Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

aSD11
.A42
Reserve

United States
Department of
Agriculture

Forest Service

**Rocky Mountain
Forest and Range
Experiment Station**

Fort Collins,
Colorado 80526

**General Technical
Report RM-229**

Status and Management of Neotropical Migratory Birds

**September 21-25, 1992
Estes Park, Colorado**

USDA
NAT'L AGRIC. LIBRARY
NOV 16 '93

Finch, Deborah M.; Stangel, Peter W., eds. 1993. Status and Management of Neotropical Migratory Birds; 1992 September 21-25; Estes Park, CO. Gen. Tech. Rep. RM-229. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 422 p.

Abstract

This proceedings is the product of a National Training Workshop held at the Estes Park Center, Estes Park, Colorado, 21-25 September, 1992. Invited papers discuss all aspects of management, monitoring, and conservation of neotropical migratory birds on the breeding grounds. The proceedings is divided into seven sections that range from philosophical discussions to methods and solutions for managing migratory birds in concert with other wildlife.

Sponsoring Organizations:

U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Bureau of Land Management
U.S. National Park Service
Department of Defense
The Wildlife Management Institute
Environmental Protection Agency
National Fish and Wildlife Foundation

USDA Forest Service
General Technical Report RM-229

July 1993

Status and Management of Neotropical Migratory Birds

September 21-25, 1992
Estes Park Center
YMCA of the Rockies, Colorado

Editors:

Deborah M. Finch
Rocky Mountain Forest and Range Experiment Station
Flagstaff, Arizona

Peter W. Stangel
National Fish and Wildlife Foundation
Washington, DC

Rocky Mountain Forest and Range
Experiment Station
U.S. Department of Agriculture
Fort Collins, Colorado

Received By: JYB
Indexing Branch

Preface

This proceedings is the product of a National Training Workshop, Status and Management of Neotropical Migratory Birds, held at the Estes Park Center, YMCA of the Rockies, in Estes Park, Colorado, 21-25 September, 1992. The workshop was organized to help address management and research needs identified by members of Partners in Flight - Aves de las Americas, an international program to conserve neotropical migratory birds. The primary purpose of the conference was to bring together researchers and natural resource managers to discuss ideas, problems, and solutions for managing neotropical migratory birds, focusing on migrants that breed in Canada and the United States and winter in Mexico, Central America, South America, and the Caribbean. This volume represents invited papers discussing all aspects of management, monitoring, and conservation of neotropical migrants.

Proposed and organized by the Research Working Group for Partners in Flight in consultation with regional, monitoring, and information and education working groups, the conference drew participation from a diverse community of natural resource managers, biologists, educators, researchers, industry representatives, and amateur birdwatchers. Over 700 people attended it, representing every state of the United States, as well as Canada, Mexico, Costa Rica, and the Commonwealth of Puerto Rico. A companion product of this conference is a volume soon to be published by Oxford University Press that reviews the state-of-the-art literature on neotropical migrants. While this conference emphasized topics related to the North American breeding grounds, follow-up workshops are scheduled for the future in Latin American countries.

The editors wish to personally thank Tom Martin, U.S. Fish and Wildlife Service, for his significant contributions of time and energy in preparing the original proposal for the workshop and in helping to organize the slate of speakers. In addition, we are grateful to co-chairs of the Workshop Local Arrangements Committee, Dick Roth, U.S. Forest Service and Stephanie Jones, U.S. Fish and Wildlife Service, and to committee members, Mike Carter, Colorado Bird Observatory; Jeff Conner, National Park Service; Susan Skagen, U.S. Fish and Wildlife Service, and Bob Hamre, U.S. Forest Service. The local committee worked diligently to schedule field trips, conference facilities, special video-taping sessions, registration, manuscript collection, poster session, meals and banquet, and planned and impromptu meetings and socials. Many workshop volunteers, too numerous to name, were also generous with their time. The Agenda Steering Committee, whose composition varied from meeting to meeting, put together a well-coordinated program of speakers, breakout sessions, and special events. We also thank Chris Paige, Dick Hutto, Diane Pence, C.J. Ralph, Greg Butcher, Ben Wigley, Scott Klinger, and Naomi Edelson for chairing paper sessions. Bob Hamre and Carol LoSapio are to be congratulated for their efforts in publishing the proceedings. Finally, we thank all workshop sponsors, U.S. Fish and Wildlife Service, U.S. Forest Service, Department of Defense, Environmental Protection Agency, Bureau of Land Management, National Park Service, National Fish and Wildlife Foundation, and The Wildlife Management Institute for their generous financial support.

Contents

Introduction 1
Deborah M. Finch and Peter W. Stangel

Changing Values and Partners in Flight

Partners in Flight: Past, Present, and Future

A Government Perspective 5
John G. Rogers, Jr., Thomas J. Dwyer, and Catrin Martin

Nongovernment Organization Perspective 6
Stanley E. Senner

Prospects for Neotropical Migratory Bird Conservation in Canada 8
J.S. Wendt

Closing the Gap Between Research and Management 12
Deborah M. Finch and Marcia Patton-Mallory

Population Trends and Management Opportunities for Neotropical Migrants 17
Chandler S. Robbins, John R. Sauer, and Bruce G. Peterjohn

Biological Diversity, Ecological Integrity, and Neotropical Migrants: New Perspectives for Wildlife Management 24
Brian A. Maurer

Birding Economics and Birder Demographics Studies as Conservation Tools 32
Paul Kerlinger

Cooperative Partnerships and the Role of Private Landowners 39
T. Bently Wigley and James M. Sweeney

Involving the Private Sector in Georgia's Conservation Initiatives for Neotropical Birds 45
Terry W. Johnson

Population Dynamics and Habitat Concerns

Are Populations of Neotropical Migrant Birds Limited in Summer or Winter? Implications for Management 47
Thomas W. Sherry and Richard T. Holmes

Stopover Habitat: Management Implications and Guidelines 58
Frank R. Moore, Sidney A. Gauthreaux, Jr, Paul Kerlinger, and Ted R. Simons

Management and Conservation of Migratory Landbirds Overwintering in the Neotropics 70
Daniel R. Petit, James F. Lynch, Richard L. Hutto, John G. Blake, and Robert B. Waide

Management Implications of Cowbird Parasitism on Neotropical Migrant Songbirds 93
Scott K. Robinson, Joseph A. Grzybowski, Stephen I. Rothstein, Margaret C. Brittingham, Lisa J. Petit, and Frank R. Thompson

Incorporating Effects of Natural Disturbances in Managed Ecosystems 103
John T. Rotenberry, Robert J. Cooper, Joseph M. Wunderle, and Kimberly G. Smith

Prioritizing Regional Species of Concern

The Partners in Flight Species Prioritization Scheme 109
William C. Hunter, Michael F. Carter, David N. Pashley, and Keith Barker

An Interactive Database for Setting Conservation Priorities for Western Neotropical Migrants .. 120
Michael F. Carter and Keith Barker

Status of Neotropical Migrant Landbirds in the Midwest: Identifying Species of Management Concern 145
Frank R. Thompson, Stephen J. Lewis, Janet Green, and David Ewert

Neotropical Migratory Landbird Species and Their Habitats of Special Concern Within the Southeast Region 159
William C. Hunter, David N. Pashley, and Ronald E. F. Escano

Status of Neotropical Migratory Birds in the Northeast: A Preliminary Assessment 172
Charles R. Smith, Diane M. Pence, and Raymond J. O'Connor

Monitoring Bird Populations and Habitats

Monitoring Neotropical Migrants on Managed Lands: When, Where, Why 189
Sam Droege

Overview of National Bird Population Monitoring Programs and Databases 192
Gregory S. Butcher, Bruce Peterjohn, and C. John Ralph

Designing and Implementing a Monitoring Program and the Standards for Conducting Point Counts 204
C. John Ralph

The Monitoring Avian Productivity and Survivorship (MAPS) Program: Overview and Progress 208
David F. DeSante, Oriane E. Williams, and Kenneth M. Burton

EMAP and Other Tools for Measuring Biodiversity, Habitat Conditions, and Environmental Trends 223
Eric M. Preston and Christine A. Ribic

A Checklist Approach for Monitoring Neotropical Migrant Birds: Twenty-year Trends in Birds of Québec Using ÉPOQ 229
André Cyr and Jacques Larivée

Evaluation of Mist-netting, Nest-searching and Other Methods for Monitoring Demographic Processes in Landbird Populations 237
Nadav Nur and Geoffrey R. Geupel

Organizational Monitoring Goals and Programs

Monitoring Goals and Programs of the U.S. Fish and Wildlife Service 245
John R. Sauer

U.S. Forest Service Goals and Programs for Monitoring Neotropical Migratory Birds 252
Patricia Manley

Integrated Natural Resource Monitoring on Army Lands and its Application to Conservation of Neotropical Birds 258
Timothy J. Hayden and David J. Tazik

Monitoring Goals and Programs of the Bureau of Land Management 265
Terrell D. Rich

A Western State Perspective on Monitoring and Managing Neotropical Migratory Birds........ 269
Frank Howe

Virginia's Monitoring Goals and Programs: An Eastern State Perspective 272
Dana Bradshaw

Monitoring Bird Populations: The Role of Bird Observatories and Nongovernmental Organizations.. 275
Geoffrey R. Geupel and Nadav Nur

Land Use Practices and Neotropical Migrants

Effects of Temperate Agriculture on Neotropical Migrant Landbirds 280
Nicholas L. Rodenhouse, Louis B. Best, Raymond J. O'Connor, and Eric K. Bollinger

Effects of Livestock Grazing on Neotropical Migratory Landbirds in Western North America... 296
Carl E. Bock, Victoria A. Saab, Terrell D. Rich, and David S. Dobkin

