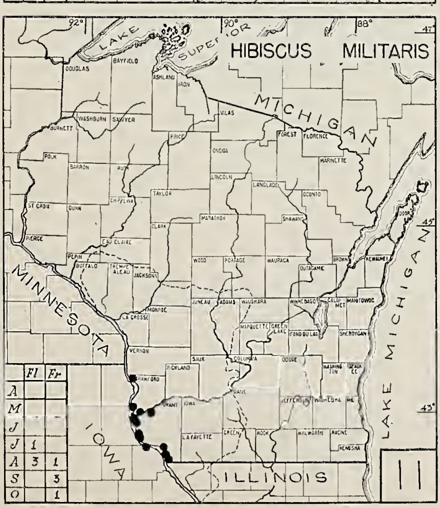
Procumbent to ascending, branched biennial to perennial, 1–5 dm tall, from a slender unbranched taproot. Leaves round–cordate with 5–9 shallow lobes, crenate, 1–5 (–6) cm long (petiolar leaf insert to lobe tip), 3–9 cm wide, long petiolate. Flowers 2–6 in leaf axils, the fruiting pedicels 1–3.5 (–4.5) cm long. Calyx 5-lobed, with simple pubescence at anthesis, accrescent at maturity. Bractlets 3, linear, ciliate, 2.9–3.8 mm long. Petals 5, oblanceolate–obcordate, 3.2–4.5 mm long, white with pale blue or purplish tips, the claws bearded. *Staminal column ca. 3 mm long.* Styles and stigmas purple. *Marginal outline of carpel ring circular,* the depressed center ca. 1/5 the diameter of the head (Figs. 1 & 2). *Mature carpels 9–11,*

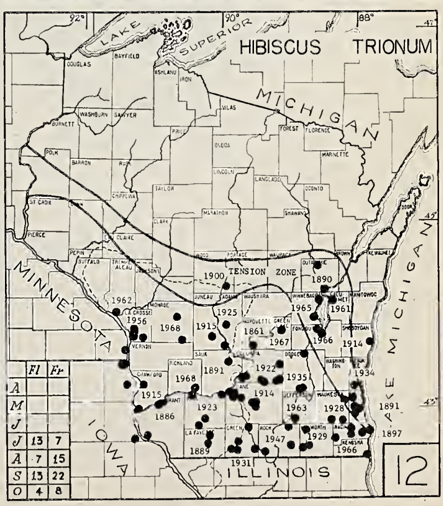

MALVA ROTUNDIFOLIA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A .
M
J 2 1
J 4 6
A 2 4
S 7 11
O 4 6
7


CALLIRHOE TRIANGULATA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 1
J 13 5
A 7 7
S 1
O
8


NAPAEA DIOICA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 6
J 13 2
A 8 7
S 1 3
O 1
9


ABUTILON THEOPHRASTI
LAKE SUPERIOR
MICHIGAN
TENSION ZONE
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 6 3
A 9 5
S 41 36
O 8 10
10


HIBISCUS MILITARIS
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 1
A 3 1
S 3
O 1
11


HIBISCUS TRIONUM
LAKE SUPERIOR
MICHIGAN
TENSION ZONE
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 13 7
A 7 15
S 13 22
O 4 8
12

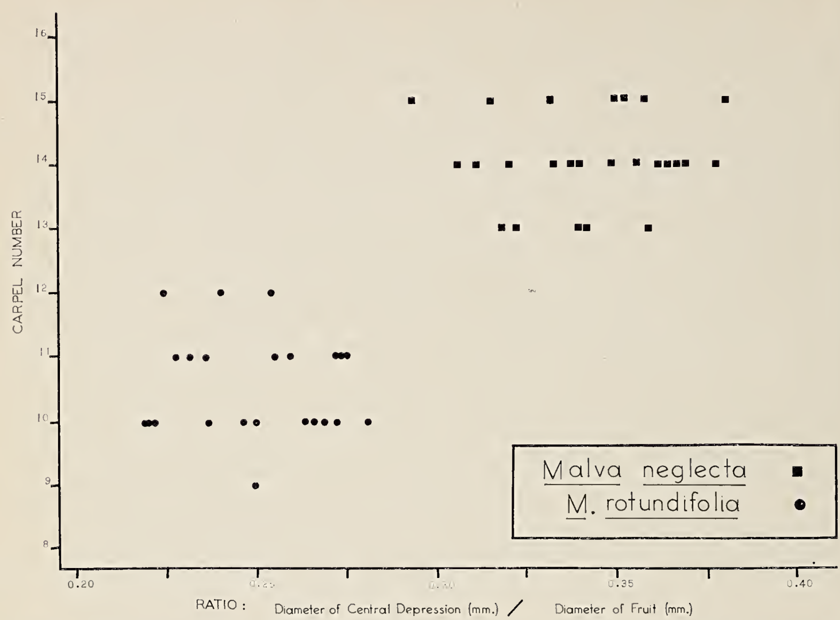
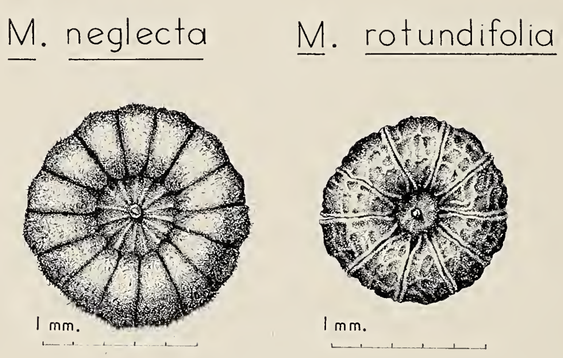



FIGURE 1. Scatter-diagram comparing the number of carpels per fruit and the width ratio of the central depression diameter divided by the fruit diameter of *Malva neglecta* and *M. rotundifolia*.




| Length (mm) | Malva rotundifolia | Malva neglecta |
|---|---|---|
| Bractlets | 2.9 - 3.8 | 3.6 - 4.6 |
| Petals | 3.2 - 4.5 | 6.0 - 12.0 |
| Staminal column | ca. 3 | ca. 6 |

FIGURE 2. Comparative carpel illustrations and floral measurements for *Malva neglecta* and *M. rotundifolia*.

*commonly 10, when young tomentulose, glabrous with maturity, conspicuously rugose–reticulate on back,* the lateral face radially veined. Seeds reniform, 1.8–2 mm long, laterally depressed, dark brown, glabrous.

Native of eastern Europe and western Asia (central Europe to Siberia and India), a world-wide adventive like *Malva neglecta* though not as frequent, a weed in southern Wisconsin in sandy, gravelly soils, about dwellings, waste and disturbed places, roadsides and railroad tracks. Similar in appearance to *M. neglecta,* but with fewer and glabrous carpels (Fig. 1) and shorter bractlets, staminal tube and petals (Morton 1937). Some European floras use *M. pusilla* Smith (ex Withering), because *M. rotundifolia* is considered a *nomen ambiguum.* Flowering and fruiting from April to November.

MALVA VERTICILLATA L. var. CRISPA L. Curled-mallow.

*Erect perennial to 1 m (or more) tall,* with large reniform leaves crenately 5- to 7-lobed, *the margins crisped. Petioles pubescent along a single line on the upper surface,* 5–11.7 (–17) cm long. *Flowers crowded in axillary fascicles, nearly sessile, the fruiting pedicels 8–15 mm long.* Bractlets 3, linear–lanceolate, 4.4–5.4 mm long, with simple trichomes. *Calyx 5-lobed, acuminate, with short stellate pubescence. Petals* 5, ovoid–obcordate, notched, *4.8–6 mm long,* white with pale blue tips, *Mature carpels 8–11, glabrous, obsurely reticulate near carpel margins.* Seeds ca. 2 mm wide, gray–brown, glabrous.

Native of China, naturalized from S Asia to SE Europe, introduced to European gardens with *Alcea rosea* in the 16th century, sporadically adventive in North America, now seldom grown as a salad green or garden plant (Hegi 1925), in Wisconsin rarely persisting after cultivation: Racine Co.: Racine, (ca. 1860), *Hale s.n.* (WIS). Sheboygan Co.: Sheboygan, waste land, *Goessl s.n.* (WIS). Walworth Co.: Darien, brought in from Pflaum garden, 31 July 1935, *Wadmond s.n.* (WIS). Flowering from July to August.

## 4. CALLIRHOE L. POPPY MALLOW.

Perennial herbs with *erect stems fascicled from a thick fusiform taproot.* Leaves triangular–cordate, crenate to deeply divided. Calyx 5-lobed, *either naked or with a 3-leaved involucre at its base.* Petals 5, triangular, broadly truncate, erose or fimbriate at summit, purple, red–purple, occasionally pink or white. *Staminal column antheriferous along more than half its length. Styles* slender, stigmatic along inner surface, *greatly elongated at anthesis.* Carpels 10–15, these separating at maturity into as many one-seeded, indehiscent, reniform schizocarps.

New World genus with 7 species of the Great Plains and northern Mexico.

### Key to Species

A. *Leaves triangular, crenate; involucre of 3 spatulate bractlets;* carpels keeled, strigose, the lateral faces not radially veined; native, dry sand prairies ___________1. *C. TRIANGULATA.*

AA. *Leaves deeply 5- to 7-parted, the segments incised; involucral bractlets lacking;* carpels strongly rugose, the lateral faces radially veined; rare, waif introduction _2.*C. ALCAEOIDES.*

1. Callirhoë triangulata (Leavenw.) Gray — Poppy mallow. Map 8.

Erect perennial herbs with several stems to (2.5–) 6–8 dm tall, from a *stout fusiform taproot,* to 3 dm long. *Stems, leaves and calyx harshly stellate.* Leaves triangular–hastate, 6.5–13 cm long, 3.6–9.5 cm wide, coarsely crenate, truncate to cordate at base, with variable petiole lengths 3–17 cm. Stipules oblong, persistent, 6–11 cm long. *Flowers showy, panicled from axillary peduncels, 8.6–20 cm long, the pedicels 1.6–2.2 cm long at maturity. Bractlets 3, spatulate, ciliate, 6–9.5 mm long.* Calyx deeply 5-parted, the lobes 2.1–4.7 mm long at maturity. *Petals magenta–purple,* broadly truncate at summit, 1.9–2.6 cm long. Staminal column 10–13 mm long, *antheriferous laterally,* the anthers yellowish brown. Carpels 10–12, one seeded, indehiscent, short beaked, keeled, strigose, not rugose on back, the lateral faces not radially veined. Seeds reniform, laterally depressed, dark brown, 2.3–2.9 mm long.

Rare showy sand prairie species of the Ozarks and Great Plains, confined in Wisconsin to the dry and sandy valleys of the Wisconsin and Mississippi Rivers: in Prairie du Chien cemetery on Mississippi River sand terrace, (*Jones 416,* WIS); in Grant Co., Boscobel, prairie remnant along railroad, (*Musselman 2036,* WIS); sandy upland, Midway Prairie, La Crosse Co., (*Hartley 1404,* WIS); sandy *Pinus banksiana* woods E of Gotham, Richland Co., (*Nee 1068,* WIS). The preservation of this handsome species is insured by the inclusion of the Midway Prairie as one of the Scientific Areas of Wisconsin. Flowering and fruiting in July and early August.

CALLIRHOË ALCAEOIDES (Michx.) Gray

Perennial with numerous erect slender stems to 4 dm tall from a shallow, swollen taproot. Lower leaves triangular–cordate, shallowly 5–7 lobed, *the upper deeply 5–7 parted, these incised into numerous linear segments. Involucral bractlets lacking.* Calyx 5-lobed, the lobes acuminate, elongating to 1 cm at maturity. Flowers 2.5–4 cm wide, *the petals 1.4–1.8 cm long, pale rose to white,* fimbriate *or erose at summit.* Staminal column commonly 6 mm long, antheriferous along sides, the anthers dark red. *Styles exceeding staminal column by 1.5 cm at anthesis.* Carpels commonly 12, glabrous, strongly rugose on back, the lateral face radially veined. Seeds reniform, reddish brown, glabrous, 2.1–2.3 mm long.

Native of dry sand barrens, plains and prairies of south–central United States, where locally restricted. In Illinois limited to dry, gravelly or sandy, exposed soils, frequent along railroads (Jones and Fuller 1955), the only Wisconsin collection probably a waif introduction: Milwaukee Co.: Bay View, summer 1888, *Runge 140* (MIL).

5. NAPAEA [CLAYT.] L. GLADE MALLOW.

1. NAPAEA DIOICA L. Glade mallow. Map. 9.

*Napaea dioica* L. forma *stellata* Fassett, *Torreya* 42:179–180. 1943. [Type: Dane Co.: Along a railroad 3.8 miles west of Cross Plains, Aug. 16, 1942, *Fassett 22057,* (WIS, Isotypes in US, NY, GH, and several other herbaria.)]

Robust, *white-flowered, dioecious perennial,* 1–2 m tall from a stout taproot. Leaves 1–3 dm wide (basal leaves larger, to 6 dm), deeply 5–9 (–11) lobed or parted, the lobes coarsely toothed or incised, the lower surfaces strigose–pilose with or without admixture of short stellate hairs. *Flowers numerous, dioecious, without involucel, in large terminal panicles.* Calyx lobes 5, united, ovate to triangular, 5–8 mm long. Petals white, notched, those of the staminate flowers 5–9 mm long, those of pistillate shorter. Staminate flowers with 16–20 anthers, pistils lacking, the pistillate with a short column of (usually) antherless filaments, the styles stigmatic along the inner surface. *Carpels 8–10, when mature irregularly dehiscent into as many reniform, one-seeded schizocarps,* the back with stellate trichomes, rugose and ribbed. Seeds reniform, reddish brown, 3.5–3.8 mm long, glabrous. 2N = 30, N = 15 (Iltis & Kawano 1964).

The phytogeography, ecology and nomenclatural history of *Napaea dioica* have been reviewed by Iltis (1963) and Mickelson & Iltis (1966). The heliophytic habitat preference strongly suggests that it is a wet prairie, not a forest species, which was associated with the formation and extension of the prairie peninsula. Flowering late June to mid-August, fruiting July to early September.

*Napaea* is the *only* endemic *genus* confined almost completely to the glaciated north–central United States, and with its monotype *N. dioica* being the only strictly dioecious Malvaceae in the Western Hemisphere. The Californian *Sidalcea malachroides* with 2N = 20 appears to be the closest morphologically, but only as a putative relative. Based on karyotype analysis, Iltis and Kawano (1964) suggest that *Napaea* is an ancient allopolyploid hybrid between a 2N = 20 species of *Sidalcea* and another species (*Sidalcea* ?), now extinct, in which 2N = 10. The basic number would then be 5, not 7 as in all other members of the subtribe Malvinae. This would suggest segregation of *Napaea* and *Sidalcea* into their own subtribe.

Some plants have simple, straight appressed hairs and few stellate trichomes on the lower leaf surface. In others, these simple hairs are lacking, except on the larger veins, and are replaced by the short branched stellate trichomes (forma *stellata* Fassett, 1943). Frequently, the same plant will have upper leaves with mostly stellate trichomes, while the large basal leaves have mostly simple unbranched trichomes. Under the microscope these extremes are striking, yet there are numerous collections with both types mixed in various proportions (Iltis 1963). Though it might be useful to name these extremes, it is impossible to know whether the Linnean type specimen has stellate, simple or mixed pubescence. Fassett assumed, on the flimsy basis of Sprengel's (Syst. Veget. 3:122) statement that it is a "herba hirsuta", that the type had simple hairs. This conclusion is not warranted, since any plant may be hirsute with simple hairs. It seems best to ignore forma *stellata* until the Linnean type has been examined.

### 6. ABUTILON [Tourn.] Miller VELVET-LEAF.

1. ABUTILON THEOPHRASTI Medic. Velvet-leaf, Butter-print.
Map 10.

Stout branched annual herb (2–) 5–18 dm tall, from shallow thick taproot 8–17 cm long, *softly velvet-pubescent throughout.* Leaves cordate, 4–12 (–19) cm long, 3.5–11 (–17) cm wide, acuminate, the margin entire or slightly toothed; petiole 4–11 cm long. *Peduncles 13–26 mm long, jointed above the middle. Bractlets lacking;* calyx 5, united at base, ovate–elliptic, persistent, 7–12 mm long. Flowers yellow, 14–28 mm across. *Carpels 12–15 (–17) with conspicuous, horizontally spreading beaks, 3.1–3.5 mm long, the* *"schizocarps" ventrally dehiscent and not separating readily from the central axis.* Seeds 3–6 (–8)/carpel, 3.1–3.4 mm long, dark brown with short scattered stellate pubescence. 2N = 42 (Skovsted 1935, Smith 1965).

Native of India and central Asia, a world-wide adventive, common below the tension zone in southern Wisconsin, climate-limited (Lindsay 1935), as a noxious weed in cultivated and fallow fields, especially corn, but occasionally in gardens, along fence rows and waste places. The seeds retain their viability for over 50 years and are not killed by siloing (Steyermark 1963). The arrangement of the carpels resembles the print-blocks used on farms for stamping rolls of butter. Flowering and fruiting continuously from July to October or till frost.

7. HIBISCUS [Tourn.] L. ROSE-MALLOW.

Annual or perennial herbs or shrubs with entire to palmately lobed or dissected leaves. Flowers large, showy, in terminal racemes or solitary in upper axils. *Involucral bracts linear, 7–15.* Sepals 5, broadly triangular, enlarged in fruit. *Stamen-column long, with numerous lateral anthers; stigmas 5, capitate.* Fruit a 5-locular, subglobose or prismatic loculicidal capsule, subtended or enclosed by the persistent, accrescent calyx.

World-wide, subtropical to tropical genus, with ca. 150 species; *Hibiscus esculentus* L., okra or gumbo, a garden vegetable grown for its soft immature edible pods and *H. syriacus* L., Rose-of-Sharon, a showy ornamental shrub, are common temperate economic species.

KEY TO SPECIES

A. Tall perennial herbs, 1–2 m; petals pink, 5–9 cm long; fruiting calyx not inflated about the capsule.

B. Leaves obovate-lanceolate, canescent beneath; involucral bracts 10–15; *seeds not pubescent*__1. *H. MOSCHEUTOS.*

BB. Leaves hastate, green on both surfaces, glabrous; involucral bracts 9–10; *seeds with reddish brown hairs;* Wisconsin and Mississippi River bottoms ____________ __________________________________2. *H. MILITARIS.*

AA. Low annuals, 3–6 dm; petals pale yellow with purple center, 1.5–3.0 cm long; fruiting calyx inflated; common southern Wisconsin weed __________________________3. *H. TRIONUM.*

### 7. HIBISCUS [Tourn.] L. ROSE-MALLOW.

1. HIBISCUS MOSCHEUTOS L. subsp. PALUSTRIS (L) Clausen
*Hibiscus palustris* L.

Robust perennial to 2 m; stems densely to remotely stellate–pubescent. Leaves ovate to elliptic lanceolate, 8–20 cm long, 9–15 cm wide, serrate to crenate, rarely lobed, green above, with whitish to grayish pubescence beneath. *Petioles adnate to peduncle.* Involural bracts 9–14, linear, 1.4–2.5 cm long. *Petals pink, rarely white, lacking red band at base, 6.5–9 cm long.* Styles with spreading pubescence. Capsules abruptly contracted to a beak, glabrous or essentially so. *Seeds dark brown, papillose,* 3–3.2 mm long.

Saline, brackish or fresh water marshes of the northern coastal plain with inland extension to the Great Lakes region of southern Ontario, southern Michigan, northern Indiana and northeastern Illinois, in Wisconsin known from only one collection and now probably extinct: Rock Co.: Janesville, flowers pink, 25 Aug. 1889, *Gertil Skavlem s.n.* (WIS).

Radford *et al.* (1968) treat *Hibiscus palustris* L. as a subspecies of the sympatric and southern *H. moscheutos* L., as previously suggested by Fernald (1942, 1950).

2. HIBISCUS MILITARIS Cav. Rose-mallow. Map 11.

Robust, essentially glabrous perennial 1–2 m tall, with several erect stems arising from a crown root. *Leaves triangular to hastate,* 8–12 cm wide, 8–15 cm long, acute at apex, *basal lobes diverging,* green on both sides; petioles 7–13 cm long. Flowers showy, solitary in upper axils, the peduncles 2.3–5.8 cm long. Bractlets 9–12, glabrous and linear, 1.7–2.3 cm long. *Petals 5, pink with red–purple base, 6–8.5 cm long.* Carpels 5, dehiscent and beaked with 6–8 seeds carpel. *Seeds with stiff, brownish-red trichomes, 3–3.3* mm long. 2N = 38 (Nakajima 1936 ex Darlington 1955).

Native of marshes and muddy shores of pond and streams of the coastal plain, extending north of the Mississippi Embayment to Iowa, Minnesota, Indiana, Illinois and Wisconsin. The few Wisconsin stations are limited to the Mississippi and Wisconsin River bottoms where deposition and silting occur—levees, boat landings and alluvial forests. *Leersia lenticularia* Michx., *Sagittaria montevidensis* Cham. & Schlect. ssp. *calycina* (Engelm.) Bogin, and *Rorippa sessiliflora* (Nutt.) Hitchcock have similar distributions.

Dispersability and habitat preference suggest a recent northward migration. Dispersal is no problem, for the seeds are eaten by ducks and bobwhites (Steyermark 1963). Recent migration is noted for Indiana by Deam (1940): "I have known well the shores of the

Wabash River near Bluffton for a distance of 5 miles since 1880. The first colony of this species was noted in 1897 and is now common all along the muddy shores and on the muddy bars in the river. In the early history of the state our streams were clear and when the forests were removed the streams became muddy and sediment was deposited on the shores and on the gravelly and rocky bars which made a suitable habitat for this species." Wisconsin's earliest collection dates from 1914: Crawford Co.: Bridgeport, 6 Aug. 1914, *Denniston s.n.* (WIS). Later collections indicate sites where deposition and silting would occur and create suitable habitats. Apparently native, though its recent northward extension has probably been due to man's activity. Flowering late July to early August, fruiting August to September.

3. HIBISCUS TRIONUM L. Flower-of-an-hour. Map 12.

Low hairy annual, much branched at base, 3–6 dm tall; taproot slender. Leaves deeply 3-parted, 1.5–6 cm long, the segments oblong–obovate, irregularly incised; petioles 2–5 cm long. Bractlets 10–12, linear, ciliate with white trichomes, 7–12 mm long. *Calyx 5-lobed, membranaceous, ribbed. Flower sulfur yellow with a red–purple center, showy, but ephemeral* (hence common name); petals 1.5–3 cm long. Mature capsules 5-locular, black with long yellow trichomes, 5–7 seeds/carpel; the calyx surrounding it highly inflated, translucent, with many vertical dark green ribs, papillose and long hirsute. Seeds brown–black, papillose, 2–2.3 mm long. 2N = 28 (Medvedeva 1936, ex Darlington 1955) and 2N = 56 (Skovsted 1935).

Native of SE Eurasian agricultural center, found in the neolithic Aggtelek kitchen middens of Croatia (Yugoslavia), a *Kulturbegleiter* ("culture follower") now adventive throughout Europe, eastern Asia to China, N. Africa and N. America (Hegi 1925), its numerous seeds with unusual viability contributing to its spread (Deam 1940), a common weed in southern Wisconsin, in sandy soils of cultivated fields, gardens, roadsides, and disturbed or waste places. Flowering and fruiting from early July to late October or till frost.

## BIBLIOGRAPHY

BAILEY, L. H. 1906. *The Standard Cyclopedia of American Horticulture.* New York: Doubleday, Page and Co.

BRAUN, *E. L.* 1960. The genus *Tilia* in Ohio. *Ohio J. Sci.* 60(5):257–261

CURTIS, J. T. 1959. *The Vegetation of Wisconsin.* Univ. of Wisconsin Press, Madison. 657 pp.

DARLINGTON, C. D. and A. P. WYLIE. 1955. *Chromosome Atlas of Flowering Plants.* George Allen & Unwin, Ltd., London.

Deam, C. C. 1940. *Flora of Indiana*. Dept. of Conservation, Indianapolis. 1236 pp.

Derman, H. 1932. Chromosome numbers in the genus *Tilia*. *Journ. Arnold Arboretum* 13: 49–50.

Desmarais, Y. 1948. *Dynamics of leaf variations in the sugar maples*. Ph.D. Dissertation, Univ. of Wisconsin, Madison.

————. 1952. Dynamics of leaf variations in the sugar maples. *Brittonia* 7(5): 347–388.

Fassett, N. C. 1943. Some new forms from the Middle West. *Torreya* 42: 179–181.

Fernald, M. L. 1942. *Hibiscus moscheutos* and *H. palustris*. *Rhodora* 44: 266–278.

————. 1950. *Gray's Manual of Botany*, ed. 8. New York: American Book Co.

———— and K. M. Wiegand. 1910. A summer's botanizing in eastern Maine and western New Brunswick. *Rhodora* 12: 140–141.

Fowells, H. A. 1965. *Silvics of Forest Trees of the United States*. U. S. Dept. Agr., Forest Service, Agr. Hand. No. 271, Washington.

Gleason, H. A. and A. Cronquist. 1963. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. New York: van Nostrand Co.

Hagen, A. 1932. Preliminary Reports on the Flora of Wisconsin. No. 20. Malvales. *Trans. Wis. Acad. Sci. Arts and Letters*, Vol. 27: 247–249.

Hartley, T. G. 1962. *The Flora of the Driftless Area*. Ph.D. Dissertation, State Univ. of Iowa, Iowa City.

Hegi, G. 1925. *Illustrierte Flora von Mittel–Europa*. München: J. F. Lehmann Verlag, Vol. 5, I.

Iltis, H. H. 1963. *Napaea dioica* (Malvaceae): Whence came the type? *Am. Midl. Nat.* 70(1): 90–109.

———— and S. Kawano. 1964. Cytotaxonomy of *Napaea dioica* (Malvaceae). *Am. Midl. Nat.* 72(1): 76–81.

Jones, G. N. 1968. Taxonomy of American species of linden *(Tilia)*. *Ill. Biol. Mono.* 39, Univ. of Illinois Press, Urbana.

———— and G. D. Fuller. 1955. *Vascular Plants of Illinois*. Univ. of Illinois Press, Urban. 593 pp. 1375 maps.

Kearney, T. H. 1951. The American Genera of Malvaceae. *Am. Midl. Nat.* 46(1): 93–131.

Lindsay, D. R. 1953. Climate as a factor influencing the mass ranges of weeds. *Ecology* 34: 308–321.

Mickelson, C. J. and H. H. Iltis. 1966. Preliminary Reports on the Flora of Wisconsin. No. 55. Compositae IV—Composite Family IV (Tribe Helenieae and Anthemideae). *Trans. Wis. Acad. Sci. Arts and Letters*, Vol. 55: 197–222.

Morton, C. V. 1937. The correct names of the small-flowered mallows. *Rhodora* 39: 98–99.

Mulligan, G. A. 1961. Chromosome numbers of Canadian weeds. III. *Can. J. Bot.* 39: 1057–1066.

Radford, A. E., H. E. Ahles and C. R. Bell. 1968. *Manual of the Vascular Flora of the Carolinas*. Univ. of North Carolina Press, Chapel Hill. 1183 pp.

Seymour, F. C. 1960. *Flora of Lincoln County Wisconsin*. P. F. Nolan, Taunton, Mass.

Skovsted, A. 1935. Chromosome numbers in the Malvaceae. I. *J. Genet.* 31: 263–296.

SMITH, E. B. 1965. Chromosome numbers of Kansas flowering plants. II. *Kansas Acad. Sci.* 68: 463–464.

SORENSEN, P. D. 1966. *The Flora of the old bed of Glacial Lake Wisconsin and the adjacent terminal moraine.* MS. thesis, State Univ. of Iowa, Iowa City.

STEYERMARK, J. A. 1963. *Flora of Missouri.* Iowa State University Press, Ames. 1725 pp.

STOEVER, D. H. 1794. *The Life of Sir Charles Linnaeus.* London.

SUGIURA, T. 1936. Studies on the chromosome numbers in higher plants, with special reference to cytokinesis. I. *Cytologia* (Tokyo) 7: 544–595.

TUTIN, T. G., *et al.* 1968. *Flora Europaea.* Vol. 2. Rosaceae to Umbelliferae. London: Cambridge Univ. Press. 455 pp.

URBAN, E. and H. H. ILTIS. 1957. Preliminary Reports on the Flora of Wisconsin. No. 38. Rubiaceae–Madder Family. *Trans. Wis. Acad. Sci. Arts and Letters,* Vol. 46: 91–104.

ZOHARY, M. 1963a. Taxonomical Studies in *Alcea* of Southwestern Asia. Part I. *Bull. Res. Council Israel,* Vol. II D4: 210–229.

————. 1963b. Taxonomical Studies in *Alcea* of Southwestern Asia. Part II. *Israel J. Bot.* 12: 1–26.

# PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 61[1]. HYPERICACEAE—ST. JOHN'S–WORT FAMILY

*Fred H. Utech and Hugh H. Iltis*

The Hypericaceae, a natural group often segregated from the more polymorphic, woody, tropical Guttiferae, has 2 genera and 14 species in Wisconsin. All but the ubiquitous Common St. John's-wort *(Hypericum perforatum)* are native and occur either in dry, exposed sands or wet marly marshes or bogs, sandy swales and lake, river or stream-sides. A southern origin for the Great Lakes–Central Wisconsin endemic *Hypericum kalmianum* is suggested. Three species are reported here as new for the state: *Hypericum prolificum,* x *H. dissimulatum* and *Triadenum virginicum.*

The present treatment revises McLaughlin's (1931) preliminary report on Hypericaceae. Material from the following herbaria was intensively studied: University of Wisconsin (WIS), University of Wisconsin–Milwaukee (UWM), Milwaukee Public Museum (MIL), University of Minnesota (MIN), University of Minnesota–Duluth (DUL), State University of Iowa (IA), Oshkosh State University, La Crosse State University, Northland College (Ashland, Wis.), Beloit College and the private herbarium of Katherine Rill (Clintonville, Wis.–RILL). We are grateful to the curators of these herbaria for the loans of specimens.

Dots on the maps represent exact locations, triangles, county records. Some locations have been added from Thomas Hartley's unpublished "Flora of the Driftless Area" (1962), Paul Sorensen's unpublished range maps from his Glacial Lake Wisconsin studies (1966), Olga Lakela's *Flora of Northeastern Minnesota* (1965), Jones and Fuller's *Flora of Illinois* (1955) and Frank Seymour's Lincoln County sight record index (WIS).

The map inset numbers record Wisconsin flowering and fruiting dates; plants with vegetative growth only, in bud or with dispersed fruit were not included. For introduced species the year of earliest collection within a county is also recorded. Nomenclature and order of genera and species follows Gleason and Cronquist (1963) and Fernald (1950).

---

[1] Field work and preparation of manuscript supported in part by the Research Committee of the University of Wisconsin, on funds from the Wisconsin Alumni Research Foundation.

Numerous people deserve special recognition for their help in manuscript preparation: Mrs. Katherine Snell, for encouragement and timely aids; Mr. Brian G. Marcks and Mr. Michael H. Nee, for comment and criticism; Mr. Eugene G. Coffman for photographic reproductions; Miss Bethia Brehmer and Miss Cynthia Loughran for artistic work; and Dr. John W. Thomson and Dr. Preston Adams for critical manuscript reading.

## HYPERICACEAE Lindley St. John's–Wort Family

Herbs or shrubs with opposite, simple, entire, often pellucid- or black-punctate leaves; stipules lacking. *Flowers perfect, regular, hypogynous, solitary, axilliary or in cymes.* Stamens 5 to over 100; filaments elongate, free or basally connate in 3 or 5 bundles, these opposite petals; anthers 2-celled, longitudinally dehiscent. Ovary superior; carpels 3–6; placentation parietal, pseudo-axile or axile (Fig. 1); styles distinct or united. Capsules septicidal, 1, 3 or 5 loculate. Seeds many, small, without endosperm.

A small family with 12 genera and 600 species, usually segregated from the tropical Guttiferae (Clusiaceae).

### KEY TO GENERA

A. Petals yellow to orange, convolute in bud; stamens numerous to few, distinct or united at base into 3 to 5 clusters; hypogynous glands lacking ______________________ 1. Hypericum.

AA. Petals pink to mauve-purple, imbricate in bud; stamens 9, strongly triadelphous; hypogynous glands 3, orange, alternate with the stamen bundles ____________________2. Triadenum.

### 1. HYPERICUM [Tourn.] L. St. John's–Wort.

Annual or perennial herbs or shrubs; leaves simple, frequently pellucid or black-dotted, opposite, entire, frequently with axillary decussant branchlets; stipules lacking. Inflorescence cymose. Sepals 5, often unequal, persistent. Petals 5, yellow to orange, convolute in bud, often black-dotted. Stamens numerous or few (small fld. spp.); filaments free or basally connate. Ovary superior; styles united or separate and divergent; stigmas minute or capitate. Placentation parietal (1-celled), pseudo-axile by intrusion of placentae (partially 3- or 5-celled) or axile (completely 3- or 5-celled) (Fig. 1). Capsules septicidal, 1- to 5-carpellate. Seeds small (ours 0.5–3.0 mm), short-cylindric, aerolate.

The largest genus of the Hypericaceae, world-wide, throughout temperate and tropical montane regions, with ca. 300 species of annuals, perennials with persistent rhizomes, and woody shrubs.

### Key to Species

A. Styles united at base into a single straight beak at anthesis, splitting at maturity; stigmas minute, never capitate; stamens many, distinct. (Sect. MYRIANDRA)

B. *Small woody shrubs;* leaves and sepals articulate at base; withered stamens deciduous soon after anthesis. (Subsect. Centrosperma).

C. Midstem leaves 2.6–4.5 cm long, sessile; styles and carpels 5; *cymes chiefly terminal, 3- to 7-flowered.* ____________________________1. *H. KALMIANUM.*

CC. Midstem leaves 3.5–7 cm long, short-petiolate; styles and carpels 3; cymes terminal and axillary, *11- to 19-flowered; rare.* __________2. *H. PROLIFICUM.*

BB. *Perennial herbs slightly suffrutescent at base;* leaves and sepals not articulate at base; withered stamens persistent long after anthesis. (Subsect. Pseudobrathydium).

D. Plants robust, 30–60 cm tall, rhizomatose, the rootstock often woody; leaves linear–elliptic, 30–58 mm long; seeds 2.0–2.7 mm long; rare, moist prairies, Green Co. and Rock Co. ______ __________________3. *H. SPHAEROCARPUM.*

DD. Plants slender, 15–35 cm tall from horizontal rhizome, the bases herbaceous; leaves elliptic to ovate, 16–33 mm long; seeds 0.5–0.8 mm long; central and northern Wisconsin lakes and river margins._______4. *H. ELLIPTICUM.*

AA. Styles free to base, the capsules not beaked; stigmas capitate; stamens many to few, connate basally into 3 or 5 bundles (phalanges).

E. Stigmas and styles 5; capsules 5-celled, 8–15 mm wide; flowers 50–60 mm across; stamens 5-delphous, numerous (over 150); larger leaves 5–8 cm long; robust perennial of wet habitats. (Sect. ROSCYNA) ________________ _____________________________5. *H. PYRAMIDATUM.*

EE. Stigmas and styles 3; capsules 1- or 3-celled, 1–5 mm wide; flowers 5–30 mm across; stamens 60–5; larger leaves less than 5 cm long.

F. Capsules 3-celled, with azle placentae; flowers 6–32 mm across; corolla black-dotted; stamens 60–27, weakly 3-delphous.

G. Capsules oblong-conic, 4.5–6.5 mm long; styles 4–5 mm long; flowers 15–30 mm across; petals black-dotted on margin only; stamens (45)–50–(60); common Eurasian weed. (Sect. HYPERICUM ______________6. *H. PERFORATUM.*

GG. Capsules subglobose-ovate, 3.8–4.6 mm long; styles 1.5–2.5 mm long; flowers 6–10 mm across; petals and sepals marked with black dots and lines; stamens (27)–35–(40); native. (Sect. ELINEATA) ____7. *H. PUNCTATUM.*

FF. Capsule 1-celled, with parietal placentae; flowers 4–7 (–10) mm across; corolla yellow, lacking black dots; stamens 20–5, weakly 5-delphous: (Sect. BRATHYS)

H. Leaves linear to elliptic-ovate, 8–44 mm long, 1–15 mm wide, 3- to 7-nerved; inflorescence cymose.

I. Capsules broadly ellipsoid or oblongoid, the apex rounded to obtuse; inflorescence diffuse and leafy-bracted, not well defined, the angle between a pair of lateral peduncles 70° or more (Fig. 5); sepals oblong to elliptic, widest near middle.

J. Uppermost bracts highly reduced, setaceous; cauline leaves often over 20 mm long, deltoid to ovate, usually cordate-clasping; sepals acute, equaling capsule; plants often 3–5 dm tall; mostly Driftless Area. ____________ ________________8. *H. MUTILUM.*[2]

JJ. Uppermost bracts foliaceous; cauline leaves 8–15 mm long (rarely longer), ovate to elliptic, sessile but not strongly clasping; sepals obtuse, shorter than capsule; plants usually 1–3 dm tall; widespread. ___________ _________________9. *H BOREALE.*[2]

II. Capsules ovoid to conic, the apex narrowed; inflorescence rather compact and clearly defined, setaceous-bracted not leafy, the angle between a pair of lateral peduncles 70° or less (Fig. 5); sepals lanceolate to linear, acute or acuminate.

K. Leaves elliptic-lanceolate to oblong, the larger 5–12 mm wide, rarely narrower, the bases subcordate-clasping; sepals 4–6.5 mm long; capsules elliptic-ovate, 5–7.8 mm long; plants often 3–5 dm tall; common throughout state. ________________10. *H. MAJUS.*[2]

KK. Leaves linear to linear-elliptic or -oblanceolate 1–3 mm wide, 1–(3-)nerved, the bases sessile-attenuate; sepals 2.5–4.4 mm long; capsules conic, 3–5.2 mm long; plants usually 1–3 dm tall; mostly northern Driftless Area. __________11. *H. CANADENSE.*[2]

HH. Leaves minute, scale-like, 1.5–3 mm long, 0.5 mm wide, strictly 1-nerved; inflorescence racemose; branches wiry; dry sands, Driftless Area. ____________13. *H. GENTIANOIDES.*

1. Hypericum kalmianum L. Kalm's St. John's-Wort. Map 1, Figs. 1–4.

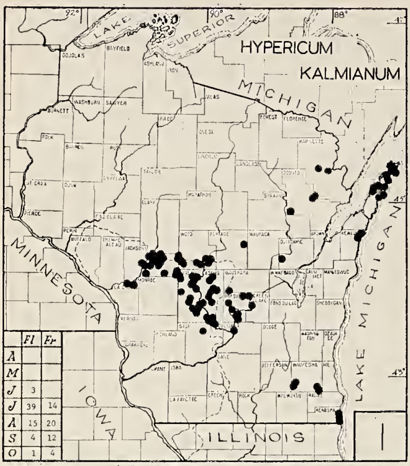
Slender shrubs 2–6 (–10) dm high, with branches 4-angled, the branchlets 2-angled. *Leaves linear-elliptic to oblanceolate, revolute, coriaceous, sessile, obtuse, mostly 26–45 mm long, 4–8 mm wide* (Fig. 4). *Cymes 3- to 7-flowered (rarely more), restricted to terminal node* (Fig. 2). Flowers 20–35 mm across. Sepals oblong-elliptic, foliaceous, 6–8 mm long. Petals 5–14 mm long. Stamens numerous, distinct. *Ovary 1-locular, usually with 5 pseudo-axile intruding placentae* (Fig. 1); styles (3)–5–(6); stigmas never capitate. Capsules ovoid, 5-carpellate (rarely 3, 4 or 6), 7–10 mm long, 4–7 mm wide. Seeds light brown, 0.7–1.1 mm long. N = 9 (Hoar & Haertl 1932; Robson & Adams 1968).

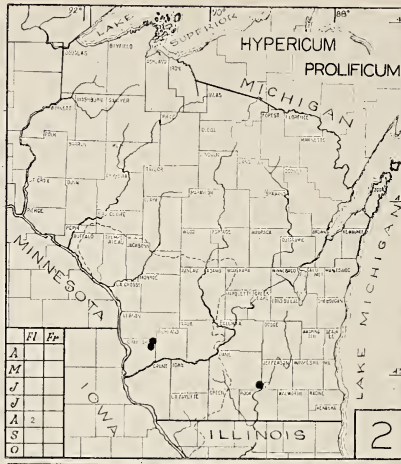
Central Wisconsin sand plains and sphagnum-sedge meadows, in rocky shores, sandy swales, behind dunes, and calcareous low prairies about Lakes Michigan, Huron and Erie, to the Ottawa River, Quebec (Fig. 3: cf. maps McLaughlin 1930, Guire & Voss 1963, Adams 1959b), its Wisconsin distribution closely associated with the desiccated beds and outwash plains of Glacial Lakes Wisconsin, Oshkosh and Chicago. Flowering late June to early October; fruiting early July through October.