Effects of Pesticides and Contaminants on Neotropical Migrants 310
Nicholas W. Gard, Michael J. Hooper, and Richard S. Bennett

Effects of Land Use Practices on Neotropical Migratory Birds in Bottomland Hardwood Forests 315
David N. Pashley and Wylie C. Barrow

Effects of Land Use Practices on Western Riparian Ecosystems............................... 321
David J. Krueper

Habitat Fragmentation in the Temperate Zone: A Perspective for Managers 331
John Faaborg, Margaret Brittingham, Therese Donovan, and John Blake

Migrant Songbirds, Habitat Change, and Conservation Prospects in Northern Petén, Guatemala: Some Initial Results 339
David F. Whitacre, Julio Madrid M., Ciriaco Marroquín, Mark Schulze, Laurin Jones, Jason Sutter, and Aaron J. Baker

Adding a Landscape Ecology Perspective to Conservation and Management Planning 346
Kathryn E. Freemark, John R. Probst, John B. Dunning, and Sallie J. Hejl

Silvicultural Options for Neotropical Migratory Birds 353
Frank R. Thompson III, John R. Probst, and Martin G. Raphael

Management of New England Northern Hardwoods, Spruce-Fir, and Eastern White Pine for Neotropical Migratory Birds 363
Richard M. DeGraaf, Mariko Yamasaki, and William B. Leak

Effects of Silviculture on Neotropical Migratory Birds in Central and Southeastern Oak Pine Forests 374
James G. Dickson, Frank R. Thompson III, Richard N. Conner, and Kathleen E. Franzreb

Effects of Silvicultural Treatments on Forest Birds in the Rocky Mountains: Implications and Management Recommendations... 386
Richard L. Hutto, Sallie J. Hejl, Charles R. Preston, and Deborah M. Finch

Conflicts and Solutions for Integrating Neotropical Migratory Birds with Management of Other Wildlife

Protection of Neotropical Migrants as a Major Focus of Wildlife Management 392
Lawrence J. Niles

Antelope, Sage Grouse, and Neotropical Migrants 396
Reg. Rothwell

Integrating Management of Forest Interior Migratory Birds With Game in the Northeast 402
Glenn D. Therres

Wapiti and Warblers: Integrating Game and Nongame Management in Idaho 408
C. R. Groves and J. W. Unsworth

Integration of Neotropical Migrant Bird Conservation into Other Resource Management Activities in the Midwest

Information Needs for Forest Songbirds: The Minnesota Approach 418
Lee A. Pfannmuller

Integrated Resource Management for Grassland Birds in Wisconsin 419
Gerald Bartelt

Integration of Neotropical Migrant Birds into Natural Resource Planning and Research in Missouri 419
Brad Jacobs

Landscape Scale and Pattern - Implications for Management of Neotropical Migrant Birds and Forest Openings in the Hoosier National Forest, Indiana 420
Monica J. Schwalbach

Summary of Southeastern Group Breakout Sessions 421
Bob Ford and Charles P. Nicholson

Integrated Wildlife Management: Western Working Group 422
Moderated by Beaumont C. McClure

Introduction

Deborah M. Finch[1] and Peter W. Stangel[2]

The future for neotropical migratory birds rests with our commitment and ability to provide them adequate habitat during all periods of their life cycle. Our commitment to this cause is apparent in the groundswell of interest in neotropical migrants and the many proactive and cooperative partnerships resulting from the *Partners in Flight - Aves de las Americas* Neotropical Migratory Bird Conservation Program. Our commitment will be tested, however, by the need to balance competing priorities and demands, i.e., for jobs; commercial resources such as wood, livestock, minerals, and land; recreation and scenic beauty; clean air, water, and space; and other wildlife such as game. To be successful, we will need to continually renew and strengthen this commitment, while seeking creative, flexible, and cooperative approaches for addressing multiple human concerns.

Our ability to provide adequate habitat for neotropical migratory birds on lands under different ownerships and uses is the subject of this volume. It represents the proceedings of a National Training Workshop held at Estes Park Center, YMCA of the Rockies, in Estes Park, Colorado, from 21 to 25 September, 1992. The total tally of participants, over 700 people, is a true affirmation of the workshop's timeliness and value. The conference was the first major training event of its kind that dealt exclusively with neotropical migratory landbirds, and that was designed to address the multitude of interests and needs of natural resource managers, researchers, educators, industry representatives, and environmentalists. Its primary purpose was to bring together researchers and resource managers to discuss the challenges and problems, solutions and alternatives, for conserving neotropical migratory birds. If the tremendous interest in neotropical migratory birds is a true indication of our commitment to conserve these species and their habitats, then this volume will find its place on every natural resource manager's bookshelf alongside classic wildlife management books such as *Wildlife Habitats in Managed Forests* (Thomas 1979), *The White-tailed Deer: Ecology and Management* (Hall 1984), *Wildlife 2000, Modeling Habitat Relationships of Terrestrial Vertebrates* (Verner et al. 1986), and *The Wild Turkey: Biology and Management* (Dickson 1992).

Conserving viable populations of migratory species may seem impossible when we consider that only 7% to 8% of available lands in the United States have been set aside as nature preserves, wilderness, refuges, sanctuaries, and parks (Salwasser 1989). Most other lands are privately owned, or managed for multiple uses by states, counties, cities, or federal natural resource agencies such as the U.S. Forest Service and Bureau of Land Management. Yet, such multiple-use lands serve as invaluable reservoirs of habitat for biological diversity (Norse et al. 1986), to which neotropical migratory birds contribute greatly. And, during the last decade, public expectations that populations of endemic, endangered, and migratory species be conserved have risen exponentially. In response to the growing problems facing wildlife species and to changes in public interest and involvement, natural resource agencies are undergoing major shifts in management philosophy and practice.

Managing habitat for neotropical migratory birds is both a challenge and an opportunity. Resource managers may wince when weighing options for managing the diverse needs of dozens of species, many of which are rare or uncommon, present for only a few months each year, and whose ecological needs are not always well-known. But private, state, and federal landowners are coming to realize that managing for single resources, such as wood products, livestock, or minerals, or single species, such as game species, endangered species, and charismatic species, is costly, time-consuming, and potentially in conflict with sustaining other resources and species. Our hope is that this workshop and its products will inspire managers and researchers to cooperate more closely together in developing and transferring information for conserving multiple species on managed lands.

Including diverse assemblages of neotropical migratory birds in management goals may be one approach for creating and maintaining more ecologically balanced habitats. Habitats used by neotropical migratory birds range widely from early to late successional stages; from prairie to shrubsteppe to forest; from nature preserves to industry-owned lands; and from Canada to South America. Protected habitats such as National Parks and privately owned wildlife sanctuaries have great value not only as habitats, but as laboratories for learning about the habitat needs of individual species, and for drawing comparisons to managed lands. Realistically, however, they alone are not adequate to support viable populations of most neotropical migratory birds. Instead, most conservation will take place on altered landscapes, from large public properties such as national

[1] *U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Southwest Forest Science Complex, 2500 S. Pine Knoll Dr., Flagstaff, AZ 86001.*

[2] *National Fish and Wildlife Foundation, 1120 Connecticut Ave., Suite 900, Washington, DC 20240.*

forests and state parks, to wildlife management areas, commercial forests and rangelands, greenbelts, non-industrial private lands, city lots, and private backyards. The information contained in this volume will provide managers of these properties with a wealth of information to improve and create habitat for neotropical migratory birds, as well as temperate migrants and nonmigratory resident birds.

Patterns of population declines and endangerment of migratory birds and other species are detected at larger observational scales than those traditionally used to manage lands. To compare and adjust patterns of land use to changing levels of biological resources, we need to recognize a multiplicity of management scales. The size of a management unit (e.g., a stand of trees, a forest district, a national refuge) may be too small or restrictive for effectively detecting severe population changes or for managing habitats for migratory species and regional biological diversity. Shifting to larger geographical scales allows us to account for and sustain integral parts and processes of landscapes and ecosystems. Such shifts in scope require that conservation partnerships be established across land ownerships and that new management ideas and techniques be implemented, such as those discussed in this proceedings.

The conference itself stimulated unusually high interest in neotropical migratory birds and cooperative methods to conserve them. In his opening speech, Perry Olson, Director, Colorado Department of Natural Resources, appealed to natural resource agencies, research institutions, and the private sector to develop knowledge bases and partnerships to conserve migratory birds and their habitats, using case examples from Colorado to stimulate direction. A busy schedule of talks, exhibitions, and events enlivened the conference, including: the annual business meeting of *Partners in Flight*; a full agenda of invited speakers, panels, and concurrent working sessions; a keynote address by Dr. Russell Greenberg, Smithsonian Migratory Bird Center; a poster session with 52 posters and video displays; an awards ceremony and banquet; various *Partners in Flight* regional and national Working Group meetings; planned and impromptu meetings of governmental and private groups; state and federal agency socials; a video-taping interview of selected speakers; and a final day of concurrent field trips to local Colorado bird hotspots and ecologically sensitive areas.

During the awards ceremony and banquet, *Partners in Flight* appreciation plaques were presented to the Program Committee co-chairs, Deborah Finch and Tom Martin, and to the Local Arrangements Committee, Dick Roth and Stephanie Jones, co-chairs, and members, Rick Bonney, Mike Carter, Jeff Conner, Bob Hamre, and Susan Skagen. Chairs and co-chairs of the eight regional and national *Partners in Flight* Working Groups, and *Partners in Flight* organizational coordinators, were also awarded with plaques for their outstanding contributions to *Partners in Flight* over the past two years. Dana Bradshaw, Virginia Department of Game and Inland Fisheries won the 1992 Zeiss Binocular award for the best neotropical migratory bird monitoring project implemented under the *Partners in Flight* umbrella.