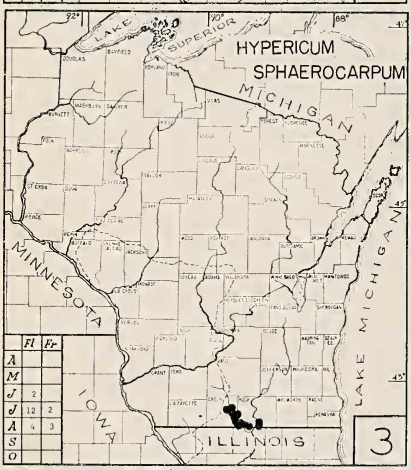
The history of *Hypericum kalmianum* is of particular interest, since all its stations are in glaciated territory (Adams 1959b, Guire & Voss 1963, McLaughlin 1931); this restriction suggests either a

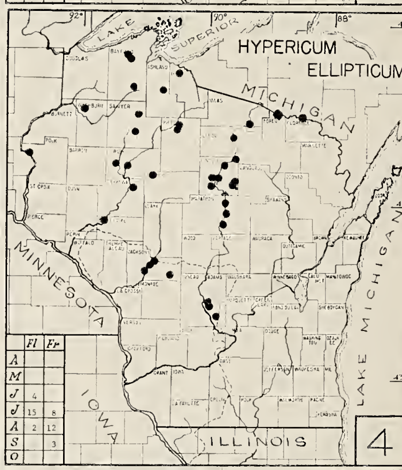
---

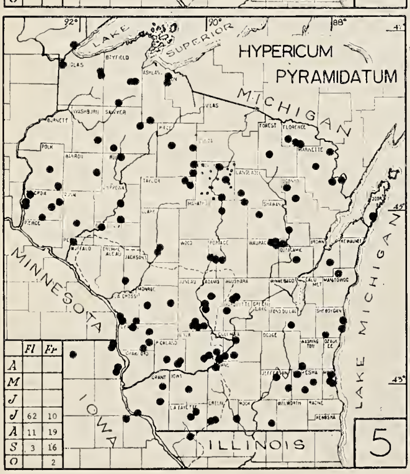
[2] Hybrids between the species 8–11 are not uncommon (cf. Hybrids of Sect. *Brathys*, 12a, 12b, and 12c, pp. 29–32). Depauperate plants are common but can be keyed with help of full grown ones nearby.

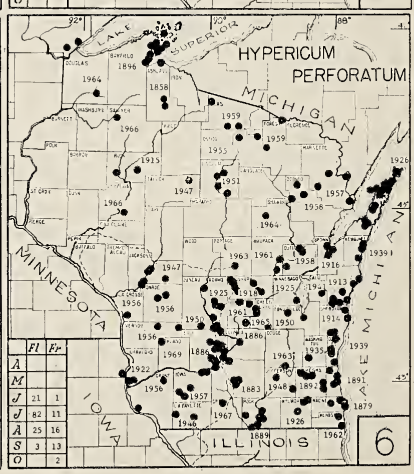

HYPERICUM
KALMIANUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 3
J 39 14
A 15 20
S 4 12
O 1 4
1


HYPERICUM
PROLIFICUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J
A 2
S
O
2


HYPERICUM
SPHAEROCARPUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 2
J 12 2
A 4 3
S
O
3


HYPERICUM
ELLIPTICUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 4
J 15 8
A 2 12
S 3
O
4


HYPERICUM
PYRAMIDATUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 62 10
A 11 19
S 3 16
O 2
5


HYPERICUM
PERFORATUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 21 1
J 82 11
A 25 16
S 3 13
O 2
6

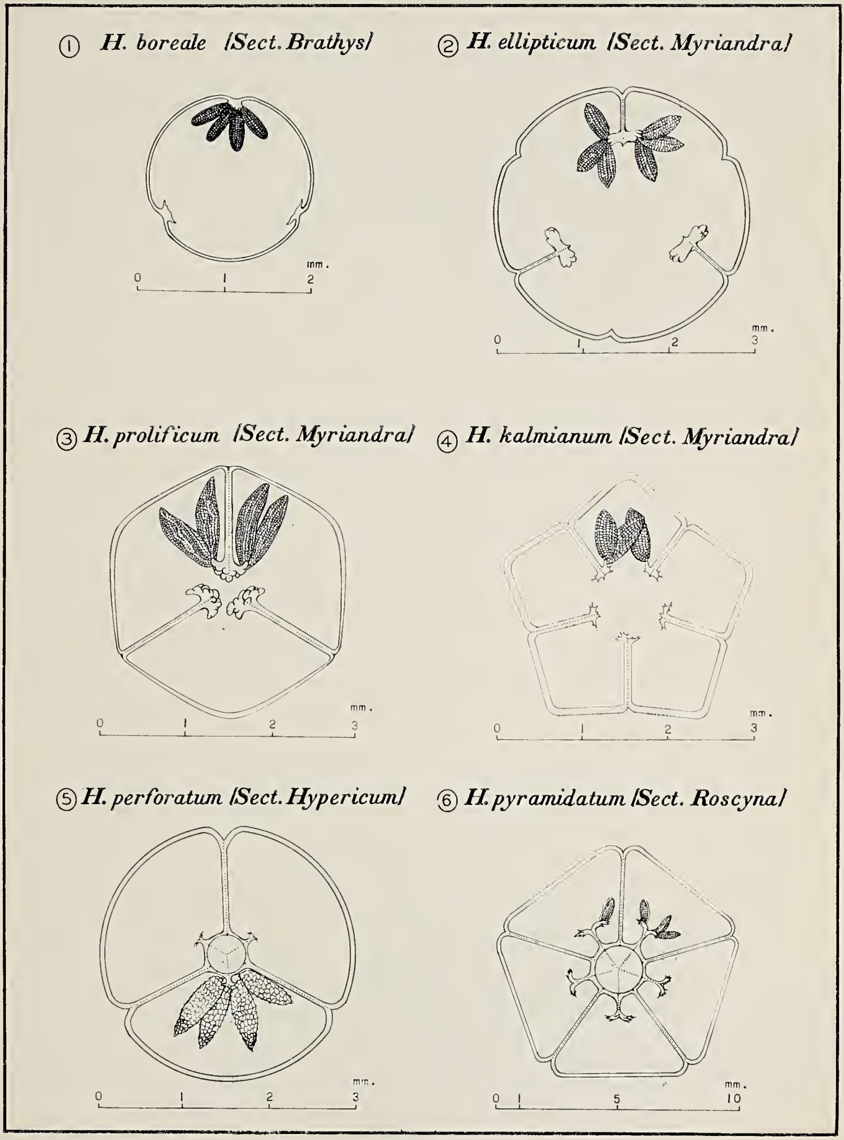
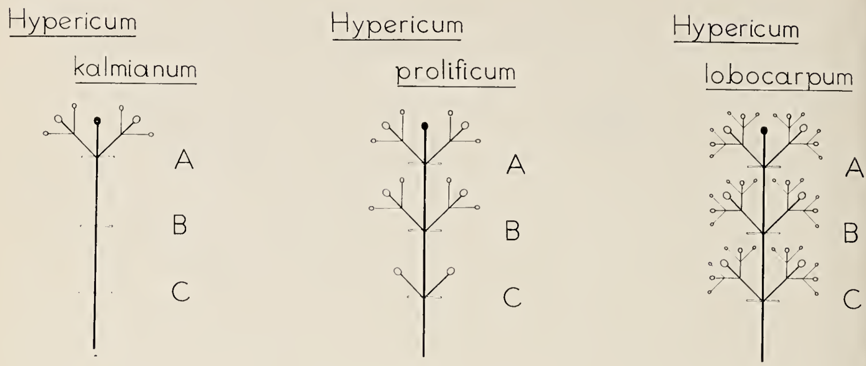
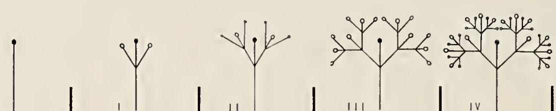



FIGURE 1. Diagrams illustrating the different types of placentation found in Wisconsin *Hypericum:* 1. *H. boreale* (Sect. Brathys)—parietal. 2. *H. ellipticum* (Sect. Myriandra)—pseudo-axile. 3. *H. prolificum* (Sect. Myriandra)—pseudo-axile. 4. *H. kalmianum* (Sect. Myriandra)—pseudo-axile. 5. *H. perforatum* (Sect. Hypericum)—axile. 6. *H. pyramidatum* (Sect. Roscyna)—axile.



| H. kalmianum | 0 | I | II | III | IV | Totals / Node | |
|---|---|---|---|---|---|---|---|
| A (terminal) | 37 (7.8%) | 168 (35.2%) | 245 (51.4%) * | 23 (4.8%) | 4 (0.8%) | 477 | (100 %) |
| B (axillary) | | 19 (3.9%) | 19 (3.9%) | | | 38 | 7.8 |
| C ( '' ) | | 3 (0.6%) | | | | 3 | 0.6 |
| D ( '' ) | | | | | | 0 | 0 |

| H. prolificum | 0 | I | II | III | IV | Totals / Node | |
|---|---|---|---|---|---|---|---|
| A (terminal) | | 32 (35.2%) | 48 (52.7%) * | 11 (12.1%) | | 91 | (100 %) |
| B (axillary) | | 28 (30.3%) | 52 (57.1%) * | 10 (10.9%) | | 90 | 98.3 |
| C ( '' ) | | 28 (30.3%) * | 24 (26.3%) | 8 (8.8%) | | 60 | 65.4 |
| D ( '' ) | | | 6 (6.6%) | | | 6 | 6.6 |

| H. lobocarpum | 0 | I | II | III | IV | Totals / Node | |
|---|---|---|---|---|---|---|---|
| A (terminal) | | 1 (1.6%) | 18 (29.5%) | 38 (62.3%) * | 4 (6.6%) | 61 | (100 %) |
| B (axillary) | | 3 (5.0%) | 19 (31.1%) | 28 (45.9%) * | | 50 | 82.0 |
| C ( '' ) | | 1 (1.6%) | 3 (5.0%) | 22 (36.0%) * | | 26 | 42.6 |
| D ( '' ) | | | 3 (5.0%) | | | 3 | 5.0 |

FIGURE 2. Statistical model and data comparing the inflorescences and degree of dichasial branching of *Hypericum kalmianum, H. prolificum* and *H. lobocarpum.*

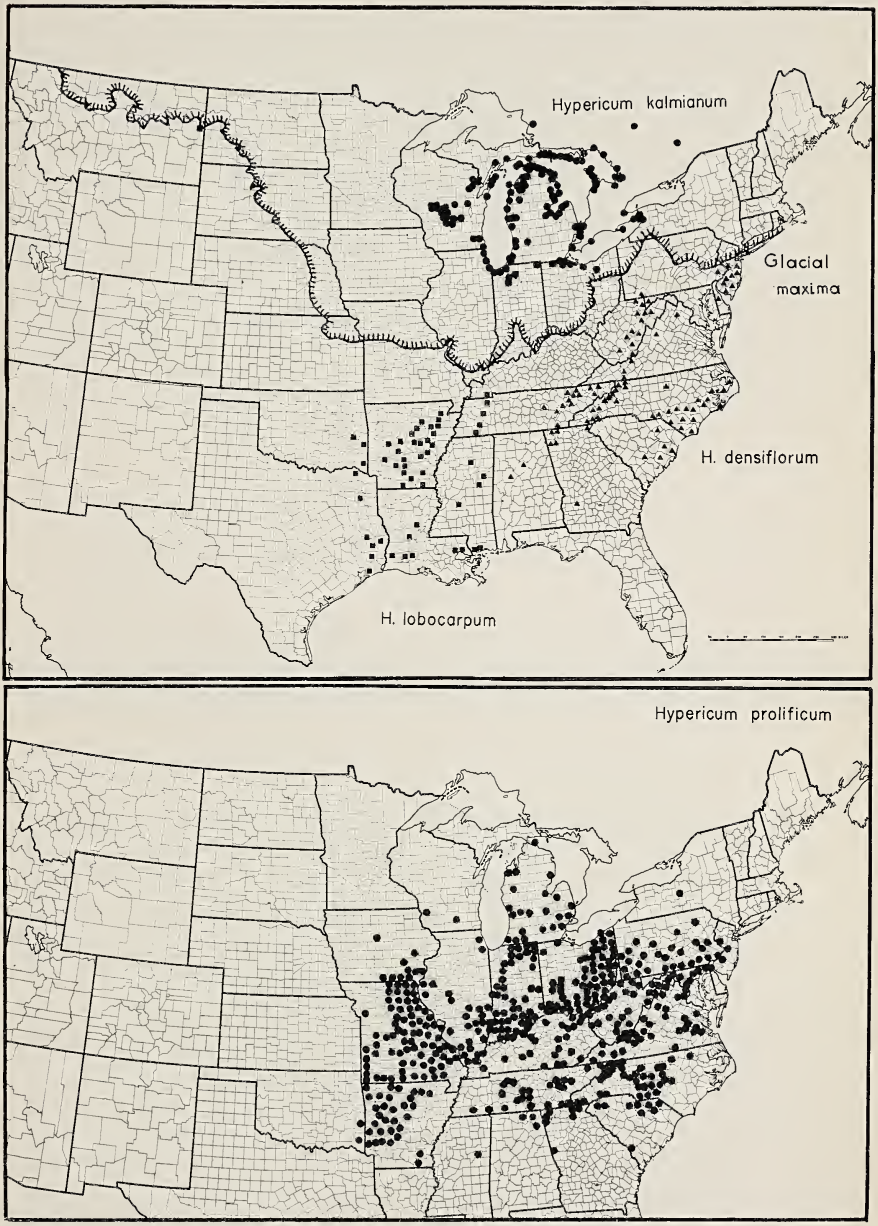



FIGURE 3. Distributional maps of *Hypericum kalmianum* L. *H. lobocarpum* Gatt., *H. densiflorum* Push and *H. prolificum* L., based in part on the unpublished map of Adams (1959b).

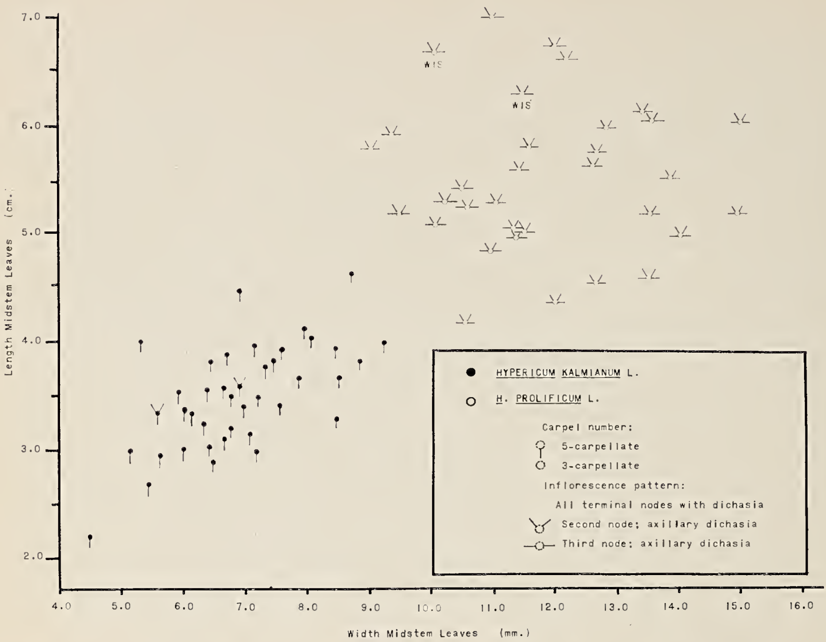



FIGURE 4. Scatter-diagram comparing leaf width and length and indicating number of carpels and degree of inflorescence branching of Wisconsin *Hypericum kalmianum* and Wisconsin and non-Wisconsin *H. prolificum.*

pre-glacial origin with subsequent survival either in unglaciated or in once-glaciated territory between differentially advancing glacial lobes, or a recent, post-glacial origin from a more wide-spread southern species. The last hypothesis seems to us the most reasonable. Adams (1959b, 1962) thinks this ancestor to be the Gulf Coastal and Mississippian Embayment *H. lobocarpum* Gatt. (= *H. oklahomense* Palmer), since this species and *H. kalmianum* both have mostly 5-carpellate ovaries, differing from the 3-carpellate, but otherwise similar and related *H. prolificum* L. The eastern coastal and inter-montane *H. densiflorum* Pursh is also commonly 3-carpellate: many authors de-emphasize carpel number and follow Svenson (1940) in considering *H. lobocarpum* as a variety of *H. densiflorum.* Carpel number is extremely variable even in well-defined species of section *Myriandra.* In any case, the fruits of both 5-carpellate taxa *(H. kalmianum* and *H. lobocarpum)* are very similar, except that those of *H. lobocarpum* tend to be smaller on the average and more deeply sulcate.

Comparison of degree of dichasial branching and flowers/inflorescence (Fig. 2) of *H. kalmianum*, *H. prolificum* and *H. lobocarpum* reveals a north to south increase, with the northern *H. kalmianum* usually fertile only in the uppermost node, the southern *H. lobocarpum* highly floriferous in many (3 to 5 or more) nodes. *H. prolificum* has the largest number of inflorescence combinations. Both *H. prolificum* and *H. kalmianum* have broad foliaceous sepals (4–8 mm long) and flowers to 30 mm wide; *H. lobocarpum* and *H. densiflorum* have usually shorter, narrower sepals (2–4 mm long) and often smaller flowers (to 20 mm across). Thus, while *H. kalmianum* was probably derived from *H. lobocarpum* (or *H. densiflorum*), the reduced inflorescence-branching, foliaceous sepals and larger flowers suggest some *H. prolificum* introgression into *H. kalmianum*, which would not be unlikely, considering the geographic proximity of the two populations.

2. HYPERICUM PROLIFICUM L. Map 2, Figs. 1–4.
*Hypericum spathulatum* (Spach) Steud. of ed. 8, Gray's Manual.

Erect bushy shrub 3–9 dm tall, diffusely branched; bark shreddy, gray, the branchlets sharply 2-angled. *Leaves oblanceolate-linear, obtuse and often mucronate, the margins strongly revolute, punctate*, the midstem leaves 3.5–7 cm long, 7–15 mm wide (Fig. 4). Petioles 1–4.6 mm long. *Cymes 11- to 19-flowered, terminal and axillary* (Fig. 2). Flowers 15–27 mm across. Sepals ovate, mucronate, 4.5–6 mm long. Petals obovate, bright yellow, 7–10 mm long. Stamens numerous, distinct. *Ovary 1-locular usually with 3 pseudo-axile intruding placentae* (Fig. 1); styles 3 (4); stigmas not capitate. Capsules ellipsoid-ovate, 3-carpellate (rarely 4 or 5), 10–13 mm long, 3.5–6 mm wide. Seeds black, 1.2–1.8 mm long. N = 9 (Nielsen 1924, Robson and Adams 1968).

A variable species in eastern and central United States (Fig. 3) on dry creek beds, sandy or rocky slopes, roadsides and old fields, occasionally cultivated, reported here for Wisconsin for the first time, Swezey's (1883) use of this name being based on collections of *H. kalmianum* (*Lapham s.n. and Hale s.n.*, WIS, MIL). All collections are recent, perhaps escapes from cultivation. Crawford Co.: town of Clayton, S. 11 SE ½, 9 July 1960, *Densmore s.n.* (WIS); sandy hillside E of Soldiers Grove on Co. E, with *Silphium perfoliatum*, *Corylus americana*, *Rhus radicans*, 4 Aug. 1960, *Schlising & Musolf 1749* (WIS). Dane Co.: Edgerton, Camp Hickory Hill, open, light sandy soil, 5 Aug. 1947, *Dorney s.n.* (RILL). Flowering late July and early August.

3. HYPERICUM SPHAEROCARPUM Michx. Map 3.
*Hypericum cistifolium* of authors, not Lamark

Erect perennials from woody branched rootstocks, the deep rhizomes with adventitious shoots. Stems herbaceous, 30–58 cm tall, 4-lined. Leaves linear-oblong to narrowly elliptic, acute to obtuse, sessile, 3–7 cm long, 4–15 mm wide. Cymes compact, compound, many-flowered; bracts lanceolate. *Sepals ovate-lanceolate,* 2.8–4.8 mm long. Petals yellow, 5.3–8.6 mm long. Stamens numerous. *Ovary 1-locular, with 3 intruding parietal placentae. Capsules globose to ovoid,* firm, few-seeded, 4.5–6.7 mm long; styles 3, united in sharp beak. *Seeds blackish-brown,* coarsely reticulate, pitted, *2.0–2.7 mm long,* the raphe developed into a keel.

Species of low or mesic prairies, limestone outcrops and cedar glades, Ala. to SW Ark., north to Iowa, Ill. and N Ind., rare in Wisconsin, confined to low wet prairies along the Sugar and Rock Rivers, as in low rich prairie (near Monticello, Green Co.), with scattered willows, dogwood, bur oak, *Potentilla arguta, Eryngium yuccifolium,* and *Ratibida pinnata.* The plants are almost always pulled up without the very deep slender horizontal rhizomes. Flowering late June to mid-August, fruiting mid-July through August.

4. HYPERICUM ELLIPTICUM Hook. Creeping St. John's-Wort.
Map 4, Fig. 1.

Erect unbranched perennial from a *reddish, spongy, slender, creeping rhizome.* Stems 15–35 cm tall, obscurely 4-angled. Leaves elliptic to elliptic-lanceolate, the larger 16–33 mm long, 4–13 mm wide, pellucid-punctate, not revolute, the midvein prominent. Cymes terminal, few-flowered; bracts linear to lanceolate. *Sepals narrowly obovate to oblanceolate,* 4–6 mm long. Petals oblanceolate, 4.6–8.6 mm long, often reddish in bud. Stamens numerous. *Ovary 1-locular with 3 intruding parietal placentae* (Fig. 1). Capsules subglobose to ovoid, 4–7 mm long, many-seeded; styles 3, united at base. *Seeds dark reddish brown,* striated, pitted, *0.5–0.8 mm long.* N = 9 (Hoar & Haertl 1932).

A "northern hardwoods" species, from NE Tenn. to Newfoundland, west to Lake Superior, in central and northern Wisconsin along stream banks, pond and lake shores, river flats and sand bars, as in cold streamside *Alnus* thickets in sunny *Carex* meadows, Brule River, Florence Co. The northern-most member of the 30 species of section *Myriandra* (Adams 1962) and the only Wisconsin *Hypericum* with prominent (oft-collected) rhizomes. Flowering late June to early August, fruiting July to latest October.

Submerged aquatic plants with simple sterile stems and round to ovate "feather-veined" leaves, resembling *Callitriche,* have been designated as forma *SUBMERSUM* Fassett (1939, 1960), while terrestrial plants with axillary branches overtopping the mature infructescence, as forma *FOLIOSUM* Marie–Victorin (Le Nat. Canadien 71: 201. 1944.)

5. HYPERICUM PYRAMIDATUM Ait. Giant St. John's-Wort.
*Hypericum ascyron* of Am. authors, not L. Map 5, Fig. 1.

Robust erect perennial herbs, 6–16 (–20) dm tall; branches 4-angled; root-crown woody. Leaves ovate-oblong to lanceolate, the larger 5.5–9.6 (–11) cm long, 2.5–4 (–5) cm wide, acute or obtuse, with sessile clasping bases. Stamens numerous (over 150), 5-delphous; anthers versatile. Sepals ovate-triangular, 6.5–8 mm long. *Petals broadly obovate, persistent, 1.8–2.8 cm long.* Styles 5, 6–10 mm long, halfway united, divergent above; stigmas capitate. Capsules conic-ovoid, completely 5-celled, septicidally dehiscent, 15–25 mm long, 8–15 mm wide (Fig. 1). Seeds brown, lustrous, reticulate, 1.1–1.4 mm long, the raphe keeled. N = 9 (Nielsen 1924).

Quebec to Minn., south to Penn., Ind., Mo. and Kansas, in Wisconsin in wet and open habitats as gravelly river banks, sphagnous sedge meadows, mesic forest edges and drainage ditches, as in low wet muck meadow near Mauston with *Carex, Polygonum, Physostegia virginiana,* or in a weedy floodplain prairie along Pine River, Richland Co., with *Napaea dioica, Artemisia serrata, Silphium perfoliatum, Urtica sp., (Nee 1453,* WIS). Flowering late June to mid-September, fruiting mid-July to early October.

It is closely related to the true *Hypericum ascyron* L. of eastern Asia (E Siberia, Japan & China).

6. HYPERICUM PERFORATUM L. Common St. John's-Wort, Klamath wed. Map 6, Fig. 1.

Erect branching perennials from a subligneous crown with short shallow rootstocks and deep branching taproot. Stems 2-angled, 4–6.5 (–8) dm tall, *with numerous sterile basal shoots and leaf axillary decussate branchlets.* Leaves linear-oblong to elliptic, pellucid-dotted, obtuse, sessile, 5-nerved, commonly 12–36 mm long, 3–9 mm wide, reduced on axillary branchlets. Cymes paniculate, flat-topped; flowers numerous, 15–30 mm across. Sepals linear-lanceolate, acuminate, 4–7 mm long. *Petals orange-yellow, black-spotted near margins, 9–14 mm long. Petals and stamens persistent.* Stamens (45)–50–(60). Ovary 3-loculate; styles 3, divergent, 3–4.5 mm long; stigmas capitate. Capsules completely 3-celled (Fig. 1) oblong-elliptic to conic, veiny, 4–7 mm long, 3–5 mm wide. Seeds blackish brown, lustrous, reticulate, 0.8–1.2 mm long. N =

16, 2N = 32 (Hoar & Haertl 1932, Mulligan 1957, Robson & Adams 1968).

A noxious world-wide weed, native to N Africa, W Asia and Europe (Hegi 1925), naturalized in E and W North America, in Wisconsin a common weed in open, sandy, poor or worn soils, chiefly on roadsides, railroads, neglected fields, beaches, sand plains, blowouts and barrens, occurring with such disturbance indicators as *Comptonia peregrina, Hieracium aurantiacum, Ambrosia artemisiifolia, Daucus carota, Asclepias syriaca* and *Euphorbia esula.* Flowering from early June to early September, fruiting from late June to early October.

This adventive is especially troublesome in the Klamath River Basin (N Calif. & S Ore.). The stem's numerous resin canals contain hypericin, which is poisonous to livestock, but probably not fatal (Marsh & Clawson 1930, Kingsbury 1964). Eradication is difficult due to deep perennial roots, vigorous leafy basal offshoots and numerous, highly viable, genetically similar seeds, megasporogenesis being 97% apomitic (pseudogamous) (Tutin *et al.* 1968).

The name "St. John's Wort" is derived from the belief that the plant's dew precented sore eyes on St. John's eve, June 24, when huge ceremonial bonfires of this plant blazed throughout Europe. Bouquets then gathered were hung in windows as talismans against thunder, witches and other misfortune, while in Switzerland, young women put them under their pillows believing they would marry the men of their dreams. The dark-red pellucid leaf dots supposedly appeared on August 29, the day John the Baptist was beheaded (Hegi 1925, Clohisy 1930).

7. HYPERICUM PUNCTATUM Lam. Map 7.

Sparingly branched perennial with terete stems 4–10 (–12) dm tall. Leaves oblong-elliptic to lanceolate, the larger 3–7 cm long, 1–2 (–3) cm wide, dark punctate, blunt or retuse, 5- to 7-nerved; base clasping to attenuate. Corymbs compact; flowers 6–10 mm wide, short-pedicellate. *Sepals ovate-oblong, broadly acute, black-spotted and -lined, 3.8–6.8 mm long.* Stamens (27)–35–(40), weakly 3-delphous; anthers black-dotted. Ovary 3-locular; styles 3, free, 1.5–2.5 mm long; stigmas capitate. *Capsules 3-celled, subglobose to ovoid, 3.8–4.6 mm long, 3.6–4.2 mm wide, with elongate oil vesicles.* Seeds yellowish-brown, 0.6–0.7 mm long. N = 8, 2N = ring of 16 at anaphase (Hoar 1931, Robson & Adams 1968).

Eastern North America, from Maine to Minn., south to Fla. & Texas, in Wisconsin along forest edges, open wooded slopes, floodplain thickets, wet prairies, abandoned fields and roadsides: in low, mesic woods (near Tomah, Monroe Co.), with *Trillium cernuum,* *Uvularia sessiliifolia, Mitchella repens, Aster macrophyllus* and in bottomland woods on floodplain terraces (Trempealeau Co.), with *Quercus bicolor, Fraxinus spp., Betula nigra, Carex spp.* Though widely distributed, it is never abundant, this possibly related to the *"Oenothera-like"* ring chromosome segregation pattern, producing various isolated and inbred populations. Flowering from early July to early September, fruiting August to mid-September.

8. HYPERICUM MUTILUM L. Map 8, Fig. 5.
*H. mutilum* var. *longifolium* Bob. Keller, in *Bull. Herb. Boiss.* (ser. 2) 8: 184. 1908, *ex char.* [Type: Visconsin (sic!), *Kumelien* (sic!), *113*.]

The variety *longifolium* is apparently nothing but a long-leaved plant, not taxonomically recognized here. There are no *Hypericum* specimens in the very fragmntary Kumlien Herbarium deposited at WIS. The type is presumably in G.

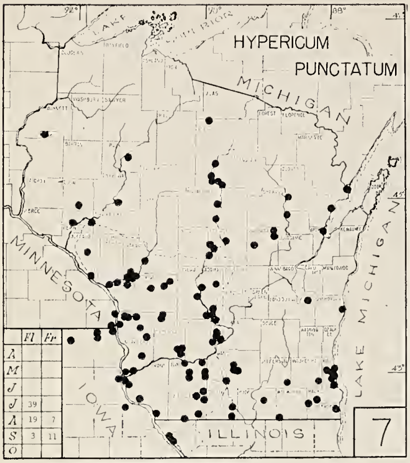
Erect slender annuals or perennials (1–) 2–6 dm tall, branched diffusely above, the leafy-bracted bases decumbent. Leaves deltoid-ovate to oblong-lanceolate, obtuse, cordate-clasping, 3- to 5-nerved, minutely punctate, the larger 1–2 (–3) cm long, (3–) 8–13 mm wide. *Inflorescences lax and diffuse, poorly defined, leafy-bracted, the pedicels very slender, unequal, the angle between a pair of lateral peduncles ca. 70–105°. Uppermost bracts setaceous, 1.5–3.8 mm long* (Fig. 5). Flowers 2.6–4.5 mm wide. Sepals linear-oblong, acute, 2–4 mm long, equaling capsule. Petals 2–3 mm long. Stamens 5–10. Ovary 1-locular, the styles 0.5–0.9 mm long; stigmas capitate. Capsules ovoid to ellipsoid, greenish at maturity, 2–4 (–5) mm long, 1.6–2.4 mm wide. Seeds yellow, striate, minutely rugose, 0.45–0.55 mm long. N = 8 (Hoar & Haertl 1932).

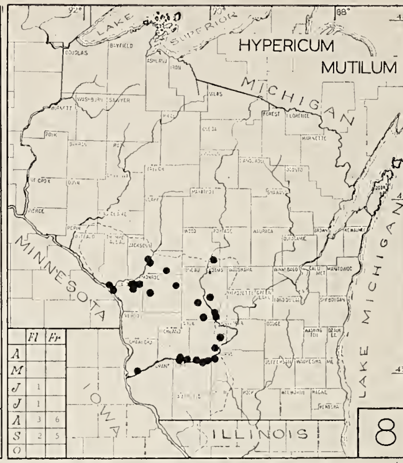
Eastern N. America, from Minn. to Newfoundland, south to Fla. and Texas, in Wisconsin mostly in the lower Wisconsin River valley and Driftless Area, on sandstone cliff ledges, sandy creek margins and river flats, moist sandy or black muck lowland meadows, swales and desiccated temporary pools, rarely in moist woods or abandoned fields. Flowering July to September; fruiting early August to late September.

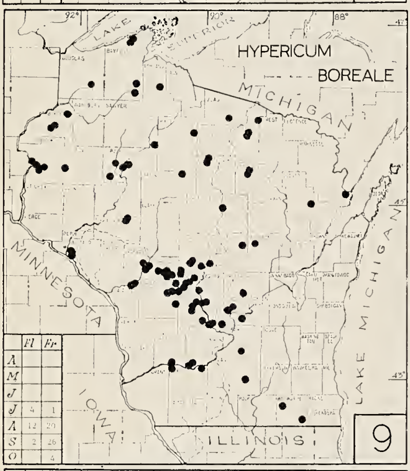
A highly variable species with populations in Brazil, Hawaii and Europe.

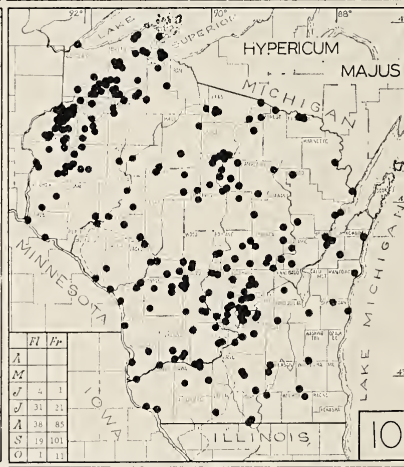
9. HYPERICUM BOREALE (Britton) Bicknell Map 9, Figs. 1, 5, 6.
Northern St. John's–Wort.

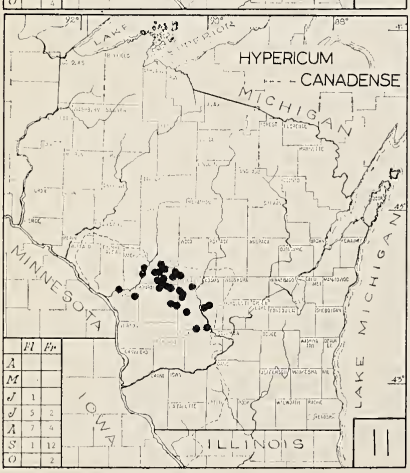
Slender, rhizomatous and decumbent, branched perennial herbs with terete to obscurely 4-angled stems 1–3 (–4 in tall grass) dm tall, the bases often with leafy short-shoots. Leaves ovate to ellip-


HYPERICUM PUNCTATUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 39
A 19 7
S 3 11
O
7


HYPERICUM MUTILUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 1
J 1
A 3 6
S 2 5
O
8


HYPERICUM BOREALE
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 4 1
A 12 20
S 2 26
O 4
9


HYPERICUM MAJUS
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 4 1
J 31 21
A 38 85
S 19 101
O 1 11
10


HYPERICUM CANADENSE
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J 1
J 5 2
A 7 4
S 1 12
O 2
11

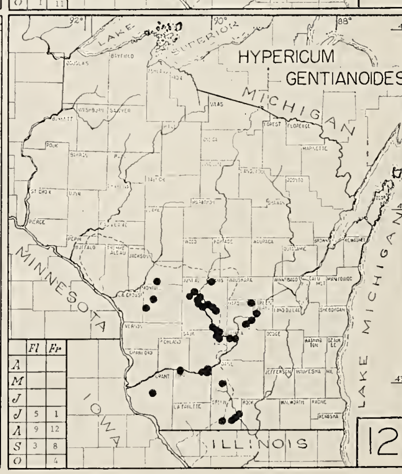

HYPERICUM GENTIANOIDES
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 5 1
A 9 12
S 3 8
O 4
12


FIGURE 5. Line-drawings of several Wisconsin small-flowered *Hypericum* (Sect. *Brathys*), (From N. C. Fassett, 1960, p. 246, with permission).

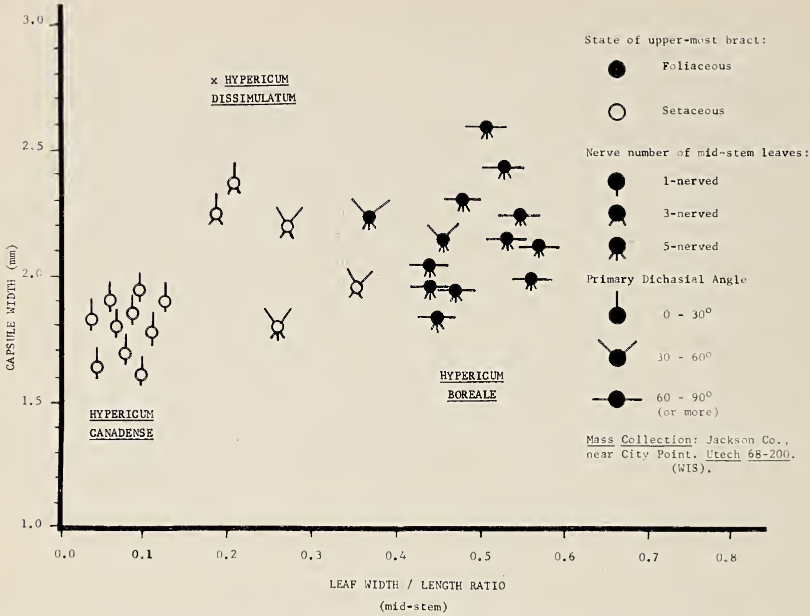



FIGURE 6. Scatter diagram of mass collection *(Utech 68–200)* clearly showing intermediates (x *Hypericum dissimulatum* Bicknell) between *H. boreale* and *H. canadense.*

tic, if aquatic suborbicular, obtuse to rounded, obscurely punctate, sessile, 3- to 5-nerved, the larger 8–15 (–25) mm long, 4–8 mm wide. *Inflorescence lax and diffuse, leafy-bracted, the angle between a pair of lateral peduncles ca. 85–110°. Uppermost bracts foliaceous, resembling small leaves, 2.5–4 mm long* (Fig. 5). Flowers 3.4–5 mm wide. *Sepals oblong-elliptic, 2.7–3.8 mm long, equaling petals but shorter than capsule.* Stamens 5–10. Ovary 1-locular; styles 3; stigmas capitate. Capsules ovoid to ellipsoid, 3–5 mm long, 1.5–3 mm wide. Seeds light brown, 0.6–0.75 mm long. N = 8 (Hoar and Haertl 1932).

Northeastern N. America, from Minn. to Newfoundland, south to N.Y., W Penna., N Ind. and E Iowa (disjunct to Tenn.?—Sharp *et. al.* 1960), apparently limited to glaciated areas, in Wisconsin common in moist acid habitats as rocky or sandy shores, mud flats, acid tamarack bogs, alluvial marches, floating sedge mats, damp swales and sandy fields, as Sphagnum—Cyperaceae wet meadows (Black River Falls, Jackson Co.) with scattered *Larix, Drosera intermedia, Eriophorum virginicum, Muhlenbergia uniflora, Spiraea tomentosa* and *Juncus spp.* Flowering mid-July to September, fruiting late July to early October.

Hybridizes in Wisconsin with *H. canadense* (pp. 26, 29–30; Fig. 6), these hybrids, called x. *H. dissimulatum* Bicknell (1913) and reported here for the first time for Wisconsin, represent the western-most station of this supposedly "unusually constant and recurring hybrid" (Fernald 1950).

9a. HYPERICUM BOREALE forma CALLITRICHOIDES Fassett

A sterile, submerged aquatic form with simple, flexible stems and small, 3-nerved leaves lacking pellucid-punctate dots, occasional in northern and central Wisconsin lakes (Adams, Bayfield, Jackson, Juneau, Langlade, Monroe and Oconto Counties) and grading shoreward into normal plants.

10. HYPERICUM MAJUS (Gray) Britton Map 10, Fig. 5.
Common St. John's–Wort.

Erect stout perennial with solitary or tufted stems, 1–4 (–6) dm tall, often with small leafy basal offshoots. *Leaves commonly ascending, lanceolate or elliptic to oblanceolate or broadly acute to narrowly oblong, acute to obtuse, subcordate-clasping, 5- to 7-nerved, the larger 1.5–4.4 cm long, 5–12 mm wide. Inflorescences well-defined, often compact, the angle between a pair of lateral peduncles only 25–50°*; bracts setaceous-subulate, 1-nerved, 1.8–3.8 mm long (Fig. 5). Sepals lance-acuminate, 4.2–6.5 mm long. Petals equaling sepals; stamens 15–20, weakly 5-delphous. Ovary 1-locular; styles 3, 1–1.5 mm long; stigmas capitate. Capsules narrowly ovoid to ellipsoid, obtuse, reddish-purple at maturity, 5–7.8 mm long, 2–4 mm wide. Seeds pale brown, lustrous, reticulate, 0.6–0.7 mm long. N = 8 (Hoar & Haertl 1932).

Western and northeastern N. America, from British Columbia, E Wash. and Colorado to Quebec and Penna. (2 disjunct stations in Tenn.—Gillespie 1959; Sharp *et. al.* 1960), frequent throughout Wisconsin, chiefly in open, moist, gravelly, sandy or sometimes muddy habitats, as shores and beaches, low wet prairies, shrub-carrs, black spruce and tammarack bogs, *Carex* swales, moist talus and cracks of sandstone cliffs, spring and marly marsh margins, and weedy in pastures, sandy fields, roadsides and cranberry bogs. Flowering late June through September; fruiting earliest July to mid-October.

Extremely variable in Wisconsin, especially as to size, hybridizing not infrequently with *H. boreale* and *H. canadense* (cf. page 32).

11. HYPERICUM CANADENSE L. Canadian St. John's-Wort.
Map 11, Figs. 5, 6.

Slender erect annual or perennial herbs, 1–3 (–4.6) dm tall; stems unbranched except above, sharply 4-angled. *Leaves linear-oblanceolate to linear, obtuse, sessile-attenuate, 1- or weakly 3-nerved, 6–25 (–40) mm long, 1–3 mm wide. Inflorescences well-defined but open, the angle between a pair of lateral peduncles ca. 30–65°; bracts subulate, 2–2.7 mm long* (Fig. 5). Flowers 4–7 mm wide. Sepals linear-lanceolate, acuminate, 2.5–4.4 mm long. Petals 2–5 mm long; stamens 5–10. Ovary 1-locular; styles 3, 0.7–1.0 mm long; stigmas capitate. *Capsules ovoid to conic, acute, reddish-purple at maturity, 3–5.2 mm long, 1.3–2.6 mm wide.* Seeds light yellow, reticulate, 0.5–0.6 mm long. N = 8 (Hoar & Haertl 1932).