Authors of this proceedings were invited to submit manuscripts outlining the status of neotropical migratory landbirds, and describing methods and options for managing and monitoring populations and habitats. Thus, proceedings papers identify gaps in our knowledge of species' requirements; recommend management approaches that are new, modified, or integrated with other strategies; and stimulate the research necessary to effectively manage neotropical migratory birds and their habitats. Papers focus on breeding habitat in the United States and to a lesser extent Canada and Mexico, with some information on habitat needs at migratory stop-over areas. Critical habitat requirements during the nonbreeding season have not been ignored, but rather will be the focus of similar workshops and conferences to be held on the nonbreeding grounds themselves.

Authorities in avian ecology, conservation, and habitat management were invited to author and co-author papers in their areas of expertise. In many cases, multiple experts were requested to unite their thoughts and differing viewpoints by co-authoring papers on invited topics. Before submitting papers, authors were asked to have their manuscripts reviewed by a minimum of two peers. Upon submission, the proceedings co-editors reviewed each manuscript and returned them to authors for revisions. Each published paper therefore went through several drafts. In two cases (Whitacre et al., and Cyr and Larivee), poster presenters were invited to submit papers to help round out the international picture for neotropical migratory birds. In addition, some authors were requested to submit two papers, a review chapter for a book to be published by Oxford University Press and a shorter paper for the proceedings that focused on management options.

This proceedings is broken down into seven sections. Part I, *Changing Values and Partners in Flight* introduces readers to the history and status of *Partners in Flight* from the perspectives of United States governmental agencies, nongovernmental institutions, and Canadian organizations. This is followed by philosophical and imaginative papers emphasizing the need for increased cooperation between researchers and natural resource managers, conservationists and private industry, birdwatchers and landowners. A pivotal paper discussing declining population trends of many neotropical migrant species underscores the reasons why we need to expand and merge our ecological, sociological, and economic thinking. The papers in this section suggest that by evaluating unique socioeconomic opportunities, and by consciously integrating human needs into our efforts to conserve neotropical migratory birds and biological diversity, the future for migrants may indeed be bright.

Part II, *Population Dynamics and Habitat Concerns*, provides overviews of issues, problems, habitat limitations, and management options for neotropical migrants during breeding, migration, and nonbreeding periods. The majority of papers in this proceedings emphasize conservation and management concerns during the breeding period, so rather than include a recapitulation of breeding concerns in this section, a specific breeding season issue - cowbird parasitism - is highlighted.

Part III, *Prioritizing Regional Species of Concern*, is a special section prepared by the four regional Working Groups of *Partners in Flight*. Prioritized lists of species of management concern were formulated for neotropical migratory birds inhabiting four geographic regions: West, Midwest, Southeast, and Northeast. We recommend that those interested in applying the prioritization scheme consult with Partners in Flight regional or state working groups and state fish and wildlife agency coordinators. Note that the regional affiliations of states are the same as those defined by the International Association of Fish and Wildlife Agencies. An overview paper by Chuck Hunter, Mike Carter, David Pashley, and Kieth Barker explains how the prioritization strategy works and why it was needed. At the request of the *Partners in Flight* oversight committees, this paper received extensive scientific review by the Technical Review Subgroup of the *Partners in Flight* Research Working Group to insure that the prioritization scheme was technically sound. We thank David Capen, University of Vermont, for arranging the technical review. Before implementing the results of regional priority lists, we recommend that readers develop a solid understanding of the scheme itself, keeping in mind that priorities will shift as populations of species recover or change, as new knowledge accumulates, and as humans redefine their needs and concerns. The authors and the editors view the prioritization scheme and resulting regional lists as working models, subject to modification or replacement. Also, readers should be aware that species requiring high priority attention within specific states and physiographic areas may not be directly discerned through regional lists. As such, we urge managers and biologists to use regional lists wisely when planning projects, communicating closely with other agencies and landowners, and adhering to the philosophy of "adaptive management". We also emphasize that the priorities for nonmigratory bird species and animal groups other than birds were not defined here, but that these species, and especially endemic, endangered, and sensitive species, must be considered and prioritized alongside migratory species.

Part IV, *Monitoring Bird Populations and Habitats*, explains why monitoring programs and databases for neotropical migratory birds are needed, and describes strategies, standards, and techniques for implementing them on the breeding and nonbreeding grounds. Specific methods for monitoring and counting breeding birds, such as point counts, mist-netting, and nest searches, are discussed in depth in individual papers. Examples of standardized monitoring programs used in Canada and the United States are also described. For additional recommendations on monitoring, please refer to the Monitoring Working Group's 1992 Monitoring Needs Assessment for Neotropical Migratory Birds, published by *Partners in Flight* and available from Cornell Laboratory of Ornithology.

Part V, *Organizational Monitoring Goals and Programs,* is comprised of papers contributed by invited panelists, each of whom reviewed plans and strategies for monitoring neotropical migratory birds established by his or her specific organization. Papers are presented by representatives of U.S. Fish and Wildlife Service, U.S. Forest Service, Bureau of Land Management, U.S. Department of Defense (Army), and state fish and wildlife agencies. While the Environmental Protection Agency was also represented on the panel, its written contribution was included in Section IV. Western and eastern state perspectives were provided by state agency representatives from Utah and Virginia. Completing this section is a paper by ornithologists of the Point Reyes Bird Observatory on the monitoring capacities of nongovernmental organizations and bird observatories.

Part VI, *Land Use Practices and Neotropical Migrants*, is an important and lengthy section that identifies and reviews the relationships between neotropical migratory birds, land use, and habitat patterns. Discussed in detail are various management options for lands that have been converted to agricultural crops or for multiple-use lands where livestock grazing and silviculture are dominant practices. The problems migrants face in relation to toxic chemicals are also discussed, and it is our hope that more research on regional levels of pesticide use and exposure will be initiated on both the breeding and nonbreeding grounds. New perspectives are given on habitat fragmentation and management approaches at the landscape level. Finally, because silvicultural practices vary widely by region, Section VI ends with three papers on regional alternatives for forest management.

Part VII, *Conflicts and Solutions for Integrating Neotropical Migratory Birds with Management of Other Wildlife*. This section focuses on the need to integrate conservation of neotropical migrants with that of other wildlife species, particularly game species. This topic is of special interest to state wildlife agencies, whose financial support for conservation projects comes primarily from hunters. Several authors provide regional case studies that explore ways to integrate management for neotropical migrants with dominant game or endangered species. To accommodate growing concerns about conserving biological diversity, including over 250 neotropical migrant species, emphasis must shift from traditional single species methods for managing habitats and populations to multi-species approaches. Concurrent breakout sessions on this topic followed oral presentations, and session summaries by three regional Working Groups conclude the chapter.

This volume is far from exhaustive. Many basic questions, such as the minimum habitat area required to support particular species, macro- and micro-habitat requirements necessary for successful reproduction, importance of forest interiors, and a host of other important issues remain unclear. Many users of this volume should be surprised, however, by how much we do know and what can be done now to improve environmental conditions for migratory birds. A companion product of the workshop is a book soon to be published by Oxford University Press entitled *Ecology and Management of Neotropical*

Migratory Birds: A Review and Synthesis of the Critical Issues. Invited chapters of the Oxford book review and collate existing knowledge on the ecology of neotropical migratory birds.

With this proceedings as a starting point, we recommend that *Partners in Flight* Working Groups now take a coordinating role to fine-tune management recommendations via training workshops sponsored at regional, state, and local levels. Stimulated by enthusiasm and interactions at the conference, state working groups have formed throughout the United States, assuming leadership roles to coordinate Partners in Flight. Management programs for neotropical migratory birds are being implemented, but have not reached the scale necessary to maintain viable populations of many species. Management of these species can no longer be ignored due to lack of interest or information. Much remains to be learned, but plenty can be done right now. We hope this proceedings will stimulate managers to incorporate neotropical migratory birds into their plans.

LITERATURE CITED

Dickson, J.G. 1992. The Wild Turkey: Biology and Management. Stackpole Books. Harrisburg, PA. 463 p.

Hall, L.K. 1984. White-tailed Deer: Ecology and Management. Stackpole Books, Harrisburg, PA. 870 p.

Norse, E.; Rosenbaum, J.; Wilcove, D.; Wilcox, B.; Romme, W.; Johnston, D.; Stout, M. 1986. Conserving biological diversity in our national forests. The Wilderness Society, Washington, D.C.

Salwasser, H. 1989. Conserving biological diversity in the national forests: An overview of the issue and approaches to its attainment. Staff Paper. USDA Forest Service, Washington, D.C.

Thomas, J.W., ed. 1979. Wildlife Habitats in Managed Forests: The Blue Mountains of Oregon and Washington. U.S. Department of Agriculture, Forest Service, Agriculture Handbook Number 553. U.S. Government Printing Office, Washington, D.C. 512 p.

Verner, J.; Morrison, M.L.; Ralph, C.J. eds. 1986. Wildlife 2000, Modeling Habitat Relationships of Terrestrial Vertebrates. University of Wisconsin Press, Madison, WI. 470 p.

Partners in Flight: Past, Present, and Future

A Government Perspective

John G. Rogers, Jr.[1], Thomas J. Dwyer[2], and Catrin Martin[2]

On behalf of the fourteen Federal agencies represented on the Federal Neotropical Migratory Bird Conservation Committee, welcome to this first national workshop on management of neotropical migratory birds. The response and interest in this workshop and *Partners in Flight* has been tremendous. Your participation this week is evidence of the serious commitment of your agencies and organizations, and you personally to this effort.