Eastern N. America, from Ga. to Ala. to Newfoundland, west to Iowa, the Black Hills and SE Manitoba, in Wisconsin mostly in the northern Driftless Area, in sandy-peaty roadsides, along railroads, wet sandy meadows, swales and marshes, moist sandstone ledges, in *Sphagnum* of Ericaceae–Cyperaceae bog (near City Point, Jackson Co.) with *Ledum groenlandicum, Chamaedaphne calyculata, Larix laricina, Picea mariana, Rhynchospora alba, Carex oligosperma, Solidago uliginosa, Eriophorum virginicum, Betula pumila* and *Aronia melanocarpa.* Flowering early June to late August, fruiting mid-July to early October.

Of the 30 collections from Wisconsin, only 6 date from before 1930 and these from only 2 stations (McLaughlin 1931). The recent building of roads and flowages may have made the region's glacial lake beds more receptive to botanizing and to the establishment of pioneers such as *H. canadense* and its hybrids with*H. boreale* and *H. majus* (cf. below for citations).

## HYBRIDIZATION IN *HYPERICUM* SECT. *BRATHYS* IN WISCONSIN:

Four Wisconsin members of section *Brathys (mutilum, boreale, canadense, majus)* are morphologically and ecologically similar, often two or three growing together in the same station in Wisconsin's Driftless Area, especially in the beds of glacial lakes (Maps 8–11), where all but the uncommon *H. mutilum* tend to hybridize. Hybrids are especially common in sandy, moist, flat, acid habitats. This region, at least post-glacially, has been a very suitable "open habitat" for the establishment of many Coastal Plain species (McLaughlin 1932, Peattie 1922), such as *Xyris spp., Bartonia virginica, Gratiola lutea, Drosera spp., Rhynchospora spp., Helenium flexuosum* (= *H. nudiflorum*) (Mickelson & Iltis 1966), and the microevolution of others (Johnson & Iltis 1963, pp. 267–8).

Potential for long range dispersal in this small-seeded group is probably very great: all four species occur in Europe, probably introduced by birds or in fodder (Heine 1962, Tutin *et al.* 1968). *Hypericum mutilum* L. also occurs in Brazil (Keller 1908) and Hawaii (Doty & Mueller–Dombois 1966).

Hybrids between these taxa are very common, both putative $F_1$'s and backcrosses, which is one reason for the great taxonomic difficulties in this group. In addition, dwarf forms of each species are common and especially difficult to distinguish. Hybrids, being intermediate morphologically, are only briefly described below.

12. HYPERICUM BOREALE (Britton) Bicknell x H. CANADENSE L.
HYPERICUM x DISSIMULATUM Bicknell Fig. 6.

Similar to *H. canadense,* but more lax and branched, with smaller, lanceolate-elliptic leaves and shorter, reddish-green capsules (Bicknell 1913). *H. canadense* is evidently a southern species, which post-glacially overlapped the northern *H. boreale.* The latter species, confined as it is to glaciated territory, has a most anomalous distribution and its Pleistocene survival or origins is not clear. It may represent a "stabilized hybrid" between *H. mutilum,* a wide-ranging eastern species, and *H. majus,* a western element, which is now limited to glaciated territory of northeastern North America. Jackson Co.: Indian Creek, sand flats ca. 1 mi W of City Point, 22 Sept. 1968, *Utech 68–200* (WIS), a mass collection, represented by the hybrid analysis scatter diagram of Fig. 6.

12b. HYPERICUM BOREALE A*Britton*Q *Bicknell* x H. MAJUS (Gray) Britton

Hybrids of these dissimilar species are erect but shorter than *H. majus* and with diffuse-branched inflorescences and short, elliptic-ovoid capsules like *H. boreale. H. majus* is clearly a cordilleran (Pacific Northwest ?) element which, like so many other taxa, invaded NE N. America post-glacially to hybridized with an easttern vicarious element (Mason & Iltis 1965), in this case *H. boreale* (see above). Barron Co.: mud flat, edge of small lake, ca. 2 mi N of Turtle Lake, 21 Aug. 1956, *Iltis et al. 7280 B* (WIS). Juneau Co.: Sprague Flowage (T. 19 N., R. 2 E., Sec. 1), dry sandy-peaty, sedge-grass marsh, 23 Sept. 1967, *Iltis et al. 25,851 pro parte,* (WIS—mass collection).

12c. HYPERICUM MAJUS (Gray) Britton x H. CANADENSE L.

Two very similar species form hybrids of shorter stature than *H. majus* and with leaves of intermediate shape, vein number and width; sepals and capsules also intermediary. The parental species represent a vicarious pair (W. and E. North America) which postglacially became sympatric in glaciated northasteen North America, where they hybridize freely. Clark Co.: Trow, moist ground, 15 July 1915, *Goessl 1303* (MIL). Jackson Co.: temporary sandy margined pool, (T. 20 N., R. 1 W., Sec. 22), 22 Sept. 1968, *Utech 68–300* (WIS—mass collection). Lincoln Co.: Wilson twp. (T. 35 N., R. 5 E., Sec. 4), ditch, 11 Sept. 1949, *Seymour 10,968* (WIS). Monroe Co.: NW of Warrens, railroad ditch, 15 Sept. 1935, *Fassett 17.686* (WIS). Oneida Co.: Rhinelander, Silver Bass Lake, on shore stump, 29 Aug. 1945, *Hein 34* (WIS). Wood Co.: swale and desiccated pond, ¾ mi W of Dexterville, 22 Sept. 1968, *Utech 68–100* (WIS—mass collection); Birch Bluff, S of City Point. (T 21 N., R. 2 E., Sec. 19), 31 May 1958, *Iltis & Koeppen 12,271a* (WIS).

13. HYPERICUM GENTIANOIDES (L.) B.S.P. Orange-grass, Pine Weed Map 13.

Erect, strict, very slender annual 1–2.5 dm tall; stems, 4-angled, punctate, with numerous ascending filiform branches. *Leaves subulate, appressed, acute, sessile, 1.5–2.8 mm long, 0.5 mm wide.* Inflorescence racemose; flowers minute, nearly sessile. Sepals linear–lanceolate, 1.6–2.2 mm long. Petals pale yellow, 2.8–3.6 mm long. Stamens.

5–10. Ovary 1–locular; styles 3, separate, 0.6–0.9 mm long; stigmas capitate. Capsules slenderly conic to lance-subulate, 4–4.8 mm long, 0.8–1.5 mm wide. Seeds yellowish brown, obscurely areolate, 0.3–0.4 mm long. N = 12 (Hoar & Haertl 1932).

Eastern United States (Maine to SW Ontario & Minn., south to Fla. and Texas), in open, dry, rock or acid outcrops, sand barrens and sand prairies in southern Wisconsin. At maturity, the entire plant turns copper or brick-color, hence called "orange grass." Flowering mid-June to mid-September; fruiting late June to late September.

2. TRIADTNUM Raf. MARSH ST. JOHN'S–WORT.

Erect glabrous perennial, stoleniferous herbs with simple, opposite, entire, often pellucid–punctuate leaves. Flowers 5-merous, regular, perfect, hypogynous, small, in axillary and terminal cymules. *Petals oblong, mauve or pinkish to greenish. Stamens 9, the filaments connate into 3 fascicles (3-delphous) and alternating with 3 conspicuous hypogynous glands.* Ovary superior, completely 3-loculate; styles 3, separate, divergent; stigmas capitate. Capsules septicidal, 3-carpellate. Seeds small, short-cylindric, reticulate.

*Triadenum* has 4 species in eastern North America and 1 in Asia (Japan, Korea, Manchuria, Ussuri & Amur, *Triadenum japonicum*

(Bl.) Makino; Ohwi (1965)), which are often considered as section *Elodea* (Juss.) Choisy [non section *Elodes* (Adans.) Koch] of *Hypericum.* Segregated by Rafinesque *(Fl. Tell.* 3: 78. 1836) on its pink petals and 3 hypogynous glands, it differs in addition (Holm 1906) by petals imbricate not convolute in bud, 9 stamens strongly 3-delphous into 3 fascicles alternating with 3 hypogynous glands, prominent veins repeatedly branched laterally to the blade margins, and tuberous subterranean stolons with paired scale-like leaves usually with one, rather than many adventitous roots above each bud. Chromosome counts of N = 19 (Hoar & Haertl 1932) do not suggest a relationship to *Hypericum,* but rather to *Cratoxylon,* a pan-tropical tree genus.

### Key to Species

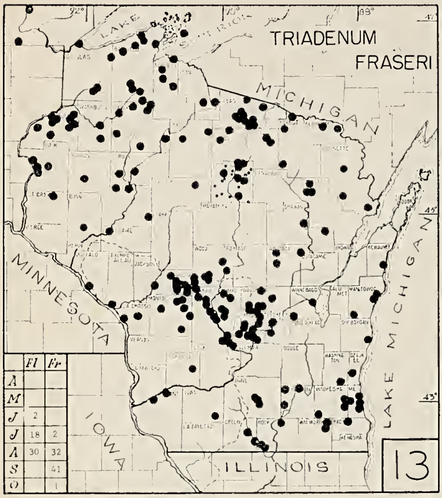
A. Sepals elliptic to spatulate, summit obtuse to rounded, 2.8–4.8 mm long; fruiting styles 0.6–1.5 mm long; common Wisconsin marsh and bog plant. ______________1. *T. FRASERI.*

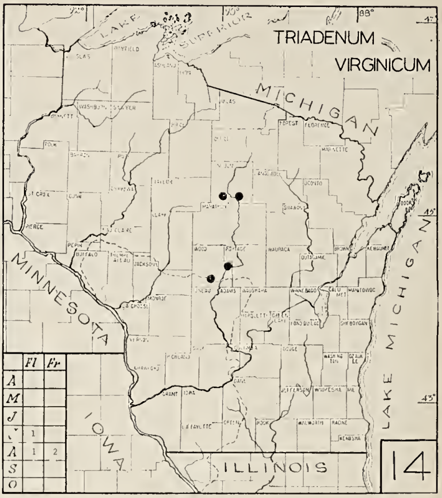
AA. Sepals oblong to lanceolate, summit acuminate to acute, 4.3–8 mm long; fruiting styles 2.1–3.6 mm long; rare, central Wisconsin. ____________________________2. *T. VIRGINICUM*

1. Triadenum fraseri (Spach) Gl. Marsh St. John's–Wort.
*Hypericum Fraseri* Spach May 13, Fig. 7.
*Hypericum virginicum* L. var. *Fraseri* (Spach) Fernald

Erect, glabrous, stoloniferous perennial herbs 2–6 dm tall, *mostly reddish-purple in age; internodes terete, without decurrent lines.* Leaves ovate-cordate to elliptic, 2.3–6.5 cm long, 1–3 cm wide, emarginate to obtuse, sessile and cordate-clasping. Cymules numerous, terminal and axillary, few-flowered. *Sepals 3–4.8 (–5.2) mm long, elliptic-oblong to spatulate, obtuse to rounded.* Petals mauve or pink, oblong, 5.4–8 mm long. Stamens 9, 3-delphous, persistent; hypogynous glands 3, oval, orange. Ovary 3-celled; *styles 3, free, 0.6–1.5 mm long at maturity;* stigmas 3, capitate. Capsules conic-ovoid, 7–10 mm long, 3–5 mm wide, abruptly narrowed to styles. Seeds cylindric, dark brown, reticulate, 0.9–1.1 mm long.

Native of northeast North America (NE Nebraska & SW Manitoba to Newfoundland & Labrador, south to Conn., Penna., N. Y., the mountains of W. Va., N. Ind. and Iowa), abundant in Wisconsin's wet acid habitats, as tamarack-black spruce- leather-leaf-sphagnum bogs, sedge meadows, shrub carrs, sloughs and peaty marshes: in Comstock Marsh, Marquette Co., an extensive quaking bog with abundant *Drosera rotundifolia, Sarracenia purpurea* and patches of *Phragmites communis, (Nee 1345,* WIS); along Turtle Lake, Marquette Co., with *Carex spp., Potentilla fruticosa* and *P.*



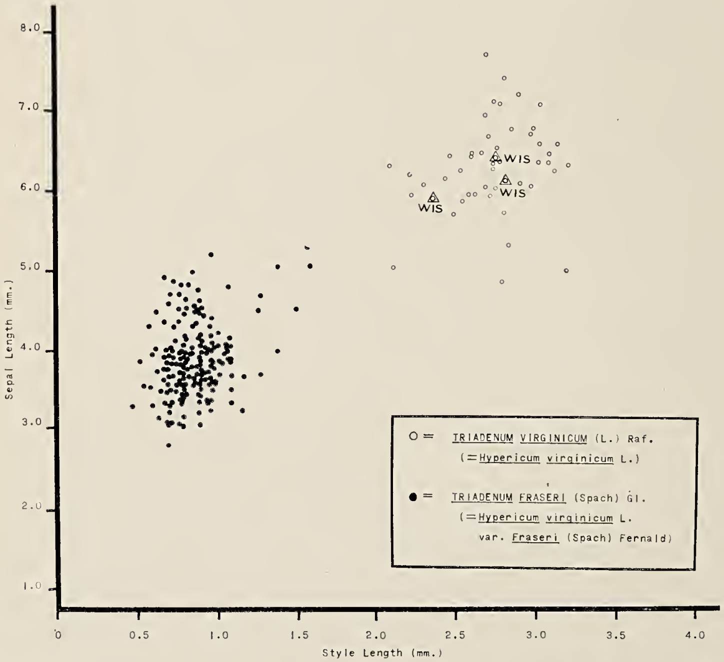




FIGURE 7. Scatter diagram comparing sepal and style length of Wisconsin *Triadenum fraseri* and Wisconsin and non-Wisconsin *T. virginicum.*

*palustris, Chamaedaphne calyculata,* sedge meadow and adjoining thickets; in Vilas Co., along Lac Vieux Desert, in shallow acid waters of slow stream draining sphagnum bog with *Larix laricina, Picea mariana, Ledum groenlandicum, Sarracenia purpurea, Calopogon pulchellus, Nuphar rubrodiscum, Utricularia, Hippurus,* etc., *(Iltis 18,149,* WIS). Flowering from early July to latest August, fruiting mid-July till late September.

2. TRIADENUM VIRGINICUM (L.) Raf. Map 14, Fig. 7.
*Hypericum virginicum* L.

Similar to above, but *sepals oblong–lanceolate, acuminate to acute, 4.3–8 mm long.* Petals obovate, 6.3–9.8 mm long. Ovary 3-celled; *styles 3, divergent, 2.1–3.6 mm long;* stigmas capitate. Capsules ovoid-cylindric, 7.6–13.4 mm long, 3–5 mm wide, gradually tapering to styles. Seeds cylindric, dark brown, reticulate, 0.9–1.1 mm long. N = 19 (Hoar & Haertl 1932).

An Atlantic coastal plain element, *Triadenum virginicum* extends inland to S. N. Y., S. Ontario, and disjunct to N. Ind. and central Wisconsin: Lincoln Co.: Merrill, dry sandy field along Prairie River with *Comptonia peregrina, Hieracium aurantiacum* and *Robinia pseudoacacia,* 19 Aug. 1956, *Iwen 419* (WIS). Bagga Marsh, among cranberry beds along Copper River, 25 Aug. 1957, *Schlising & Peroutky 660* (WIS). Wood Co.: burned over sphagnum bog, 5 mi NW of Babcock, 20 Aug. 1937, *Catenhusen s.n.* (WIS). Biron township, Huffman farm, 16 July 1953, *Dana s.n.* (WIS). It is noteworthy that all collections are recent, since 1937.

In Wisconsin, *T. Fraseri* is quite common and easily separatable from both Wisconsin and non-Wisconsin *T. virginicum* (Fig. 7). Taxonomically and morphologically, Gleason (1947) distinguished them on sepal and style length. Fernald (1936), using var. *Fraseri* to indicate this difference, notes that, where sympatric, they usually show clear segregation into a southern or lowland and a northern or upland series.

## BIBLIOGRAPHY

ADAMS, P. 1959a. The status of *Hypericum prolificum. Rhodora* 61:250–251.

————. 1959b. *The taxonomy of Hypericum Section Myriandra (Hypericaceae).* Ph.D. Dissertation, Harvard Univ., Cambridge, Mass.

————. 1962. Studies in the Guttiferae. I. A. synopsis of *Hypericum* Section *Myriandra.* Gray Herb. No. CLXXXIX, 1–50. Harvard Univ., Cambridge, Mass.

BARTHOLOMEW, E. A. 1949. The Family Hypericaceae in West Virginia. *Castanea* 14:102–109.

BICKNELL, E. P. 1895. *Hypericum boreale* (Britton) and related species. *Bull. Torr. Bot. Club* 22(5):211–215.

————. 1913. The ferns and flowering plants of Nantucket—XI. *Bull. Terr. Bot. Club* 40(11):610–611.

Clohisy, M. 1930. *Wisconsin Wild Flowers*. Milwaukee. 122 pp.

Curtis, J. T. 1959. *The Vegetation of Wisconsin*. Univ. of Wisconsin Press, Madison.

Darlington, C. D. and A. P. Wylie. 1955. *Chromosome Atlas of Flowering Plants*. George Allen & Unwin, Ltd., London.

Doty, M. S. and D. Mueller-Dombois. 1966. *Atlas for Bioecology in Hawaii Volcanoes National Park*. Hawaii Bot. Science Paper No. 2, Univ. of Hawaii, 507 pp.

Fassett, N. C. 1939. Notes from the Herbarium of the University of Wisconsin—XVII. *Elatine* and other aquatics. *Rhodora* 41:376.

————. 1960. *A Manual of Aquatic Plants*, 2nd ed. Univ. of Wisconsin Press, Madison.

Fernald, M. L. 1936. Plants from the Outer Coastal Plain of Virginia. *Rhodora* 44:434–435.

————. 1950. *Gray's Manual of Botany*, ed. 8. New York: American Book Co.

Gillespie, J. 1959. The Hyperiaceae of Tennessee. *Castanea* 24:24–32.

Gleason, H. A. 1947. Notes on some American plants. *Phytologia* 2:288–291.

———— and A. Cronquist. 1963. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. New York: von Nostrand Co.

Guire, K. E. and E. Voss. 1963. Distribution of distinctive shoreline plants of the Great Lakes region. *Mich. Bot.* 2:99–114.

Hartley, T. G. 1962. *The Flora of the Driftless Area*. Ph.D. Dissertation, Univ. of Iowa, Iowa City.

Hegi, G. 1925. *Illustrierte Flora von Mittel-Europa*. München: J. F. Lehmann Verlag, Vol. 5, I.

Heine, H. 1962. Les Millepertuis américains dans la flore d'Europe. *Bauhinia* 2(1):71–78.

Hoar, C. S. 1931. Meiosis in *Hypericum punctatum*. *Bot. Gaz.* 92:197–204.

———— and Haertl. 1932. Meiosis in the genus *Hypericum*. *Bot. Gaz.* 93: 197–204.

Holm, T. 1906. Art. XXXVI. *Triadenum virginicum* (L.) Rafin. A morphological and anatomical study. *Amer. J. Sci.* IV, Vol. XVI, No. 95:369–376.

Johnson, M. F., and H. H. Iltis. 1963. Preliminary Reports on the Flora of Wisconsin. No. 48. Compositae I—Composite Family I (Tribes Eupatorieae, Vernonieae, Cynarieae and Cichorieae). *Trans. Wis. Acad. Sci. Arts and Letters*, Vol. 52:255–342.

Jones, G. N. and G. D. Fuller. 1955. *Vascular Plants of Illinois*. Univ. of Illinois Press, Urbana.

Keller, R. 1908. Zur Kenntnis der Sectio Brathys des Genus *Hypericum*. *Bull. de l'herbier Boissier* ser. 2, 8:175–191.

Kingsbury, J. M. 1964. *Poisonous plants of the United States and Canada*. Englewood Cliffs: Prentice-Hall, Inc. 626 pp.

Lakela, O. 1965. *A Flora of Northeastern Minnesota*. Univ. of Minnesota Press, Minneapolis.

Marsh, C. D. and A. B. Clawson. 1930. Toxic effect of St. Johnswort *(Hypericum perforatum)* in cattle and sheep. *U.S.D.A. Tech. Bull.* No. 202: 1–23.

Mason, C. T. and H. H. Iltis. 1965. Preliminary Reports on the Flora of Wisconsin. No. 53. Gentianaceae and Menyanthaceae—Gentian and Buckbean Families. *Trans. Wis. Acad. Sci. Arts and Letters*, Vol. 54:295–329.

McLaughlin, W. T. 1931. Preliminary Reports on the Flora of Wisconsin. No. 14. Hypericaceae. *Trans. Wis. Acad. Sci. Arts and Letters,* Vol. 26:281–288.

————. 1932. Atlantic Coastal Plain Plants in the Sand Barrens of Northwestern Wisconsin. *Ecol. Mono.* 2:335–383.

Mickelson, C. J. and H. H. Iltis. 1966. Preliminary Reports on the Flora of Wisconsin. No. 55. Compositae IV—Composite Family IV (Tribe Helenieae and Anthemideae). *Trans. Wis. Acad. Sci. Arts and Letters,* Vol. 55: 197–222.

Mulligan, G. A. 1957. Chromosome numbers of Canadian weeds. I. *Can. J. Bot.* 35:779–789.

Nielsen, N. 1924. Chromosome numbers in the genus *Hypericum. Hereditas* 5:378–382.

Ohwi, J. 1965. *Flora of Japan.* Smithsonian Institution, Washington. 1067 pp.

Peattie, D. C. 1922. The Atlantic coastal plain element in the flora of the Great Lakes. *Rhodora* 24:57–88.

Robson, N. K. B. and P. Adams. 1968. Chromosome numbers in *Hypericum* and related genera. *Brittonia* 20:95–106.

Seymour, F. C. 1960. *Flora of Lincoln County Wisconsin.* P. F. Nolan, Taunton, Mass.

Sharp, A. J., R. E. Shanks, H. L. Sherman and D. H. Norris. 1960. *A Preliminary Checklist of Dicots of Tennessee.* Univ. of Tennessee, Knoxville. 114 pp. (ms).

Sorensen, P. D. 1966. *The Flora of the old bed of Glacial Lake Wisconsin and the adjacent terminal moraine.* MS thesis, Univ. of Iowa, Iowa City. (ms).

Svenson, H K. 1940. Plants of Southern United States. III. Woody species of *Hypericum. Rhodora* 42:8–19.

Swezey, G. D. 1883. Catalogue of the phaenogamous and vascular cryptogamous plants of Wisconsin. In Chamberlain's: *Geology of Wisconsin,* Vol. 1: 376–395.

Tutin, T. G., *et al.* 1968. *Flora Europaea.* Vol. 2. Rosaceae to Umbelliferae. London: Cambridge Univ. Press. 455 pp.

# PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 62. COMPOSITAE VI. COMPOSITE FAMILY VI. THE GENUS AMBROSIA—THE RAGWEEDS[1,2]

*Willard W. Payne*

*Ambrosia* (including *Franseria*) is one of several genera of the Compositae which are distinguished by exceptional modification for wind pollination or anemophily. All of these genera *(Iva, Euphrosyne, Dicorea, Hymenoclea* and *Xanthium,* in addition to *Ambrosia)* are characterized by similarities in vegetative morphology, chemistry, cytology, and pollen and inflorescence structure that suggest evolutionary affinity. They have been variously classified as a distinct family, the Ambrosiaceae (Small, 1913; Rydberg, 1922), as a distinct tribe, the Ambrosieae (Cassini, 1834; Delpino, 1871; Benson, 1957; Payne, Raven and Kyhos, 1964), and as a subtribe, Ambrosiineae, of the tribe Heliantheae (Bentham, 1873; Fernald, 1950; Cronquist, 1952; Keck, 1959; Solbrig, 1963). There is growing evidence to support the derivation of this evolutionary group from helianthoid progenitors, of particular interest in this respect being the pollen wall ultrastructural studies of Larson and Skvarla (1966). At the same time, however, these plants have certain chemical and structural attributes more characteristic of the Anthemideae (Payne, 1963; Miller, 1967), and it is possible that they have been derived from a progenitor group intermediate between the Anthemideae and Heliantheae. Because of this, and taking into account the array of morphological features common to all of the genera, I believe they are best treated, for the present at least, as members of the tribe Ambrosieae.

*Ambrosia* is distinguished from other closely related genera of the Ambrosieae by capitulescences of wholly staminate and wholly pistillate capitula, the staminate with saucer-shaped, lobed involucres of connate phyllaries, the pistillate with hard, spiny, burlike fruiting involucres. The usual arrangement of head types is that in which staminate capitula are produced in racemose or

---

[1] This study has been supported in part by a grant (GB 5558) from the National Science Foundation.

[2] I wish to gratefully acknowledge the assistance and advice of Dr. Hugh Iltis, Michael Nee and Roger Thibault of the Herbarium of the University of Wisconsin, Madison. Specimens which were examined for this study were kindly made available by the curators of the following herbaria: G, ILL, ISC, KY, MICH, MIL, MSC, NY, SMU, TENN, UWM, WIS.

spicate groups at the tips of the main stems and branches, while pistillate capitula are clustered in the axils of leaves and bracts below the staminate racemes (see Figs. 1, 2, 3). Close similarity and extreme floral reduction in *Ambrosia, Xanthium* and *Hymenoclea* suggest that these genera constitute the terminal evolutionary branch of the Ambrosieae, with *Xanthium* and *Hymenoclea* independently derived from primitive forms of *Ambrosia.*

The genus *Ambrosia* is predominantly American; approximately 31 species are native to North America, eight to South America; two species, closely allied to and probably derived from American progenitors, are found in the Old World. All available evidence suggests that the genus originated in and diversified from arid and semi-arid regions in southwestern North America, where primitive species are still abundant (Payne, 1964).

All of the ragweeds are found in open habitats. Primitive, shrubby species occupy natural sites in deserts and semi-desert areas, being particularly adapted for stream banks, exposed arroyos, and the like. Such species produce fruiting involucres with many straight or hooked spines (often identical to those of the cockleburs) and are adapted for animal dispersal. In addition, involucres of the majority of the species commonly fall into streams or are carried to streams by runoff water, and dissemination by flowing water is probably important in their local distribution. Advanced species of ragweeds occur most abundantly today as weeds in association with man. The physiological characteristics that have allowed primitive members to survive in open and primary sites in arid regions are undoubtedly those which have been refined to permit derived species to successfully exploit pioneer habitats created by the agricultural and urban practices of present American cultures. Fruiting involucres of most advanced, weedy species have few or no vestigial spines, and the reduced spines appear to play no significant role in fruit dispersal (Gebben, 1965). When individuals grow along streams or river banks, or when they occur on slopes, water flow is probably important for local down-stream or down-slope transport of fruits and seeds. Studies of introduced populations of the short ragweed *(A. artemisiifolia)* in Oregon (G. H. Moose, personal communication) indicate that seeds of this species may be carried short distances by water flow, and temporary colonies of the species often flourish on sand bars and flood plains. I have obtained evidence from experiments with a captive English sparrow (Payne, 1962) that a small proportion of ingested seeds of *A. artemisiifolia* can pass unharmed through birds' alimentary canals and still germinate. In addition to these factors man is a potent, long-distance transport agent for species that occur as weeds of cultivation. Regardless, most seeds of derived species fall and re-

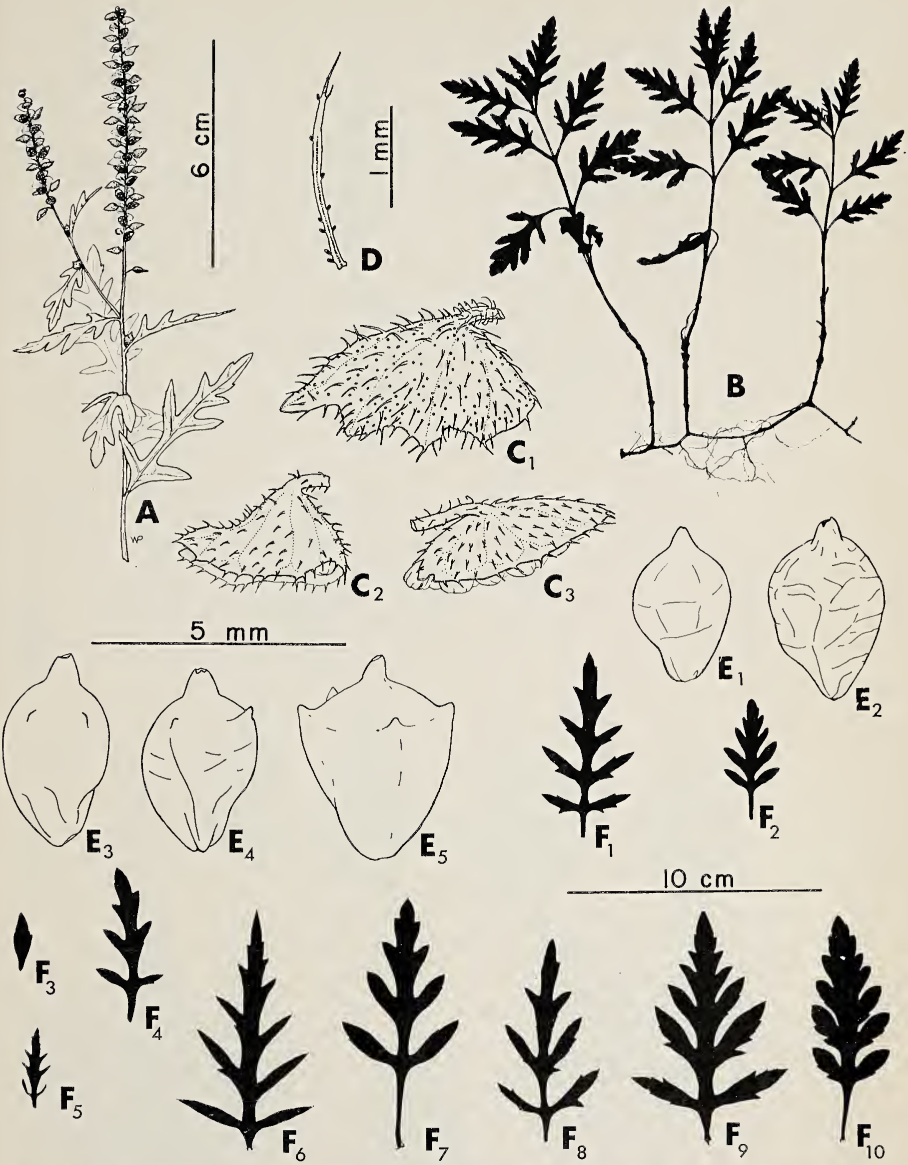



FIGURE 1. *Ambrosia psilostachya* DC. A. Capitulescence. B. Habit silhouette showing several young, adventitious shoots developed from runner-like root. C. Representative staminate heads. D. Pale. E. Representative fruiting involucres with vestigial spines or without spines. F. Leaf silhouettes from representative specimens; each silhouette from different specimen, all from median, cauline nodes.


FIGURE 2. *Ambrosia artemisiifolia* L. A. Capitulescence. B. Representative staminate heads. C. Pale. D. Representative fruiting involucres. E. & F. Heteroblastic leaf series representing leaves of two frequently encountered forms; lowest nodes toward left. G. Population sample, each leaf from a different specimen; all leaves from node five above cotyledonary node.

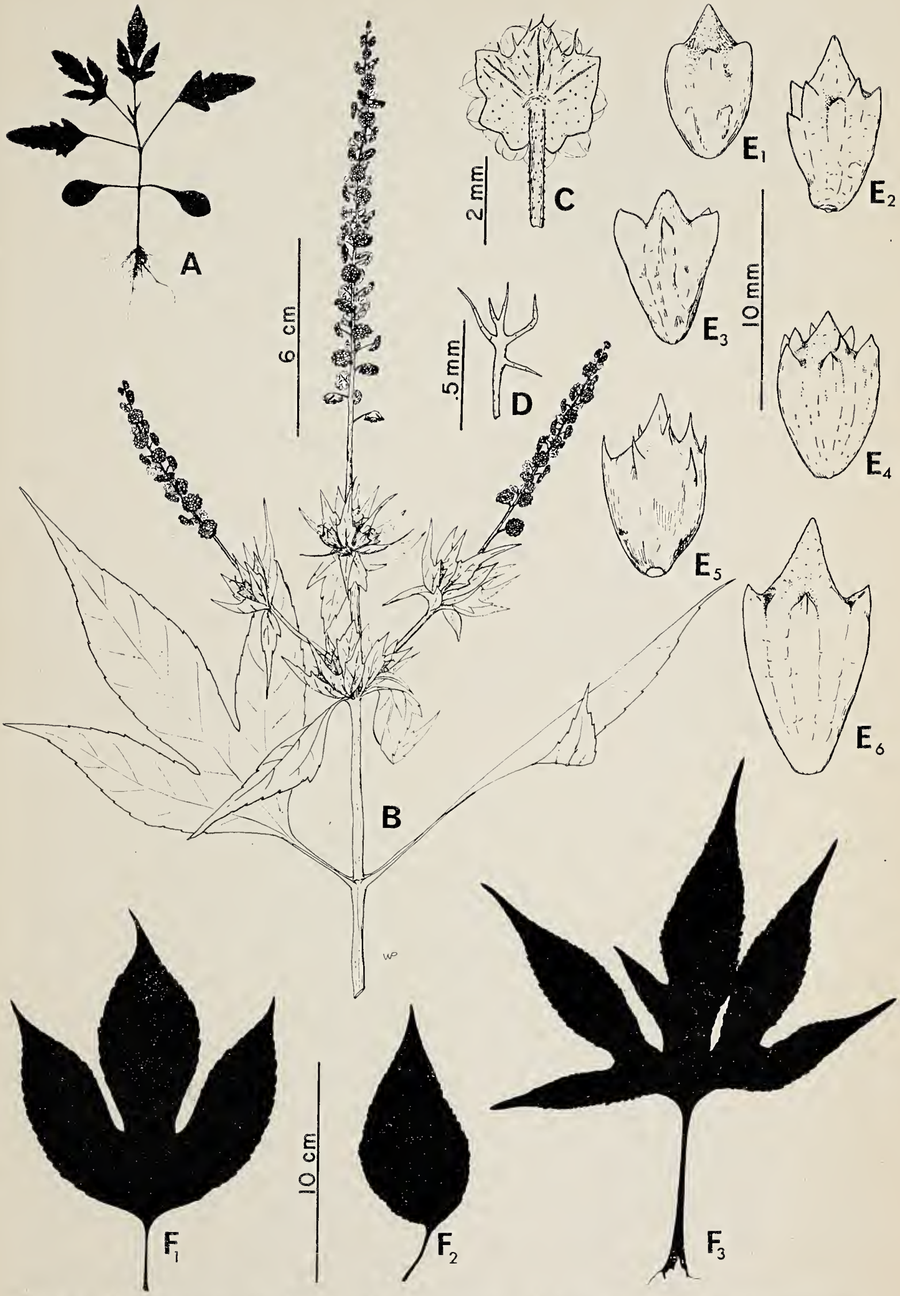


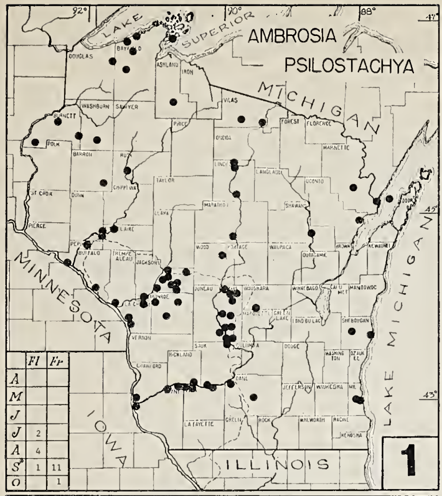

FIGURE 3. *Ambrosia trifida* L. A. Silhouette of seedling. B. Capitulescence. C. Staminate head; note distal striations. D. Pale. E. Representative fruiting involucres. F. Representative leaf silhouettes.

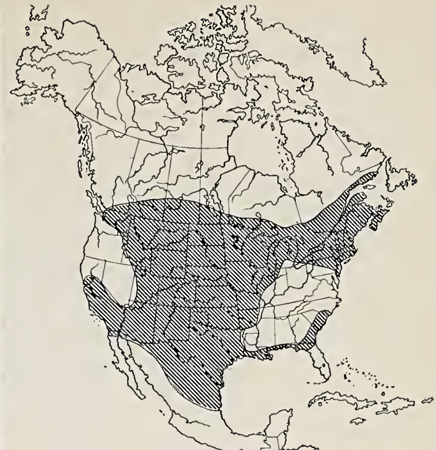
main in proximity to the parent plants, where they augment seed reserves present in soils that have previously supported the species. All of these factors are important in understanding the development and nature of the population structure of advanced species.

The three ragweeds found in Wisconsin are among the most specialized in the genus. They are widespread in the eastern and central United States (Maps 2, 4, 6), and are well known as sources of allergenic, air-borne pollen that constitutes the most serious natural air pollutant in North America, being the major cause of "hay fever" (cf. Wagner, 1959). An outstanding feature of all Wisconsin ragweed species is their morphological variability. Although this is particularly striking when the species are examined throughout their ranges, variability is also a pronounced attribute of the members of genetically restricted populations, such as the progeny grown from seeds developed by a single, self-pollinated plant (Jones, 1936). I have suggested (Payne, 1962, 1965) that for the short ragweed, heterogeneity may have been originally developed or strongly reinforced by fusion ("subspecies amalgamation") of once more distinct, subspecific groups. This hypothesis is compatible with present species structure and with the probable Pleistocene and post-Pleistocene history of the species. It may also provide at least a partial explanation for the similar attributes of Wisconsin perennial ragweed *(A. psilostachya)* and giant ragweed *(A. trifida)*.

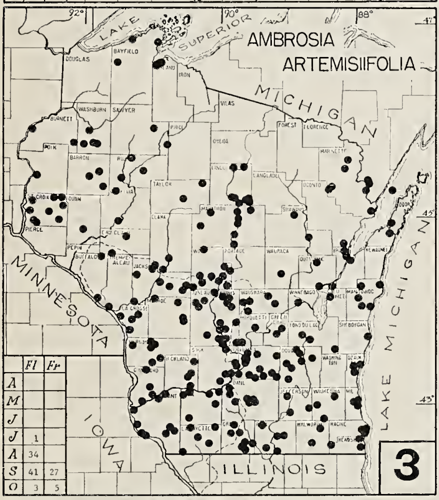
Although this paper deals specifically with only the ragweeds of Wisconsin, there is presently no treatment covering other genera of the *Ambrosia* tribe (Ambrosieae) of the Compositae with which the ragweeds are often confused. Therefore, the keys below include all of the members of the Ambrosieae found in the state. Treatment of the genus *Iva* follows that of Jackson (1960), and of the genus *Xanthium* that of Löve and Dansereau (1959).

AMBROSIEAE—Wind pollinated shrubs, perennial herbs and annuals distributed principally in desert and disturbed habitats in the Americas. Leaves alternate to opposite, usually petiolate, often lobed. Pubescence various but always including simple, uniseriate trichomes which are dead at maturity, and biseriate, glandular colleters. Capitulescences paniculate to racemose or spicate, typically maturing acropetally; capitula paleaceous, perfect or unisexual, often nodding. Perfect heads with few, free or connate phyllaries, sterile disc florets, and fertile ray florets. Unisexual heads usually with connate phyllaries (phyllaries lacking in staminate heads of *Xanthium*), the phyllaries of pistillate heads united to form winged or spiny burs with prominent beaks through which the stigmatic lobes project. All florets reduced and specialized for

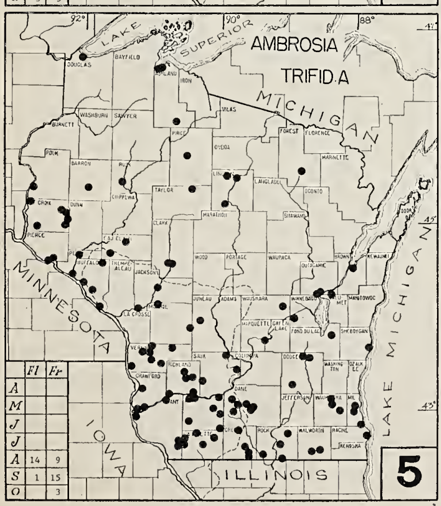

AMBROSIA
PSILOSTACHYA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
88°
Fl Fr
A
M
J
J 2
A 4
S 1 11
O 1
1



2


AMBROSIA
ARTEMISIIFOLIA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
88°
Fl Fr
A
M
J
J 1
A 34
S 41 27
O 3 5
3

4


AMBROSIA
TRIFIDA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
88°
Fl Fr
A
M
J
J
A 14 9
S 1 15
O 3
5

6

anemophily; pappus vestigial or lacking; pistillate florets with reduced corollas or the corollas wanting, without androecia, the stigma lobes elongate and minutely papillose; staminate florets with anthers weakly connate and often separating during anthesis, lacking ovaries, and with capitate, penicillate pistillodia which elongate after anthesis to push pollen from the anther cylinders. Pollen oblate, tricolporate, the colpae mostly vestigial, echinulate, cavate, the cavae enlarging to form bladder-like chambers by pronounced shrinkage of the protoplast and invagination of the inner wall layers of the grains after shedding. Base chromosome number $x=18$.