An exciting new development for *Partners in Flight* is the formation of a State Agency Committee to facilitate State natural resource agency involvement. On Monday, the State committee met for the first time in joint session with the Federal and NGO Committees. They are a welcome addition to our committee structure. The States are vital players in this effort, in large part because much of the really important management and conservation work occurs at the local level, on the ground, where states have the expertise and the relationships with landowners to put the objectives of *Partners in Flight* into action. Most of these state wildlife resources agencies are represented here today.

States have long been leaders in nongame conservation efforts and are making valuable contributions to *Partners in Flight*. Active participants in regional and technical working groups, many States are taking this commitment a step further by the creation of individual and joint State working groups. Examples of State commitment include Wyoming, where a new state working group is in action, priorities include the development of monitoring programs and management strategies. In Alaska, summer home of many of our boreal breeding birds, groups are also well organized in a newly formed Alaska *Partners in Flight*. Important research and management is also occurring on state and private lands. In the Northeast, the Mid-Atlantic Migratory Bird Corridor Study is adding to our knowledge of migratory habitat use patterns. In Minnesota, a cooperative venture is underway to develop and implement a landscape management program to protect the avian diversity of that state's northern forests.

The Federal Committee continues to grow. There are now fourteen Federal agencies that are parties to this program. Our newest members are the Tennessee Valley Authority and the Bureau of Reclamation. All fourteen are represented here. Our Federal partners have many roles to play in *Partners in Flight*. The responsibilities range from Congressional mandates and regulatory authorities for migratory birds, to stewardship of millions of acres of public lands such as national forests, parks and rangelands; protection of the nation's land, air and waters from environmental contaminants; national defense; economic assistance to developing countries; and educational outreach efforts.

Upon reviewing the list of participants, most will agree that this is one of the most impressive partnership efforts ever undertaken in the conservation of natural resources. Our collective efforts have great potential. Individual Federal agency efforts are already too numerous to list. The following representative sample of agency activities speaks to the dedication of the Federal agencies involved in *Partners in Flight*.

The Forest Service has developed a Sister Forest Partnership Program that will serve an important function as we expand our outreach into Latin America. National Forests in Texas are linked with Panama, and Cherokee National Forest in North Carolina with Jamaica. Training has been identified as the greatest need, with emphasis on integrated resource planning, fire management and agro-forestry techniques. Outreach programs such as these provide a firm foundation for future international cooperation.

As a lead agency in this initiative, the Fish and Wildlife Service has been implementing management, monitoring and research projects continent-wide. The depth of Service commitment was demonstrated by placement of migratory nongame bird coordinators in each regional office and a full-time neotropical migratory bird coordinator in Washington D.C. In cooperation with State, Federal and nongovernmental partners, the Service has funded a minimum of 108 different projects in 34 states, as well as 15 projects in Mexico. In addition, the geographic coverage of the North American Breeding Bird Survey was expanded by adding 250 additional survey routes.

The Bureau of Land Management has put together a comprehensive Nongame Migratory Bird Habitat Conservation Plan, with neotropical migrants figuring prominently in the

[1]*John G. Rogers, Jr., U.S. Fish and Wildlife Service, 500 Gold Avenue, SW, Room 3018, Albuquerque, NM 87102*

[2]*Thomas J. Dwyer and Catrina Martin, 1849 C Street, NW, 634 Arlington Square, Washington, DC 20240*

strategy. They have also hired a full-time coordinator to oversee implementation of this plan. One of the habitat management projects with direct benefit to neotropical migrants is restoration and management of sensitive riparian habitats in the southwest. This includes planting native trees, fencing riparian wetlands, evaluating and redesigning grazing systems, and providing artificial nest structures.

The Department of Defense is also an active participant in natural resources conservation. With stewardship responsibility for over 25 million acres of land, conservation and management of natural resources is a high priority. With several installations participating in such projects as Monitoring Avian Productivity and Survivorship, the military continues to make significant contributions to research and monitoring efforts for neotropical migrants.

The Environmental Protection Agency (EPA) is well known for its role in improving and maintaining environmental quality. As an active member agency of *Partners in Flight,* EPA has dedicated a significant amount of funding to information and education efforts. In the months to come, EPA, in cooperation with other partners, will be working to develop outreach materials concerning impacts of various land uses on neotropical migrants for distribution to land use planners and developers.

Those are but a few of the many activities that governmental partners are undertaking. Although our agency missions may differ, our concern for and commitment to this resource is a common bond. Neotropical migratory bird conservation offers all of us the opportunity to address the needs of a declining resource.

Management of neotropical migrants brings us together this week. How do we manage them? Where do we start? What are our priorities? These questions and more will be addressed in the days to come, and many more will be asked. As we continue to work together, I think you will find that our diversity as agencies and individuals is our greatest strength. Today, conservation of migratory birds is, and will continue to be, a complicated and challenging mission. The international and hemispheric dimension of *Partners in Flight* offers an opportunity for cooperative, international conservation on a scale seldom seen. There are many questions to answer and much work to be done. Collectively, we have the expertise, the personnel and the motivation to answer questions and meet challenges offered this week and in weeks to come.

Nongovernment Organization Perspective

Stanley E. Senner[1]

More than 20 nongovernmental organizations have signed a memorandum of understanding committing them to participate in *Partners in Flight*. Several more organizations will be signing the memorandum in the near future. Others may never sign the agreement but are contributing substantially to the program.

Partners in Flight was the brainchild of Amos Eno at the National Fish and Wildlife Foundation, and Amos, Peter Stangel, and the other foundation staff deserve enormous credit for the enterprise they launched. Although the program is innovative, the concept underlying it is simple: The problems confronting migratory birds today--to say nothing of the environment in general--are so complex and are of such broad scale that no single agency or organization operating on its own can address them successfully.

Cooperation and partnerships are required if significant and lasting results are to be achieved. Indeed Congress recognized this fact in its 1988 amendment to the Fish and Wildlife Conservation Act (P.L. 100-653), which directs the Secretary of the Interior to undertake research and conservation activities to benefit migratory nongame birds "in coordination with other Federal, State, international and private organizations..." *Partners in Flight* is exactly that--a cooperative enterprise among Federal, State, international, and private organizations.

There are many different types of participants in *Partners in Flight*: governmental and nongovernmental, state and federal, corporate and environmental, regulatory and military, and regional, national, and international. Different participants bring different mandates and perspectives, and there are many issues that divide us. One need only mention the spotted owl (*Strix occidentalis*), for example, to bring those differences to the surface.

Through *Partners in Flight* we have the chance to rise above the issues that divide us and apply our collective resources and expertise on problems for situations that are not yet highly polarized. This is not to say that there are no crises and difficult decisions in the conservation and management of neotropical migratory birds. But for the most part there is time--albeit not a lot of time--to be preventative rather than only reactive in our approach.

With that brief perspective, I offer comments on five issues to stimulate your thinking during the course of this meeting:

[1]*National Audubon Society and International Council for Bird Preservation-US Section, 4150 Darley Avenue, Suite 5, Boulder, Colorado 80303.*

KEEP COMMON BIRDS COMMON

The fundamental goal of *Partners in Flight* is to maintain and restore bird populations; we should strive for no less. Putting it another way, "how can we keep common birds common?"

Sometimes there is no choice but to focus on those species that are rare and endangered. There may be a tendency, however, to place too much weight on rarity in determining priorities for conservation and management. Traditionally, except for species that were hunted or endangered, no one but ornithologists and birdwatchers paid attention to the still-common birds (e.g., Senner 1986, 1988).

We know that abundance per se is no safeguard against extinction. The cases of the passenger pigeon (*Ectopistes migratorius*), Carolina parakeet (*Conuropsis carolinensis*), and Eskimo curlew (*Numenius borealis*) are illustrative. We also know that waiting until a species is a "basket case" may mean that the necessary recovery efforts are controversial and costly. The California condor (*Gymnogyps californianus*) is a case in point. Unfortunately, we also know that last-ditch rescue attempts are often unsuccessful, as was true for the now extinct dusky seaside sparrow (*Fringilla maritima nigrescens*).

I worked for a number of years at Hawk Mountain Sanctuary in Pennsylvania. In 1978, Hawk Mountain recorded 21,488 broad-winged hawks (*Buteo platypterus*) migrating overhead in a single day. This past year, 1991, only 5,854 were recorded during the entire season (Goodrich 1992). Unfortunately, the 1991 season was not an anomaly: it has been more than a decade since Hawk Mountain had a really good broadwing flight. The point is that we want to preserve this phenomenon of abundance. If the broadwing population drops so far that Hawk Mountain records only one thousand or so broadwings in season, then we already will have lost the battle, even though the species may not be considered endangered or even rare.

ACHIEVE RESULTS ON THE GROUND

If we are to keep common birds common, *Partners in Flight* must achieve on-the-ground benefits for bird populations. Achieving such results is its true measure of success. We can monitor and study birds, and we can inform and educate the public about conservation needs, but these actions are only means to an end. The goal is to maintain and restore bird populations, and we now know enough about the status and requirements of most species to take beneficial actions, especially to manage and protect their habitats.

ESTABLISH PROGRAM-WIDE PRIORITIES

The Federal Interagency-Nongovernmental Organization-State joint committee recognizes the importance of achieving on-the-ground results for neotropical migrants. Through a newly-adopted Charter and Implementation Plan, the joint committee has agreed to work with the regional and technical working groups to identify a list of national priority projects annually for *Partners in Flight*. We then will work with participating agencies and organizations to obtain the commitments, funds, or other resources needed to carry them out. This process should result in the implementation of more projects, and, secondarily, will give us a scorecard with which to evaluate our progress each year.