### Key To Wisconsin Ambrosieae

a. Staminate and pistillate florets in common heads; ray florets fertile, disc florets sterile *(IVA)* ---------------------------b.

b. Plants annual; phyllaries free ----------------------------c.

c. Leaves ovate, coarsely serrate; heads subtended by prominent bracts; phyllaries 3–4 ----------------*I. annua L.*

c. Leaves subcordate to ovate, usually coarsely lobed and toothed; heads ebracteate; phyllaries 5 -----------------------------------------------*I. xanthifolia* Nutt.

b. Plants perennial; phyllaries basally connate --------------------------------------------------------*I. axillaris* Pursh

a. Staminate and pistillate florets borne in separate heads -----d.

d. Staminate heads lacking phyllaries, pistillate heads 2-flowered and with many, hooked spines *(XANTHIUM)* ------e.

e. Leaves pinnately lobed; stems bearing long, golden, three-rayed, axillary spines ------------------*X. spinosum L.*

e. Leaves coarsely palmately lobed; stems unarmed ---------------------------------------------*X. strumarium* L.

d. Staminate heads with involucres of connate phyllaries, pistillate heads 1-flowered and with few vestigial spines or none -------------------------*(AMBROSIA)* See following key.

Genus 15. AMBROSIA L. Ragweed.

In Wisconsin, perennial or annual herbs with petiolate, lobed leaves opposite below or throughout. Staminate heads in terminal, racemose clusters, nodding on short stalks, many-flowered, paleaceous, with few-lobed involucres of connate phyllaries. Pistillate heads clustered in axils of upper leaves, sessile, 1-flowered, turbinate, with few sharp or blunt spines localized near the beaks or without spines.

### Key To Species

A. Leaves pinnately or bipinnately lobed or parted; staminate involucres lacking dorsal striations; upper cauline leaves usually alternate ---------------------------------------------B.

B. Plants perennial with horizontal runner-like underground roots; involucral spines blunt or absent; leaves usually coarsely lobed -----------------------1. *A. psilostachya.*

B. Plants annual with taproots; involucral spines usually sharply pointed; leaves usually delicately lobed and parted ------------------------------------2. *A. artemisiifolia.*

A. Leaves palmately lobed or unlobed; staminate involucres marked with dorsal striations; all cauline leaves usually opposite; plants annual ----------------------------3. *A. trifida.*

1. *Ambrosia psilostachya* DC. Prod. 5: 536. 1836. *(non A. psilostachya* Grisebach. 1861.) Perennial Ragweed, Western Ragweed (Maps 1, 2; Figs. 1, 4P.) Type: *Berlandier 2280* G; Isotype NY.

*A. hispida* Torr. Ann. Lyc. Nat. Hist. N.Y. 2: 216. 1828. *(non A. hispida* Pursh. 1814).

*A. coronopifolia* T. & G. Fl. N. Am. 2: 291. 1842.

*A. glandulosa* Scheele, Linnaea 22: 157. 1849. *(non A. glandulosa* Rydb. 1922).

*A. lindheimeriana* Scheele, *l.c.* 22: 157. 1849.

*A. coronopifolia* var. *asperula* Gray, Bost. Jour. Nat. Hist. 6: 226. 1857.

*A. coronopifolia* var. *gracilis* Gray, *l.c.* 6: 227. 1857.

*A. psilostachya* var. *lindheimeriana* Blank. Rep. Mo. Bot. Gard. 18: 173. 1907.

*A. californica* Rydb. N. Am. Fl. 33: 20. 1922.

*A. psilostachya asperula* (Gray) Blank. ex Rydb. *l.c.* 33: 19. 1922.

*A. psilostachya californica* (Rydb.) Blake, *in* I. Tidestrom. Fl. Utah & Nev. 580. 1925.

*A. psilostachya* var. *coronopifolia* (T. & G.) Farwell ex Fern. Gray's Man. Bot., ed. 8, 1470. 1950.

Erect, perennial herb, 0.5–10 dm high; proliferating from runner-like roots. Stems unbranched or branched; pubescent, hirsute to pilose to hispidulous, minutely glandular; light green to yellowish, occasionally blotched or suffused with red. Leaves opposite below, alternate above, occasionally opposite nearly to staminate portion of capitulescence. Median cauline leaves short-petiolate to subsessile, the petiole usually broadened with decurrent blade tissue. Blade ovate to ovate-lanceolate in outline; pinnately to bipinnately lobed (rarely nearly unlobed), lobes with entire margins or sparsely serrate; lamina somewhat coriaceous, often densely gray-green pubescent; veins prominent on under surface; pilose to scabrous. Capitulescence usually little branched or unbranched, gradually blending with vegetative portion of axis. Staminate heads paleaceous; 10–40-flowered; stalked to subsessile; ebracteate. Staminate involucre campanulate, often prominently eccentric; shallowly toothed, the distal teeth usually larger; persistent after anthesis; pubescent, often minutely glandular-punctate. Staminate florets narrowly campanulate; corolla hyaline, five-lobed. Pistillate capitula sessile; often borne singly in axils of bracts and leaves subtending staminate raceme, usually clustered. Fruiting involucre obovate; spines 0–7, terete, usually bunt, often lacking; body to 6 mm long and 3.5 mm broad, reticulate-rugose, rarely striated; beak short, blunt to vestigial. Haploid chromosome number, n = (18), 36, 54, 72.

*Ambrosia psilostachya* is the least abundant of the Wisconsin ragweeds. It is a plant of sandy soils, commonly found on sandy prairies, often along ancient lake shores, sandy, glacial outwashes, and near the Great Lakes. Typical collection data include references to sandy beaches, sandblows, sandy prairie openings, and dry, sandy, open, upland forests. It is distributed fairly generally through Wisconsin (Map 1) but because of its habitat preferences is seldom abundant in comparison with short and giant ragweeds, and it is of minor economic importance as a weed of cultivated land. Reproduction is principally vegetative, and individuals well adapted for a particular site commonly produce large, clonal populations. The tendency for vegetative reproduction is correlated in this species with production of smaller, fewer-headed capitulescences. Comparative seed production by individual, well-grown shoots, raised in experimental garden plots at the University of Michigan Botanical Gardens in 1960, gave the following results: *A. artemisiifolia* (annual)—38,800 fruits; *A. trifida* (annual)—4,700 fruits; *A. psilostachya* (perennial)—80 fruits. In contrast, 24 perennial ragweed seedlings planted in similar plots in 1960 produced 3,175 vegetative shoots the succeeding spring (Payne, 1962). This difference in capitulescence development among the species indicates that, even where relatively abundant, *A. psilostachya* is a comparatively minor contributor to the atmospheric ragweed pollen load.

Like the other Wisconsin ragweeds, *A. psilostachya* is quite variable. This morphological variability is probably related, at least in part, to the presence in this species of a polyploid series, although no close correlation between particular ploidal levels and particular morphological expressions has yet been demonstrated. While Wisconsin perennial ragweed has not been intensively investigated cytologically, the most common ploidal level is probably $n = 36$ (tetraploid, based upon $x = 18$). Octoploid ($n = 72$) and diploid ($n = 18$, this count not yet verified in my laboratory) plants have been reported only from California and eastern Texas, respectively. Hexaploid plants ($n = 54$) are common west and south of Wisconsin, and it is possible that this ploidal level is represented in the state. Studies of the comparative sesquiterpene lactone chemistry of *A. psilostachya* clones and populations, currently in progress, indicate that the morphological variability of this species is paralleled by chemical variability (Miller, 1967; Miller, *et al.*, 1968).

2. *Ambrosia artemisiifolia* L. Sp. Pl. 2: 988. 1753. Short Ragweed, Common Ragweed. (Maps 3, 4; Figs. 2, 4A.) Lectotype: *Linnaeus 1114–4*. LINN. (I select this specimen from the Linnaean Herbarium as lectotype because it is representative for the species, is clearly labeled "artemisifolia" (sic) by Linnaeus, and is readily available as a photograph in the microfilm edition of the *Linnaean Herbarium* by the International Documentation Center AB, Tumba, Sweden.)

A. *elatior* L. Sp. Pl. 2: 987. 1753.
*Iva monophylla* Walt. Fl. Carol. 232. 1788.
A. *elata* Salisb. Prodr. 175. 1796.
A. *simplicifolia* Raeusch. Nomen. Bot. 274. 1797.
A. *absynthifolia* Michx. Fl. Bor. Am. 2: 183. 1803.
A. *paniculata* Michx. *l.c.* 2: 183. 1803.
A. *heterophylla* Muhl. ex Willd. Sp. Pl. 4: 287. 1805.
A. *artemisifolia elatior* (L.) Desc. Fl. Ant. 1: 239. 1821.
A. *longistylis* Nutt. Trans. Am. Phil. Soc. N.S. 17: 344. 1841.
A. *artemisiifolia* vars. $\alpha$, $\beta$, $\delta$, $\gamma$. T. & G. Fl. N. Am. 2: 291. 1842.
A. *artemisiifolia* L. $\alpha$ *quadricornis* Ktze. Rev. Gen. Pl. I. 305. 1891.
A. *artemisiifolia* L. $\beta$ *octocornis* Ktze. *l.c.* 305. 1891.
A. *artemisiaefolia* ssp. *diversifolia* Piper, Contr. U. S. Nat. Herb. 11: 551. 1906.
A. *artemisiaefolia* L. var. *paniculata* (Michx.) Blank. Rep. Mo. Bot. Gard. 18: 173. 1907.
A. *media* Rydb. Bull. Tor. Bot. Club, 37: 127. 1910.
A. *elatior* L. var. *artemisiifolia* (L.) Farw. Rep. Mich. Acad. 15: 190. 1913.
A. *elatior* L. var. *heterophylla* (Muhl.) Farw. *l.c.* 190. 1913.
A. *diversifolia* (Piper) Rydb. N. Am. Fl. 33: 18. 1922.
A. *monophylla* (Walt.) Rydb. *l.c.* 17. 1922
A. *artemisiifolia* var. *elatior* f. *villosa* Fern. & Grisc. Rhodora 37: 185. 1935.

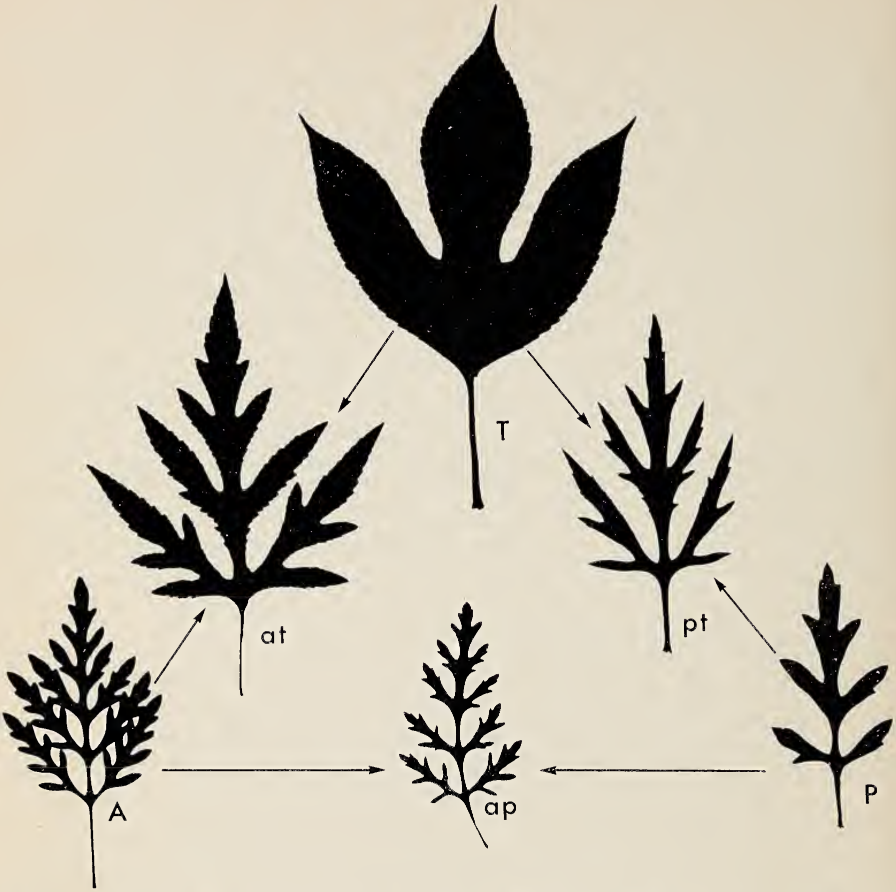



FIGURE 4. Leaf silhouettes representative for the Wisconsin ragweeds *A. artemisiifolia* (A), *A. psilostachya* (P), *A. trifida* (T), and their hybrid progeny.

Erect, annual herb, 1–7 (–20) dm high. Stems unbranched to much branched; glabrous to villous, often streaked with reddish to black longitudinal markings. Leaves petiolate, opposite below, alternate above. Lamina of median cauline leaves pinnatifid to tripinnatifid, frequently less lobed above and below, blades of uppermost cauline leaves occasionally unlobed; margin sparsely serrate, serrations blending with lobes; ovate in outline. Capitulescence much branched, occasionally wholly or predominantly staminate or pistillate, more or less abruptly differentiated from vegetative stem. Staminate heads paleaceous; 10–100 (–200) flowered; stalked, stalks to 4.5 (–15) mm long, seldom bearing more than a single, terminal head; ebracteate. Staminate involucre campanulate to cupulate to flattened; lobed, with 5–10 short-deltoid, marginal lobes, the sinuses normally extending less than ⅓ the distance to the stalk, terminal lobes usually largest; unmarked above; sparsely pubescent, sometimes obviously glandular; remaining attached after anthesis is complete. Pales linear, usually with marginal or terminal, simple or glandular trichomes. Staminate florets narrowly campanulate; corolla hyaline, 5 lobed; stamens 5, the tips of the claws usually long-attenuate; anthers connate. Pistillate heads sessile, 1 flowered; clustered in axils of bracteal and foliage leaves below the staminate racemes; all but the terminal one bracteate. Fruiting involucres obovate, the body to 2.5 mm broad and 3.5 mm long, with one beak to 2 mm long; supplied with 4–12 straight, terete spines, to 1 mm long (rarely longer, or completely vestigial and lacking), arranged in one or a few close whorls above center; glabrous or with few to abundant, short to long hairs, frequently glandular punctate, particularly below the beak; somewhat rugose; commonly with reddish-brown to black mottling or striations, sometimes suffused with pigment. Haploid chromosome number, $n = 18$.

Short ragweed is by far the most abundant and economically important of the ragweed species of Wisconsin. It is distributed generally throughout the state (Map 3), being uncollected from only a few counties in the northwestern and west-central portions of Wisconsin, where the species begins to reach the northern limits of its range at these longitudes. It is most frequently a weed of cultivated and ruderal habitats, roadsides, railroad embankments, and similar sites, and may also become abundant in overgrazed and sterile soils. Because urbanites most often encounter *A. artemisiifolia* as a roadside weed, it is popularly believed that roadside habitats support a major proportion of the plants in an area, and are, thus, the sources for most ragweed pollen production; this belief is defended by manufacturers of chemicals used to spray roadsides in weed control programs. However, three studies carried out in southeastern Michigan in 1958, 1959 and 1960 (Harrington, *et al.*, 1960; Gebben, *et al.*, 1962; Gebben, 1965) clearly demonstrate that, in areas encompassing both rural and urban land use, the great majority of plants are found in cereal grain fields, of which wheat fields lead the list.

An outstanding attribute of this species is its variability, usually with considerable distance between extremes in expression of virtually all characters (see, for example, Fig. 2, D and G). It is probable that genomes and populations capable of producing variable progeny are selected and maintained in this species. Such a mechanism enhances the ability of the species to survive with man by providing a continually varying supply of genotypes, some of which are capable of exploiting nearly any available primary site. The selective advantage for such a mechanism is obvious when one considers the variable nature of man-created primary habitats, viz., those associated with crop rotation, frequent interruption of different successional stages in different ways, and so on. A possibly significant factor in this mechanism has to do with seed longevity. The longevity experiments initiated by Beals (Darlington, 1922) and others demonstrate that seeds of *A. artemisiifolia* may remain viable in the soil for periods of 40 years or more. Thus, it is possible for plants developed from seeds produced the preceding season to interbreed with plants developed from seeds produced many ragweed generations in the past, bringing together and intermixing genomes from populations which may have been selected under quite different site conditions. Similar factors influencing population dynamics are probably also important in the biology of *A. psilostachya* and *A. trifida.*

3. *Ambrosia trifida* L. Sp. Pl. 2: 988. 1753. Giant Ragweed, Great Ragweed, Horse Cane. (Maps 5, 6; Figs. 3, 4T.)

Lectotype: *Linnaeus 1114–1.* LINN. (As for the previous species treated, this specimen is appropriately labeled and preserved, and a photograph is available from the International Documentation Center.)

*A. simplicifolia* Walt. Fl. Carol. 231. 1788.
*A. integrifolia* Muhl. ex Willd. Sp. Pl. 4: 375. 1805.
*A. aptera* DC. Prod. 5: 527. 1836.
*A. trifida* var. *integrifolia* (Muhl. ex Willd.) T. & G. Fl. N. Am. 2: 290. 1842.
*A. trifida* L. var. β *texana* Scheele, Linnaea 22: 156. 1849.
*A. trifida* L. α *normalis* Ktze. Rev. Gen. Pl. I. 305. 1891.
*A. trifida* L. α *normalis* var. *aptera* Ktze. *l.c.* 305. 1891.
*A. trifida* L. α *normalis* var. *heterophylla* Ktze. *l.c.* 305. 1891.
*A. striata* Rydb. Brittonia 1: 96. 1931.
*A. variabilis* Rydb. *l.c.* 97. 1931.
*A. trifida* L. f. *integrifolia* (Muhl.) Fern. Rhodora 40: 347. 1938.
*A. trifida* var. *polyploidea* Rousseau, Nat. Canad. 71: 215. 1944.
*A. trifida* var. *trifida* Cronquist, Rhodora 47: 396. 1945.

Erect, annual herb, 2–50 dm high. Stems unbranched to much branched; hispid-hispidulous to scabrous or nearly glabrous, sometimes tuberculate; somewhat angular and ridged; often with fine, black longitudinal striations, frequently suffused or blotched with red. Leaves opposite throughout or becoming alternate in the capitulescence; petiolate, the petiole often more or less winged with decurrent blade tissue. Blade ovate-lanceolate to broadly ovate or ovate-deltoid in outline; upper, bracteate blades often becoming narrowly lanceolate; unlobed or palmately lobed, the 3–7 primary lobes occasionally bearing pinnately arranged secondary lobes; margin serrate, the abaxial surface of each tooth often with a single, black striation; adaxial surface hispidulo-scabrous. Capitulescence little or much branched. Staminate heads minutely paleaceous; 10–125 flowered; stalked, stalks 2–8 mm long, rarely subsessile; ebracteate. Staminate involucre shallowly campanulate to saucer-shaped; crenulate or toothed at the margin, the three distal teeth usually more pronounced and marked on the upper surface with prominent, black striations; abcissing after anthesis is complete. Staminate florets narrowly campanulate; corolla hyaline, five-lobed, marked with longitudinal striations; stamens with short-attentuate claws. Pistillate capitula sessile, 1 flowered; clustered in axils of bracteal leaves below the staminate racemes; all but the terminal bracteate. Fruiting involucres obovate; spines terete to radially flattened, 3–11 in one or a few close-set whorls below the beak; body to 17 mm long and 10 mm broad usually ridged and somewhat rugose, frequently marked with black or red, somewhat pubescent. Haploid chromosome number $n = 12$.

Giant ragweed is the second most abundant species in Wisconsin, being distributed principally in the southern two-thirds of the state (Map 5). Although ordinarily less abundant regionally than short ragweed in terms of absolute numbers of specimens the greater stature and larger capitulescences make it a heavy pollen producer, and in areas of abundance it may contribute as much or more pollen to the local atmospheric pollen load. It is essentially a floodplain species and is most abundant in moist soils of drainage ditches, low fields, open stream banks, and the like.

Like short ragweed, *A. trifida* is quite variable, outstanding variability being associated with fruit size and shape, leaf shape, and pubescence. In the southern and southwestern United States the fruiting involucres are often scarcely larger than those of *A. artemisiifolia,* while in the Appalachian region fruits 10–20 times this size may be found (Payne and Jones, 1962). Similar fruiting involucre variation is common in local populations, and may also apply to different fruits taken from the same plant. Forms with unlobed leaves, or with both lobed and unlobed leaves are common, this aspect of leaf morphology being partially related to ecological conditions. Such plants have played a prominent role in the taxonomic history of the species, generating such epithets as *simplicifolia, integrifolia,* and *variabilis.* It is probable that, as with short ragweed, greatly increased population size, mixing of geographic races once more distinct, and variable selection pressures associated with modern agricultural practices and urbanization, have contributed to local variability.

The black striations distributed on all parts of the plant are related to sub-epidermal canals (resin canals?) which contain a deep red pigment. When cut, the plant bleeds red "blood," a fact that figured prominently in the "doctrine of signatures" medical practices of some American Indians, and which actually led to reverence and fear of the plant by certain tribes (Payne and Jones, 1962).