INCORPORATE INTERNATIONAL PERSPECTIVE

The thrust of this national training workshop is management in North America, and this is appropriate. Yet, no matter how much we achieve here in North America, our efforts may come to naught if problems on the wintering grounds are responsible for a species' decline. All of us then must strive to broaden our thinking--and share our resources--beyond this continent. If *Partners in Flight* is to be successful, we must achieve on-the-ground results, not only in North America, but also in Latin America and the Caribbean.

VARIED ROLES FOR NONGOVERNMENTAL ORGANIZATIONS

Lastly, regarding the role of nongovernmental organizations, our roles are as diverse as are our organizations. Among participating entities, including industry, there is tremendous expertise in ornithology and ecology, education, forest management, public policy, habitat protection and management, and "grassroots" organizing. Further, our experience and expertise exist at regional, national, and international levels. In the case of the National Audubon Society, we believe that the most important contribution we can make to *Partners in Flight* is to encourage the full participation of our 518 chapters at the local, state, and regional levels. Not incidentally, those chapters include eight groups in Central and South America.

In closing, I am excited about *Partners in Flight*. Having spent nearly 20 years in the business of conserving migratory birds, I never have seen a higher level of activity among governmental agencies and nongovernmental organizations than I have seen since this program was launched. Collectively, you will find that we--nongovernmental organizations--are eager to roll up our sleeves to identify and share in the burden of implementing projects that will benefit neotropical migrants.

That is why I am here, and I look forward to meeting and working with many of you during the course of this week and beyond.

ACKNOWLEDGMENTS

I thank Linda Leddy, Manomet Bird Observatory, for reading an earlier draft of these remarks.

LITERATURE CITED

Goodrich, L. 1992. Fall 1991: The migration. Hawk Mountain News 76:5-15

Senner, S.E. 1986. Federal research on migratory nongame birds: is the United States Fish and Wildlife Service doing its job? American Birds 40:413-417.

Senner, S.E. 1988. Saving birds while they are still common: an historical perspective. Endangered Species Update 5:1-4.

Prospects for Neotropical Migratory Bird Conservation in Canada

J.S. Wendt[1]

INTRODUCTION

The plan for conservation of Neotropical Migratory Birds - *Partners in Flight* - appeals to many Canadians. The birds themselves are loved for their beauty, their song, their mysterious migration, and their faithful return each spring. They are valued as members of healthy ecosystems, especially when they gorge themselves on caterpillars. Canadians recognize that the conservation of migratory birds should be coordinated internationally. Countries do not own the birds, but only provide accommodation for some steps of a long journey.

Today I will discuss topics that I think are important for neotropical migratory birds in Canada. I will start with some observations on what it would mean to expand *Partners in Flight* outside the United States. I will review the Canadian Wildlife Service forest bird work, and work by others. I will talk about the Canadian forest industry, and what is being done to move it towards sustainability.

Is Canada participating in *Partners in Flight?* Although it sounds as though a yes or no answer would be appropriate, really our first response should be to ensure that the asker and the answerer understand the question in the same way. For a question such as "Am I dreaming?" the answer is not important until we agree, at least somewhat, on the symptoms that identify this psychological state. The question about Canadian involvement in *Partners in Flight* also needs further definition because, as yet, this initiative has no agreed shape or context outside the United States. Therefore, I propose a list of 6 symptoms that would be evidence of meaningful involvement by Canada.

SYMPTOMS OF COOPERATION IN *PARTNERS IN FLIGHT*

1. Setting International Objectives for the Conservation of Neotropical Migratory Birds

The Canadian Wildlife Service and the U.S. Fish and Wildlife Service are responsible for ensuring that their countries observe the Migratory Birds Convention. The Convention states that these birds should not be hunted. But they have no greater plan for the conservation of nongame birds; they don't even use the same lists of birds protected under the Convention. As a first step, Canada and the U.S. should try harder to develop cooperative recovery efforts for threatened and endangered species. Beyond this, they should work on a common vision for all nongame birds. They should try to make an explicit statement

[1]J.S. Wendt, Canadian Wildlife Service, Environment Canada, Ottawa, Ontano K1A 0H3 819-953-1422.

of what they consider to be responsible management of nongame birds. This would help reduce the largely arbitrary approach now taken for the valuation of wildlife in natural areas.

2. Common Outreach, Marketing

Government agencies love to demonstrate that they are working with partners in joint ventures. The *Partners in Flight* Newsletter has done a fine job highlighting Canadian Wildlife Service projects, for which we are grateful. We also know that there are limits to the common marketing approach. Most non-government organizations survive by voluntary donations in a very competitive environment. They have to be cautious about a united appeal. At present some Canadian organizations may question the value of close association with *Partners in Flight* in their funding drives. One example is the Bring Back the Birds program that Conservation International Canada is promoting. Of course, these people want to cooperate fully with the implementation of *Partners in Flight.* At the same time they need to establish funding and build a program, and for this they need a degree of independence. They must also tailor their activities to the views and wishes of their supporters. Our challenge will be to provide the benefits that a common approach will bring, without imposing costs.

3. Coordination of Research and Monitoring in Breeding Areas

The Breeding Bird Survey has been a joint project of CWS and the USFWS since 1966. Canadian attendance at U.S. *Partners in Flight* meetings has been very valuable. However, it is not practical for Canadians to participate to a great extent in the U.S. meeting schedule, so the main mechanism for coordination is still the traditional contact between the U.S. Fish and Wildlife Service and the Canadian Wildlife Service. *Partners in Flight* is helping - the Canadian Wildlife Service is planning to increase its investment in migration monitoring, and *Partners in Flight* contacts will ensure a greater degree of coordination.

4. Coordination of Neotropical Research and Conservation Efforts

Many Canadian institutions (government, academic, development aid) are involved in research and conservation in Latin America. The Canadian Wildlife Service has its own small but beautiful Latin American Program. There is now little Canada/U.S. coordination of this activity for benefits to wildlife. This could be an important role for *Partners in Flight.*

5. Involvement in Joint Funding

The National Fish and Wildlife Foundation has helped the Canadian Wildlife Service support work on neotropical birds in the Caribbean, and has shown interest in projects in Canada. Some non-government and United Nation organizations coordinate funding among countries for a variety of nature conservation objectives. These examples do not preclude the generalization that Canadian and U.S. partners do not have a joint approach to funding. More fundamentally, we do not have a joint understanding of the basis for such funding.

Canada and the United States share concern for the welfare of neotropical migrants in Latin America. To what extent do they share concern for what happens here in the north? Consider two questions. What would it mean to the United States if the breeding populations of warblers in Canada were reduced by half? (Canada has about 90% of North America's boreal forest habitat.) What would it mean to Canada if the U.S. could not maintain breeding habitat for Prothonotary, Blue-winged, and Golden-winged warblers near the Canadian border? (These are 3 species with only limited range in Canada, that may exist there only because of larger nearby U.S. populations). Questions of this kind, with ducks and geese as the subjects, helped establish the North American Waterfowl Management Plan. In the case of game birds with exploited populations, the answers are quite straightforward and easily explained to a large part of the public. For neotropical migrants, the answers are not so obvious, and not so easy to explain to others, partly because there is less common understanding of what people value in nongame birds.

6. Development of a Parallel Organization In Canada to *Partners in Flight*

I have left this symptom of Canadian participation in *Partners in Flight* until last, because I feel that real cooperative activity is more important than outward, visible signs. Organization of Canadian effort in *Partners in Flight* will develop, but it may use some different terminology and different structure than what is familiar in the U.S. Canadian wildlife non-government organizations have indicated that they will back a Canadian implementation of *Partners in Flight.* They have indicated, however that they would want to do this according to a Canadian Landbird Conservation Strategy that would also be concerned with resident species and short-distance migrants. Forestry Canada has expressed interest in *Partners in Flight,* but their participation would naturally occur in the context of the Canada Forest Accord (see below).

At this meeting an informal network of Canadian and Alaskan biologists will be set up. It is too soon yet to say whether this will lead to a Boreal Working group for *Partners in Flight.*

Initiatives in Canada for Neotropical Migratory Bird Conservation

Much of relevance to neotropical migrants has been happening in Canada since my last report to *Partners in Flight.* Exciting changes have been taking place in the Canadian forest products industry. Within the Canadian Wildlife Service a new program for forest wildlife has developed.

Canada provides breeding habitat for large numbers of neotropical migratory birds. This habitat is also the scene of a major forest industry. Canada is the world's top exporter of pulp, newsprint, and softwood lumber, mostly to U.S. markets. It is the top producer of newsprint, the second-ranking producer of pulp (after the U.S.) and the third producer of softwood lumber (after the former USSR and the U.S.). Forest products contribute more to the Canadian balance of trade than agriculture, fishing, mining, and energy combined.

There are economic problems facing this industry. Exports are declining. The industry is "restructuring", with the result that mills in some areas are closing and unemployment is rising. Forest planners have been using sustainable yield models to determine allowable annual cuts, and the industry is falling short of this harvest by about 17%. Nevertheless, from 1986 to 1989 the commercial stock declined by about 400 million cubic meters, because of unforeseen losses to fire and insect pests[1]. Another worry for the forest industry has come from environmental groups with concerns about old growth forest, clearcutting, and forest harvest in parks and lands traditionally used by aboriginal people.

What is happening in the Canadian forest? Old growth forest is declining in British Columbia and Ontario. Over much of the country the structure of the exploited forest resembles that of land that has not been logged, at least for the 3 or 4 major trees species in any area. However, this is not true for some species, such as white pine, that have declined. Regarding the boreal forest, from 1980 to 1990 fire still accounted for loss of trees over an area about 3 times larger than that which was harvested. But major expansions of forestry into the boreal forest are underway.

In Canada, 90% of the productive forest land is owned by the public, mostly through provincial governments. This means that forest management must respond quickly to changes in public attitude. Almost 3/4 of the Canadian forest industry is controlled by Canadian-owned companies, which again facilitates response to changing attitudes. The public is demanding responsible use of the environment, and these concerns are being addressed vigorously. The use of insecticides is down, and, of these, biological controls have grown from 2% in 1981 to 62% in 1991. Mill effluents are cleaner, with decreases in total suspended solids and biological oxygen demand, and new regulations in place for dioxins and furans. The use of recycled sawmill waste has increased to 60% of the fibre for pulp and paper. Newsprint recycling has increased. Overall, the investment by government and industry in "environmental" forestry projects has increased from 8% in 1989 and 16% in 1990 to 27% in 1991[2].

In 1990 the government of Canada announced a major initiative for sustainable development, Canada's Green Plan for a Healthy Environment[3]. This led to action by several federal departments to increase the protection of the environment. Within Forestry Canada a significant new program, Partners in Sustainable Development, was allocated $100 million over six years. Of most interest to those who care about forest birds will be the Model Forests program. The model forests are to be demonstrations of the shift from sustained yield to sustainable development in large scale productive forests selected across Canada. The model forests are expected to preserve biological diversity, and environmental and social values in addition to economic values and the future productivity of the forest.

The shifts in Canadian forest policy have lead to a National Forest Strategy[4] and the Canada Forest Accord[5]. The new policy of sustainable forestry has the goal to "maintain and enhance the long term health of our forest ecosystems, for the benefit of all living things both nationally and globally...". These forest managers will surely find common ground with *Partners in Flight.*

Canada's Green Plan has also provided support for the Canadian Wildlife Service. The strategy for wildlife flows from *A Wildlife Policy for Canada*[6], which in turn refers to the World Conservation Strategy. The goals are to maintain and restore ecological processes, biodiversity, and to ensure that all uses of wildlife are sustainable.

The Green Plan has allowed a revitalized songbird conservation program to develop in the Canadian Wildlife Service. The top priorities being considered are forestry and agricultural practices (management issues), songbird population monitoring, volunteer participation (methodology), and a focus on neotropical migrant species[7]. Clearly this view coincides with *Partners in Flight.*

The need to make sense of songbird monitoring projects is typified by a review carried out recently in Ontario. There, eleven cooperative, province-wide activities are now being done, and 3 more are proposed. All 14 use volunteer participants. None are unique to Ontario, although the Forest Bird Monitoring Program, the Ontario Rare Breeding Bird Program, Project FeederWatch, and the Long Point Bird Observatory's brand of migration monitoring all have roots there. The Canadian Wildlife Service has only recently begun trying to systematically combine results from this variety of surveys to understand population trends[8].

Migratory birds that breed in the boreal forest are difficult to monitor. Access to these birds by the Breeding Bird Survey is limited by the availability of passable roads, and the shortage of volunteers in sparsely populated areas. The Canadian Wildlife Service is supporting an expansion of migration monitoring using the Long Point Bird Observatory technique at a series of sites in Canada, in an attempt to sample populations of migrants that are not counted on the breeding ground.

THE INTERNATIONAL CONTEXT

Canada signed the Convention on Biological Diversity in Rio de Janeiro in 1992. This is subject to ratification. Article 8 of the Convention discusses protected areas, regulated use of wildlife resources, and efforts to protect endangered species. Forest wildlife, and neotropical migratory birds in particular will have to figure high in Canada's implementation of the Convention. Canada's aggressive stance on the Convention typifies a growing emphasis on international conservation efforts.

Canada has moved in new directions in foreign policy respecting Latin America. It joined the Organization of American States in 1990. A strategy for the Canadian aid program in the Americas was set at that time, including emphasis on democracy and human rights, debt reduction and economic development, environmental protection, and international trade[9]. Africa and Asia dominate as recipients of Canadian aid, but the Canadian International Development Agency (CIDA) and its partners provided $343 million to the Americas in 1989. Clearly, this could be a potent force for conservation, if properly applied. In fact, CIDA is increasing its emphasis on sustainable development. A recent example was a project to help direct its activity to benefit wetlands in Central America. One non-government organization that CIDA has assisted is the Treeroots Network, which works for the "sustainability of local ecosystems through community control of trees, and forests...".

SUMMARY

The signs are positive for active participation by Canadians in many aspects of the *Partners in Flight* effort to conserve neotropical migratory birds. The Canadian forest industry is shifting from a reliance on sustained yield models, to a belief in sustainable forestry, which recognizes the value of habitat for forest birds. Canada's Green Plan has given a boost to forest wildlife programs. Canada's international programs are becoming more environmentally responsible. It still remains for the United States and Canada to create an effective mechanism to coordinate their nongame bird programs. I suggest that the two federal wildlife services draft a strategy for linking Canada to the United States via *Partners in Flight*.

REFERENCES

1. The State of Canada's Forests 1991. Second Report to Parliament. Environmental, Social and Economic Indicators. Minister of Supply and Services Canada, 1992. 85p.
2. Ibid.
3. Canada's Green Plan for a Healthy Environment. Minster of Supply and Services Canada. 1990. 174p.
4. Sustainable Forests. A Canadian Commitment. 1992. Canadian Council of Forest Ministers. 51 p. English, 51 p. French.
5. Canada Forest Accord. 1992. Canadian Council of Forest Ministers with members of the Canadian forest community.
6. A Wildlife Policy for Canada. Wildlife Minister's Council of Canada. 1990. 29p.
7. Canadian Wildlife Service Songbird Conservation Program: National overview of Issues. 1992. Canadian Wildlife Service. 38p.
8. Bird Trends. A report on results of national and regional ornithological surveys in Canada. 1991. Canadian Wildlife Service No. 1. 20p.
9. Canadian International Development Agency. Annual Report 1989-90. Minister of Supply and Services 1991. 124p English, 129p French.

Closing the Gap Between Research and Management

Deborah M. Finch[1] and Marcia Patton-Mallory[2]

Abstract — In this paper, we evaluate the reasons for gaps in communication between researchers and natural resource managers and identify methods to close these gaps. Gaps originate from differing patterns of language use, disparities in organizational culture and values, generation of knowledge that is too narrowly-focused to solve complex problems, failure by managers to relay informational needs, and failure by researchers to synthesize and package knowledge in useable forms. Information-sharing procedures that can stimulate communication among individuals in different organizations, geographical locations, positions, and disciplines include research and management reviews, information networks, research and management prioritization processes, technical assistance incentives, and demonstration projects. *Partners in Flight* can be viewed as a model program that facilitates communication and cooperation across traditional barriers.

INTRODUCTION

In government and nongovernment organizations alike, management styles and methods are changing as administrative leaders, line officers, and staff shed old ways of doing business to accommodate the environmental values and goals of a younger, more diverse, working generation. Thus, in response to public, academic, and employee demands to conserve and restore biological diversity and intact ecosystems, integrated land management approaches, such as the U.S. Forest Service's "Ecosystem Management" strategy, are being implemented by federal, state, and private organizations (Brown and Harris 1990, Salwasser 1991). New research is now focusing on spatial and temporal problems of species inhabiting managed landscapes and regions, whether the species are single or multiple, rare or common, specialized or generalized, or declining or increasing. Innovative management steps are being taken at multiple scales to mitigate species population problems related to human use of lands. However, in this new age of environmental awareness, advanced technology, and information overload, how do administrators, field managers, and policy-makers decide what methods, management designs, and institutional policies will be most effective in conserving multiple species with diverse habitat needs such as neotropical migratory birds? And how do scientists select the most critical problems in conservation research to address?

As human demands on natural resources continue to grow, and availability of native habitats for preserving biological diversity continues to decline, the necessity for increased communication between researchers and land managers has become painfully clear. Solutions for the complex environmental problems that now exist at local, national, and global scales may remain out of our reach if land managers and researchers continue to think and work apart (Davis and Ehorn 1988), divided by professional subcultures even within the same organizations. By clarifying and prioritizing management needs for research, managers can influence research direction. Likewise, research knowledge, when designed and communicated in ways that have meaning to managers, can guide management planning, prescriptions, and policy. To communicate effectively, then, resource managers and researchers must develop a common language built on mutual interest in sustaining the components and ecological linkages of natural ecosystems. This means asking the right questions; discovering scientifically-valid solutions to resource management problems; making responsible decisions that are attuned to socioeconomic factors; and implementing collaborative processes of change for a sustainable future.

[1] *Deborah M. Finch, Rocky Mountain Forest and Range Experiment Station, Forestry Scineces Laboratory, 2500 S. Pine Knoll Drive, Flagstaff, AZ 86001.*

[2] *Marcia Patton-Mallory, Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, CO 80526.*

A leading example of this kind of integrated, interactive approach to conservation is the ground-breaking program, *Partners in Flight*. Owing to the participatory nature of *Partners in Flight*, managers and scientists interested in conserving neotropical migratory birds and their habitats have opportunities to communicate and cooperate across geographical, educational, professional, and cultural boundaries. Volunteer committees and working groups of *Partners in Flight* are developed at international, national, and state levels to facilitate communication among representatives of special interest groups, agencies, and academic specialties, including ornithologists, ecologists, forest and range managers, conservationists, industry representatives, economists, educators, and extension specialists. This conference was designed to celebrate these partnerships, and especially to focus on the need for managers and researchers to communicate more often and more effectively across habitual barriers. The most important principle underlying the goals of this workshop is the notion that conservation solutions and strategies are more powerful and sound when different minds think together than when they think in isolation.