The most unusual characteristic of *A. trifida* is its chromosome compliment of $n = 12$. With the usual base of $n = 18$ in the genus, this presents the possibility of a progenitor genome of $n = 6$. Pairing behavior studies by K. L. Jones (1943) of the hybrid *A. artemisiifolia* X *trifida* have demonstrated, however, that the 12 chromosomes of giant ragweed are homologous with the 18 chromosomes of short ragweed, and the chromosome complement of *A. trifida* is interpreted to be the result of aneuploid reduction (Payne, Raven and Kyhos, 1964). Furthermore, no similar compliment is known elsewhere in the Ambrosieae, although aneuploid reduction to $n = 16$ or 17 is common in the genus *Iva,* and in *A. bidentata* $n = 17$. Polyploidy in *A. trifida* was suggested by Rousseau (1944), but was refuted by the studies of Payne and Jones (1962). To my knowledge, no *bona fide* report of polyploidy exists for the species.

## Ecological Relationships and Specialization of Wisconsin Ambrosia

The ragweed species described above appear to be specialized within the genus, and are probably more or less recently evolved. The majority of specific character expressions are interpreted as derived expressions within character gradients established by comparison of ragweeds with general conditions in the family Compositae. These specialized characteristics, common to the three species treated, include: shallowly lobed staminate involucres, eccentrically borne on relatively short stalks; vestigial pales; single flowered pistillate heads, with few, vestigial spines, localized near the beaks; prominently lobed or dissected leaves, opposite at the lower nodes or throughout; herbaceous perennial or annual habits; and distribution in non-arid eastern and northern North America. Although they share these specializations, the three species do not appear to comprise a natural, evolutionary group. *Ambrosia psilostachya* and *A. artemisiifolia* are very similar and probably are the more specialized members of a subgeneric group that includes the Mexican *A. cumanensis,* the West Indian and South American *A. peruviana,* the Caribbean *A. hispida,* and the South American *A. tenuifolia* and

*A. microcephala.* The entire group bears considerable resemblance to the *A. confertiflora* assemblage (including also *A. canescens* and *A. pumila*) and is probably derived from shrubby progenitors characterized by regularly lobed and dissected leaves, hooked involucral spines, and usually non-striated stems, involucres and leaves. *Ambrosia trifida,* however, bears greatest resemblance to species of a distinct, derivative line, characterized by irregularly lobed leaves, straight, flattened involucral spines, and prominent vegetative striations. It can be traced to shrubby progenitors of the least specialized sort in the genus (such as *A. deltoidea*) along an evolutionary line represented by *A. chamissonis, A. nivea, A. cheiranthifolia, A. grayi, A. tomentosa,* and *A. acanthicarpa.*

## Ambrosia Hybrids

The three species are capable of hybridization, although hybrid individuals are usually uncommon and highly sterile. Hybrid plants are most easily recognized by their intermediate leaf characteristics (Fig. 4). Wagner and Beals (1958) have found that the perennial hybrid *A. artemisiifolia* X *psilostachya* (*A.* X *intergradiens* Wagner & Beals) (Fig. 4ap) is persistent and fairly "common" in northern and eastern Michigan, where it often forms clonal populations that persist for many years. It is probable that similar populations are frequent in adjoining Wisconsin in areas of sympatry.

Palynological evidence (Bassett and Terasmae, 1962) indicates that ragweeds occupied sites in the northeastern United States and adjacent Canada during and since the Pleistocene, and it is probable that all of the species found today in Wisconsin were here long before the invasion of North America by European cultures. On the other hand, European man, by providing variable primary sites in much greater abundance than were ever before available for ragweed occupation, has greatly influenced the natures of the species and their population dynamics.

## Literature Cited

Bassett, I. J. and J. Terasmae. 1962. Ragweeds, *Ambrosia* species, in Canada and their history in post glacial time. Canad. Jour. Bot. 40: 141–150.

Benson, L. 1957. Plant Classification. D. C. Heath & Co., Boston.

Bentham, G. 1873. Notes on the classification, history, and geographical distribution of Compositae. Jour. Linn. Soc. Bot. 13: 335–557.

Cassini, H. 1826–1834. Opuscules Phytologiques. Tomes I, II, & III. Paris.

Cronquist, A. 1952. Compositae, pp. 323–545. *In* H. A. Gleason (ed.), The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. Vol. 3. Lancaster Press, Inc., Lancaster.

Darlington, H. T. 1922. Dr. W. J. Beal's seed-vitality experiment. Am. Jour. Bot. 9: 266–269.

DELPINO, F. 1871. Studi Sopra un Lignaggio Anemophilo delle Composte. Cellini, Firenz.

FERNALD, M. L. 1950. Gray's Manual of Botany. 8th ed. American Book Co., New York.

GEBBEN, A. I. 1965. The ecology of common ragweed, *Ambrosia artemisiifolia* L., in southeastern Michigan. Unpbl. Ph.D. thesis. Univ. Michigan, Ann Arbor.

GEBBEN, A. I., W. W. PAYNE, and W. H. WAGNER, JR. 1962. Botanical Phase, pp. 1–16. *In* J. M. Sheldon and E. W. Hewson (eds.) Atmospheric pollution by aeroallergens; prog. rept. 5. Univ. Michigan, Ann Arbor.

HARRINGTON, J. B., JR., E. S. EPSTEIN, D. L. JONES, A. N. DINGLE, G. C. GILL, F. C. ELDER, E. W. BIERLY and E. W. HEWSON. 1960. Meteorological Phase, pp. 75–177. *In* J. M. Sheldon and E. W. Hewson (eds.) Atmospheric pollution by aeroallergens; prog. rept. 4. Univ. Michigan, Ann Arbor.

HARTLEY, T. G. 1962. The flora of the "driftless area". Unpbl. Ph.D. Thesis, Iowa State University.

JACKSON, R. C. 1960. A revision of the genus *Iva* L. Univ. Kansas Sci. Bull. 41: 793–876.

JONES, K. L. 1936. Studies on *Ambrosia:* I. The inheritance of floral types in the ragweed, *Ambrosia elatior* L. Am. Midl. Nat. 17: 673–699.

————. 1943. Studies on *Ambrosia:* III. Pistillate *Ambrosia elatior* X *A. trifida* and its bearings on matroclinic sex inheritance. Bot. Gaz. 105: 227–232.

KECK, D. D. 1959. Compositae, pp. 1073–1310. *In* P. A. Munz. A California Flora. Univ. Calif. Press, Berkeley.

LÖVE, D. and P. DANSEREAU. 1959. Biosystematic studies on *Xanthium;* Taxonomic appraisal and ecological status. Canad. J. Bot. 37: 173–208.

MILLER, H. E. 1967. The chemistry and infraspecific variation of sesquiterpene lactones in *Ambrosia psilostachya* DC. (Compositae). Unpbl. Ph.D. thesis. Univ. Texas, Austin.

MILLER, H. E., T. J. MABRY, B. L. TURNER, and W. W. PAYNE. 1968. Infraspecific variation of sesquiterpene lactones in *Ambrosia psilostachya* (Compositae). Am. J. Bot. 55: 316–324.

PAYNE, W. W. 1962. Biosystematic studies of four widespread weedy species of ragweeds *(Ambrosia:* Compositae). Unpbl. Ph.D. thesis. Univ. Michigan, Ann Arbor.

————. 1963. The morphology of the inflorescence of ragweeds *(Ambrosia-Franseria:* Compositae). Am. Jour. Bot. 50: 872–880.

————. 1964. A re-evaluation of the genus *Ambrosia* (Compositae). Jour. Arnold Arb. 45: 401–438.

————. 1965. "Subspecies amalgamation" in North American short ragweed, *Ambrosia artemisiifolia* (Compositae). Am. Jour. Bot. 52: 649 (abstract).

PAYNE, W. W. and V. H. JONES. 1962. The taxonomic status and archaeological significance of a giant ragweed from prehistoric bluff shelters in the Ozark Plateau region. Pap. Mich. Acad. Sci. 47: 147–163.

PAYNE, W. W., P. H. RAVEN and D. W. KYHOS. 1964. Chromosome numbers in Compositae. IV. Ambrosieae. Am. Jour. Bot. 51:419–424.

ROUSSEAU, J. 1944. Reconstitution de l'Ambrosia préhistorique des Ozark. Nat. Canad. 71: 211–216.

RYDBERG, P. A. 1922. Carduales (Ambrosiaceae, Carduaceae). *In* North American Flora. Vol. 33. N. Y. Bot. Gard., New York.

SKVARLA, J. J. and D. A. LARSON. 1965. An electron microscopic study of pollen morphology in the Compositae with special reference to the Ambrosiinae. Grana Palynolog. 6: 210–269.

SMALL, J. K. 1913. Flora of the southeastern United States. 2nd. ed. Publ. by author, New York.

SOLBRIG, O. T. 1963. The tribes of Compositae in the southeastern United States. Jour. Arnold Arb. 44: 436–461.

WAGNER, W. H., JR. 1958. The hybrid ragweed, *Ambrosia artemisiifolia* X *trifida*. Rhodora 60: 309–316.

————. 1959. An annotated bibliography of ragweed *(Ambrosia)*. Review of Allergy and Applied Immunology 13: 353–403.

————. and T. F. BEALS. 1958. Perennial ragweeds *(Ambrosia)* in Michigan, with the description of a new, intermediate taxon. Rhodora 60: 177–204.

WYLIE, R. B. 1915. A hybrid ragweed. Proc. Iowa Acad. Sci. 22: 127–128, pl. 21.

## BIOGRAPHIES

CHARLES V. COVELL, JR., is assistant professor of biology at the University of Louisville and is curator of its insect collection. He holds a Ph.D. from Virginia Polytechnic Institute, is an officer in the Kentucky Society of Natural History, and is a member of entomological societies in the United States, Canada, and England. This year he will become editor of the Lepidopterists' Society *News*.

WILLIAM HILSENHOFF, associate professor of entomology at the University of Wisconsin, holds a Ph.D. from that institution. A specialist in the ecology of water insects, he is a member of several professional societies and has been president of the Midwest Benthological Society. Before teaching at Wisconsin he did classified research in medical entomology.

HUGH H. ILTIS is professor of botany and director of the herbarium at the University of Wisconsin. He holds advanced degrees from Washington University and the Missouri Botanical Garden in St. Louis. A specialist in plant evolution and conservation, he has done field work in several locations throughout the Western hemisphere. FREDERICK U. UTECH, who holds an M.S. from the University of Wisconsin, is presently a graduate teaching assistant there. A botany major, he has held an NSF fellowship for tropical ecology studies in Costa Rica.

MARLIN JOHNSON, who received his Masters degree in zoology from the University of Wisconsin, is an instructor in biology at the university's Waukesha County Campus. GEORGE C. BECKER is professor of biology at Wisconsin State University—Stevens Point. A Wisconsin Ph.D., he has been president of the Wisconsin Society for Ornithology and vice-president of sciences in the Wisconsin Academy of Sciences, Arts, and Letters.

WILLIAM A. KING is curator of art at the University of Wisconsin—Green Bay. He has studied at Oklahoma State University, the University of Tulsa, and l'Istituto Statale d'Arte in Florence. He has had several one-man shows in both Europe and the United States, and his paintings hang in collections both here and abroad.

Associate librarian of the Newberry Library in Chicago, DONALD W. KRUMMEL holds a Ph.D. from the University of Michigan. He is a member of several library and musicology societies and has written many articles and book reviews on music, music bibliography, and library history. He has previously been reference librarian of the music division of the Library of Congress.

HEINZ H. LETTAU, professor of meteorology and civil engineering at the University of Wisconsin, received his Ph.D. from the University of Leipzig. He is the author of many articles, primarily in the field of meteorology, and has worked on several committees of the National Academy of Sciences. ROBERT G. GALLIMORE, JR., holds the M.S. degree from the University of Wisconsin and is presently a research assistant in meteorology there.

LLOYD A. LUESCHOW, who holds an M.S. from the University of Wisconsin, is acting chief of the Laboratory Services Section of the Division of Environmental Protection in the state's Department of Natural Resources. JAMES M. HELM (M.S. Wisconsin), GARY W. KARL (B.S. Wisconsin), and DONALD R. WINTER (B.S. Wisconsin) are biologists with the Department. All four are primarily concerned with the problem of water pollution.

L. G. MONTHEY is travel-recreation specialist with University Extension, the University of Wisconsin, and he has written many articles dealing with economic recreation and travel-industry trends. He holds an M.S. from Wisconsin and has held national offices in various professional agricultural societies.

Associate professor of political science at Wisconsin State University—Whitewater, JOHN C. H. OH received his Ph.D. from New York University. He has taught previously at the University of Wisconsin and Marquette University, and he has published articles and reviews in leading political and sociological journals.

FREDERICK I. OLSON is professor of history and chairman of the department at the University of Wisconsin—Milwaukee. A Harvard Ph.D., he has also been associate dean of the University Extension, University of Wisconsin. He has published articles and reviews in many journals and is a member of various professional and public historical societies.

WILLARD W. PAYNE, who holds a Ph.D. from the University of Michigan, is associate professor of botany and associate curator of the herbarium at the University of Illinois. He is presently on leave from the campus to serve as associate program director in the Ecology and Systematic Biology Section of the National Science Foundation.

A. W. SCHORGER is emeritus professor of wildlife management at the University of Wisconsin, from which he received both his Ph.D. and an honorary D.Sc. The author of many articles and books on both chemistry and ornithology, he is a former director of the National Audubon Society and president of the Wisconsin Academy of Sciences.

S. H. SOHMER, a member of the biology department at the University of Wisconsin—La Crosse, is also curator of the university's herbarium. He holds degrees from City College of New York and the University of Tennessee, is the author of several articles, and has participated in programs in Costa Rica sponsored by the Organization for Tropical Studies.

Assistant professor of journalism at the University of Michigan, JOHN D. STEVENS received his Ph.D. from the University of Wisconsin. He is an officer in the Association for Education in Journalism and has written a number of articles for leading journalistic periodicals. The paper presented here is based on his doctoral dissertation.

ADOLPH A. SUPPAN is dean of the School of Fine Arts of the University of Wisconsin—Milwaukee. A Wisconsin Ph.D., he has held offices in many state organizations, including the chairmanship of the Wisconsin World Affairs Council and the presidency of the Wisconsin Academy of Sciences, Arts and Letters. At UWM he is also professor of English and philosophy.

GERALD E. SVENDSEN received his B.S. from Wisconsin State University—River Falls and his M.A. in zoology from the University of Kansas. He is assistant professor of biology at Viterbo College, is a member of several professional societies, and has been a research biologist for the Bureau of Sport Fisheries and Wildlife.

RONALD W. TANK, associate professor of geology at Lawrence University, holds a Ph.D. from Indiana University and a graduate school diploma from the University of Copenhagen. He is the author of articles on regional geology and clay mineral genesis, and he has been a research geologist for Standard Oil of California.

KENNETH TENNESSEN received a B.S. degree from the University of Wisconsin, majoring in entomology, and has done graduate work in this area at the University of Florida. He is presently in the armed services.

Emeritus professor of soil science and forestry at the University of Wisconsin, SERGIUS A. WILDE received his professional training at the Prague Polytechnical Institute before emigrating to the United States in 1929. He is the author of several books about soil bacteriology which have been translated into many languages.

BARBARA ZAKRZEWSKA, who holds a doctorate from the University of Wisconsin, is professor of geography at the University of Wisconsin—Milwaukee. A specialist in land form geography, she has published several articles on this subject in geographical journals.

# WISCONSIN ACADEMY OF SCIENCES, ARTS & LETTERS

Madison, Wisconsin

## OFFICERS 1969–70

*President*
William B. Sarles
Department of Bacteriology
The University of Wisconsin—Madison

*Vice-President (Sciences)*
Laurence R. Jahn
Wildlife Management Institute
Horicon

*Vice-President (Arts)*
Richard W. E. Perrin
Department of City Development
Milwaukee

*Vice-President (Letters)*
Edgar W. Lacy
Department of English
The University of Wisconsin—Madison

*President-Elect*
Norman C. Olson
NML Insurance Company
Milwaukee

*Secretary*
Corinna del Greco Lobner
Department of English
Dominican College
Racine

*Treasurer*
Jack R. Arndt
University Extension
The University of Wisconsin—Madison

*Librarian*
Jack A. Clarke
Department of Library Science
The University of Wisconsin—Madison

## APPOINTED OFFICIALS

*Editor*—TRANSACTIONS
Walter F. Peterson
University Librarian
Lawrence University, Appleton

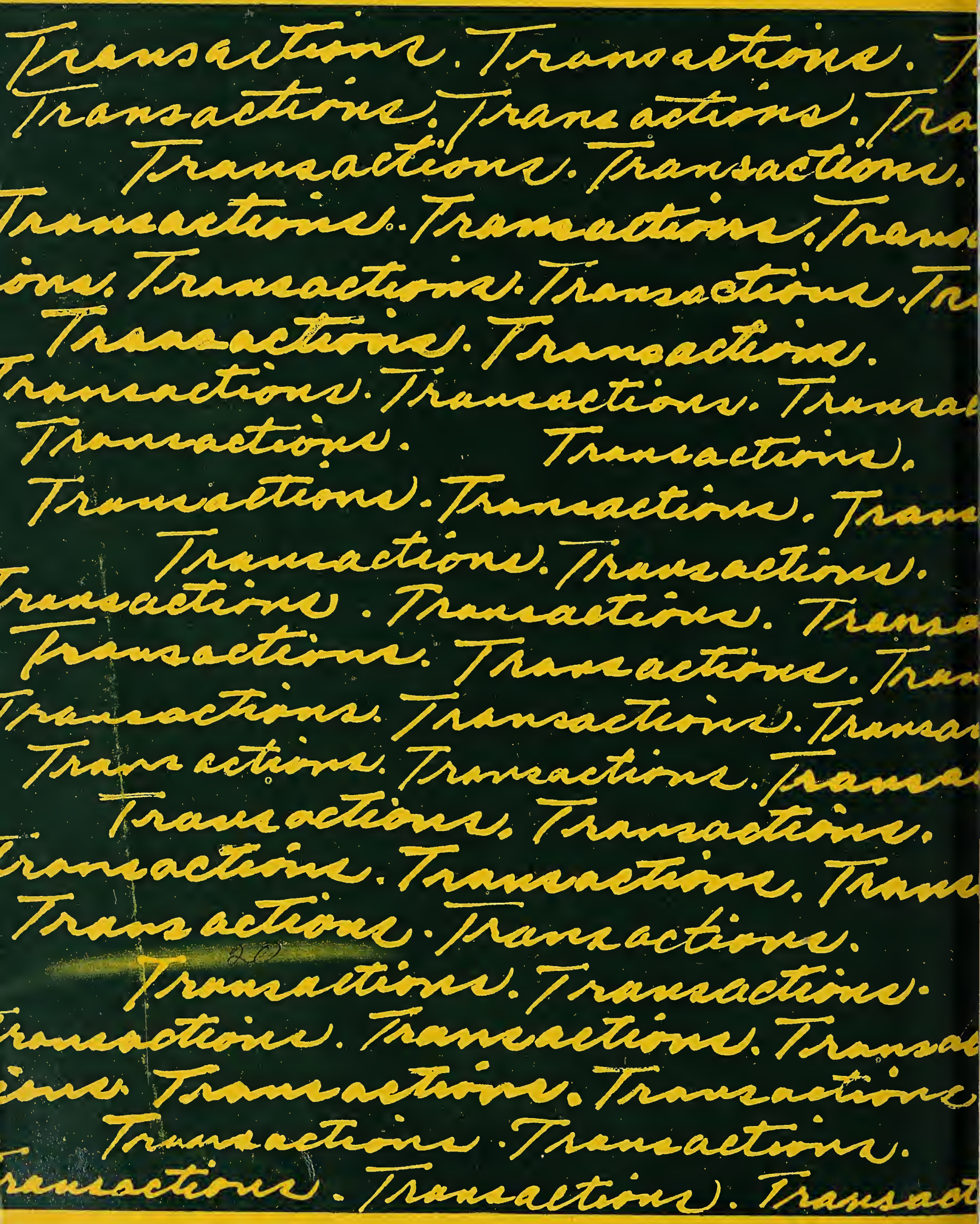
*Editor*—WISCONSIN ACADEMY REVIEW
Ruth Louise Hine
Wisconsin Department of Natural Resources
Madison

*Chairman*—JUNIOR ACADEMY OF SCIENCE
LeRoy Lee
James Madison Memorial High School
Madison

## ACADEMY COUNCIL

The Academy Council includes the above named officers and officials and the following past presidents:

Paul W. Boutwell
A. W. Schorger
Henry A. Schuette
Lowell E. Noland
Otto L. Kowalke
Katherine G. Nelson
Ralph N. Buckstaff
Joseph G. Baier
Stephen F. Darling
Robert J. Dicke
Henry A. Meyer
Merritt Y. Hughes
Carl Welty
J. Martin Klotsche
Aaron J. Ihde
Walter E. Scott
Harry Hayden Clark
John W. Thomson
Adolph A. Suppan


Transactions.