The objectives of our paper are to evaluate the reasons for the traditional gap between research and management and to identify mechanisms that help to bridge the gap. We suggest proactive steps to advance communication and describe a variety of tools to enhance the sharing, use, and value of information, particularly within the context of *Partners in Flight*.

WHY DOES THE GAP EXIST?

The research profession is in a state of transition in many government agencies, as scientists shift their emphasis from functional, single-resource studies to interdisciplinary, multi-resource team approaches (Montrey 1991). In academia, researchers in natural resource and biological disciplines are also expanding their emphasis, incorporating applied aspects to basic research designs, as evidenced by the proliferation of applied journals (e.g., Ecological Applications, Conservation Biology, and Landscape Ecology, to name a few). These philosophical shifts are related to 1) the public's increasing involvement in land management issues and their vocal demands that natural resources be sustained for future generations, 2) growing environmental problems and the need to find integrated, scientifically-valid solutions, and 3) increased informational needs of land managers who are challenged by the public and the problems.

What factors have inhibited communication between managers and researchers to begin with? While the answer is complex, it depends to some extent on historical limitations in technological communication - as knowledge has progressed, the ability to transmit, find, and apply research results has often been limited to those who can afford to travel widely to meetings or who have access to university libraries. Field managers living in remote localities (e.g., National Parks, Forests, and Refuges) have often been hampered from promptly retrieving new information due to financial and logistical constraints. It is now easier for communication to transcend geographical boundaries because our technological capability allows us to access knowledge via electronic bulletin boards, computerized information retrieval systems, and publication circulation networks. Even though technology now provides the means for complex communication networks, the gap remains. Part of the problem is that the language used by researchers frequently differs from that used by resource managers - both groups have complicated jargon that only insiders can fully understand. In addition, research may often be too basic or simplistic to supply the informational needs of land managers. More to the point, as Montrey (1991) candidly remarks, "we (researchers) didn't do a good enough job of telling our story, and more importantly, we didn't do a good enough job of listening to those whose lands these are." It is our view also that land managers have not always done a good job explaining their needs or soliciting research help.

Nicholls and Prey (1982) propose several factors that inhibit successful technology transfer, including inadequate funding, attitude, red tape, legal restrictions, and managerial resistance. In addition, there is often a time lag of 10-15 years from the time research begins until results are used (Callaham 1981). Within the wildlife biology profession, we believe the following considerations are most important in explaining why the transfer of information from researchers to managers fails:

1) Research results are typically scattered and fragmented across various publications and usually not in a form that is readily usable by managers. It takes a resource specialist to carefully synthesize and distill information into a useful package of management recommendations that can be implemented in the field.

2) We don't have a good process for identifying and prioritizing real gaps that do exist in our current state of knowledge. Such a process should include a framework where future research results can easily be incorporated with existing knowledge. This process should give guidelines for what is needed, when, why, and how it should be gathered.

3) Some research information may be of little use to managers because the results are too narrowly focused. Researchers may have an unsophisticated or narrow understanding of management issues such that the guidelines they recommend are inappropriate or fit only a piece of the puzzle. To address complex natural resource issues, knowledge from many disciplines may be required

(Beissinger 1990). To effectively conserve neotropical migratory birds, for example, it is necessary to know how to manage populations within the context of land use patterns and practices, socioeconomic factors, natural events, complications of land ownership and state/country borders, financial constraints, and national and international policy. The "value" of a migratory bird species must be considered in relation to other species, land uses, and problems. The sheer magnitude of the geographic and temporal scales used by migratory birds i.e., summer breeding grounds in North America, spring/fall migration along broad fronts and narrow corridors, winter nonbreeding grounds in Latin America, produces additional hurdles in resolving management questions.

4) Working environments may create philosophical barriers between managers and researchers. Managers who must deal with political and economic realities in day-to-day decision-making sometime view researchers as naive or arrogant in their narrow focus or unwillingness to compromise. Researchers used to operating with more academic freedom, on the other hand, may criticize managers for not confronting resistance and embracing new concepts quickly enough. The difference between the lessons one learns in a university and the training one receives in an agency job can produce a rift between academic researchers and those graduates who have gone into natural resource management. Such ideological and psychological differences can produce breakdowns in communication.

HOW DO WE BRIDGE THE GAP?

Because closing the gap between research and management is a shared responsibility, the mechanisms we identified apply to integrated activities that should be adopted by researchers and managers. Some of these ideas have already been implemented by government agencies, while others are more uniquely framed to address neotropical migratory birds.

First, managers should be involved early in the research planning process. Too often, researchers wait until the study is completed, then ask for review of manuscripts. Inviting users to be involved in the research planning process can advertise and extend the potential use of the results. The management community will be more likely to accept the results if they participated in defining the research problem and approach. In the Forest Service, for example, a broad range of users and staff are invited to comment during the development of 5-year research plans. Supervisory reviews to discuss any needed changes in direction can also be scheduled periodically.

Second, significant management plans should be reviewed for scientific accuracy by research experts early in the planning process. For example, resource management audits conducted by the Florida Department of Natural Resources have proven to be an effective way to bridge the gap between the intent and implementation of park management plans (MacLaren 1992). Technical review of the *Partners in Flight* conservation scheme for prioritizing species of concern (Hunter et al., this proceedings) is another example.

Third, information about neotropical migratory birds should be systematically shared so that issues larger than those addressed by the original study can be explored. Marx (1980) described general steps for transferring technology that are useful in a broader sense, such as matching the information to the target user group, developing an application plan, packaging the information in a useable form, selecting effective transfer media, bringing specialists and users together, arranging for troubleshooting and feedback, and evaluating the transfer process and results. Information-sharing networks and processes can be developed using media such as in-house and program-oriented newsletters, electronic mail lists and bulletin boards, subject-matter working groups, training workshops, research/management conferences, regional meetings, show-me trips, slide tape programs, publication distribution systems, and project directories. Monitoring data (e.g., bird census data, nest records, habitat inventories) can be accessed through data storage and retrieval systems, centralized data banks, and computerized data bases. Financial support for information-sharing strategies is essential to their success. Other considerations include ease of transfer, user demand and marketability, ease of application, time and personnel resources, compatibility with ongoing management methods, and degree of benefit to the user (Nicholls and Prey 1982).

Fourth, organizations need to prioritize research, monitoring, and management questions, and focus efforts on critical problems. Needs for long-term monitoring and analysis must be balanced against studies that address specific short-term issues. Where answers require consolidation of findings across specialties, multidisciplinary teams should be formed.

Fifth, researchers and research organizations must ask themselves "Do we value technical assistance as much as published research?" How willing are we as researchers to commit the time necessary for effective technical assistance when, under current performance evaluation standards, it may reduce our likelihood of achieving promotions or academic tenure? How willing are we as managers to commit the time to explore what new information is available or to commit the resources to replace existing technology? Overcoming these barriers will require that organizations develop procedures for rewarding technical assistance and management renovation. For example, credit for technical assistance and management consultations can be designed into: annual performance evaluations, research panel and tenure reviews, and cash awards. If one measure of research success is the number of problems solved (Nicholls and Prey 1982), then highlighting solutions via technology transfer will improve research value and researcher credibility.

A sixth mechanism for bridging the gap is to use demonstration areas or projects. The broad geographic concerns of migratory birds require application of knowledge across diverse habitats, ranging from boreal forests to agricultural landscapes to tropical rainforests. As demonstration areas are initiated to teach broader concepts of sustainable ecosystems, the valuable roles that neotropical migratory birds play within ecosystems should be explicitly described. For example, expanding agroforestry demonstration projects to include neotropical migratory birds can effectively capitalize on ongoing efforts.

PARTNERS IN FLIGHT

Partners In Flight working groups are developing a full network for communicating and sharing technical information. Regional working groups (Southeast, Northeast, Midwest, West, International, and Caribbean) simultaneously address management and research components under a united umbrella. To ensure greater local participation in *Partners In Flight*, state working groups have also been chartered. Technical working groups (Research, Monitoring, Information and Education) transfer new information, publications, and needs assessments throughout the *Partners in Flight* framework.

An important mandate of the Information and Education Working Group is to convey technical materials to *Partners in Flight* participants. Such materials have included slide/tape shows, brochures, news items, popular articles, videotapes, and symposia. The *Partners in Flight* Newsletter published by the National Fish and Wildlife Foundation centralizes program participation and provides a fundamental network for sharing information across disciplines and geographic boundaries. The real key here is recognizing the difference between data overload and useful information, and taking the time to package the information to serve its intended audience.

This training workshop for *Partners in Flight* exemplifies several ways of enhancing communication and transferring information:

- one-to-one and group interactions that brought researchers and managers with similar and differing viewpoints together.
- concurrent problem sessions and regional think tanks so that important issues could be addressed through group consensus processes.
- impromptu working group gatherings and organizational meetings and socials.
- oral presentations by invited speakers from multiple disciplines who were asked to review and synthesize research and management findings.
- panel presentations that allowed time for panelist and audience interactions.
- poster presentations that transferred new research and management information to workshop participants.
- videotaped interviews of various workshop participants and presenters.
- publication of this proceedings that outlines management recommendations and guidelines for conserving neotropical migratory birds.
- publication of a book that reviews and synthesizes research information to support management recommendations.

SUMMARY

The gap between research and management can be bridged by a number of mechanisms that encourage both researchers and managers to go beyond the traditional boundaries of their professions. We can no longer afford to detach ourselves from our colleagues by using words like "this is the problem I need solved" or "here are the research data." Patterns of language and vehicles for sharing information must be developed that transcend historical and habitual barriers in communication. Researchers and resource managers need to commit the time and energy to create a shared knowledge of what is known within a framework that can be applied across organizations, disciplines, and partnerships. We believe that *Partners in Flight*, a program that is geographically and hierarchically scaled to meet the concerns of all its participants, has provided such a framework for the conservation of neotropical migratory birds.

ACKNOWLEDGMENTS

We thank Kay Franzreb, Mike Marcus, Tom Nicholls, and Peter Stangel for their reviews of this paper.

LITERATURE CITED

Beissinger, S.R. 1990. On the limits and directions of conservation biology. BioScience 40:456-457.

Brown, G.A., and C.C. Harris. 1990. The U.S. Forest Service; Towards a new resource management paradigm. Moscow: Department of Resource, Recreation, and Tourism, University of Idaho.

Callaham, R.Z. 1981. Criteria for deciding about forestry research programs. U.S.D.A Forest Service, Washington Office, Washington, D.C. General Technical Report W0-29. 52 pp.

Davis, G.E., and W.H. Ehorn. 1988. Science and management in U.S. National Parks. Bull. Ecol. Soc. Am. 69: 111-114.

MacLaren, P.A. 1992. Bridging the gap between biologists and managers - Resource management audits. Pp. 181-184 in Willison, J.H., Bondrup-Nielsen, S., Drysdale, C., Herman, T.B., Munro, NW.P., and Pollock, T.L. (eds.) Science and the management of protected areas. Reprinted in Developments in Landscape Management and Urban Planning 7.

Marx, H.G. 1980. Guide to help develop a technology transfer plan. U.S.D.A. Forest Service, Washington, D.C. 26 pp.

Montrey, H. 1991. Forest Service research in the Southwest: Reflections and projections. Pp. 34-36 in D.C. Hayes, J.S. Bumstead, M.T. Richards (eds.), A Southwestern Mosaic: Proceedings of the Southwestern Region New Perspectives University Colloquium. U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-216.

Nicholls, T.H., and A.J. Prey. 1982. Providing information: Researchers to Practitioners. Pp. 156-162, in Parks, B.O., F.A. Fear, M.T. Lambur, and G.A. Simmons, Urban and suburban tress: Pest problems, needs, prospects, and solutions. Kellogg Center for Continuing Education, Michigan State University, East Lansing, MI.

Salwasser, H. 1991. New perspectives in managing the national forests and grasslands. Environmental Planning Quarterly 8:8-9.

Population Trends and Management Opportunities for Neotropical Migrants

Chandler S. Robbins[1], John R. Sauer[1], and Bruce G. Peterjohn[1]

Abstract — The Breeding Bird Survey shows that certain Neotropical migrant songbird populations have been declining over the past 26 years. Among them are forest birds that require extensive forest on the breeding grounds and also forested habitats on tropical wintering grounds. Other species have shown significant declines only since the early 1980's. Birds with broader habitat tolerance, such as those that winter commonly in agricultural and early-successional habitats as well as primary forest, show fewer consistent declines. Several grassland species have also been declining for more than two decades. Populations of many other Neotropical migrants have been stable or increasing over these periods. Examples of 26-year population trends are given. A dozen recommendations are given for managing nesting habitat for Neotropical migrants.

WHAT DO WE KNOW ABOUT POPULATION TRENDS?

Certain species of neotropical migrant songbirds have been decreasing in abundance throughout their breeding range for prolonged periods and are a cause of immediate concern. Examples of continuing declines from 26 years of Breeding Bird Survey (BBS) data are Olive-sided Flycatcher, Cerulean Warbler, Kentucky Warbler, Lark Bunting, Dickcissel, Grasshopper Sparrow (fig. 1); Rock Wren, Prairie Warbler, Painted Bunting, and Black-throated Sparrow (fig. 2). Many other species not declining in the 1960's and 1970's show strong declines during 1982-1991. Trend graphs are presented for two of these species, Wood Thrush and Bobolink (fig. 2). Other examples are Yellow-billed Cuckoo, Ruby-crowned Kinglet, Veery, Chestnut-sided Warbler, Macgillivray's Warbler, Rose-breasted Grosbeak, and Savannah Sparrow. Many additional species are decreasing in portions of their breeding range where their nesting habitats have been disappearing rapidly. Examples are Lark Sparrow in the west, White-eyed Vireo and Hooded Warbler in the central states, Canada Warbler in Canada, and Yellow-breasted Chat and Vesper Sparrow in the east. There are also many neotropical migrants whose populations have been increasing during the period 1966-1991. Examples are Ash-throated Flycatcher, Western Kingbird, Solitary Vireo, Magnolia Warbler, Blue Grosbeak, and Lincoln's Sparrow (fig. 3). Continental populations of the majority of neotropical migrants have remained stable or increased during the 26-year period, but with regional population declines for many species.

Discussion of trends in species other than neotropical migrants is beyond the scope of this paper, but important negative trends have been noted for grassland and early successional species at continental as well as regional scales (Robbins *et al.* 1986, Hagan *et al.* 1992, Hussell *et al.* 1992, James *et al.* 1992, Witham and Hunter 1992).

THE BREEDING BIRD SURVEY

These latest population trends are from unpublished BBS analyses. BBS is a cooperative monitoring program administered by the U.S. and Canadian Wildlife Services. This annual survey consists of a network of randomly distributed roadside routes, each with 50 3-minute stops at 0.8 km (half mile) intervals along secondary roads (Robbins et al. 1986). Participants are almost entirely experienced volunteers, hand-selected by state and provincial coordinators. At present more than 2,200 routes, representing more than 110,000 point counts, are run each year. The resulting records, for more than a million birds per year, go through intensive editing procedures before being added to the data bank. Sophisticated analysis programs compensate for density of coverage and changing observers on a route (Geissler and Sauer 1990, Sauer and Geissler 1990). Estimates of

[1] *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland, U.S.A. 20708-4015.*

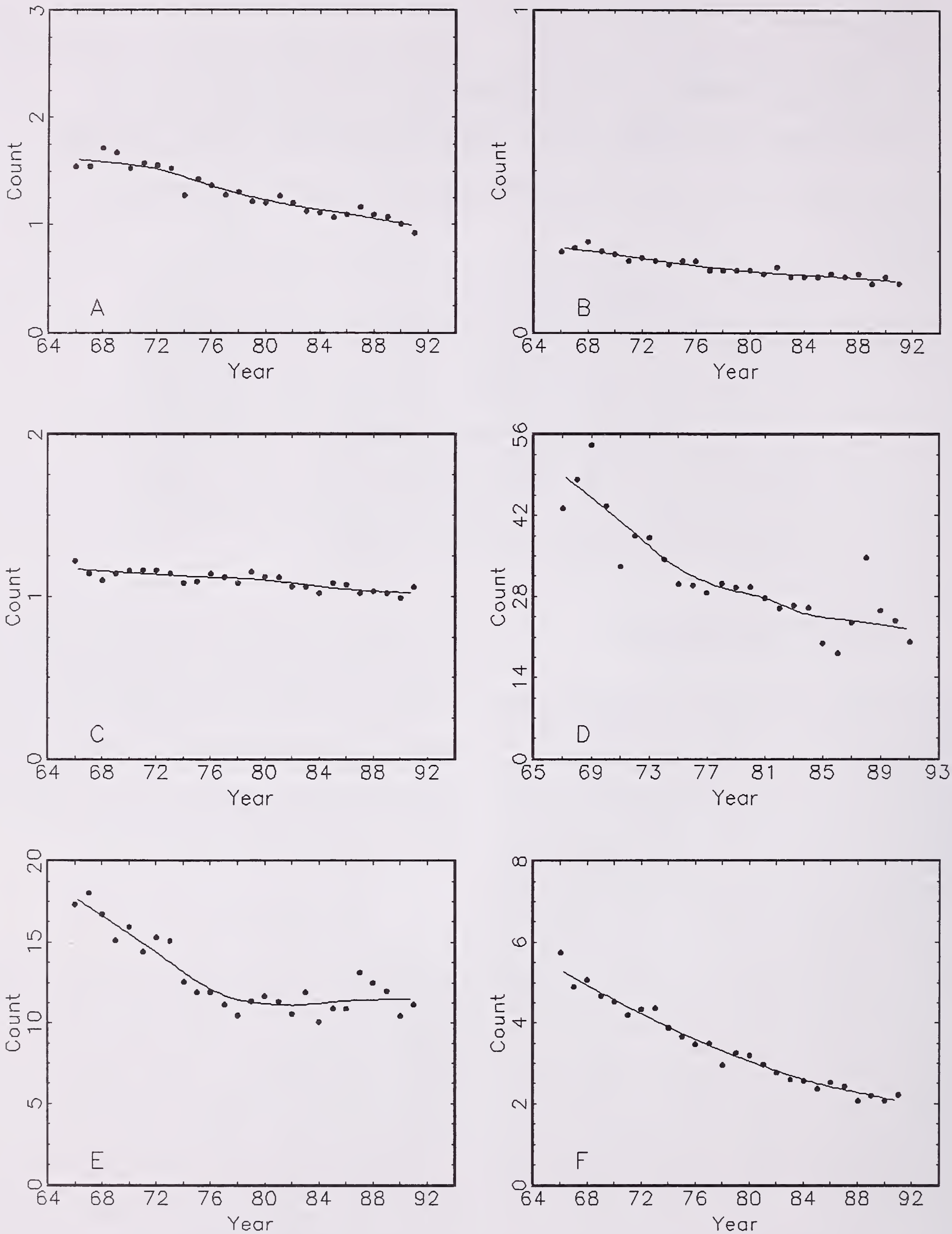


Figure 1. — Examples of long-term continental declines in three woodland (A, B, C) and three grassland species (D, E, F). A - Olive-sided Flycatcher, B -Cerulean Warbler, C - Kentucky Warbler; D - Lark Bunting, E - Dickcissel, F - Grasshopper Sparrow.

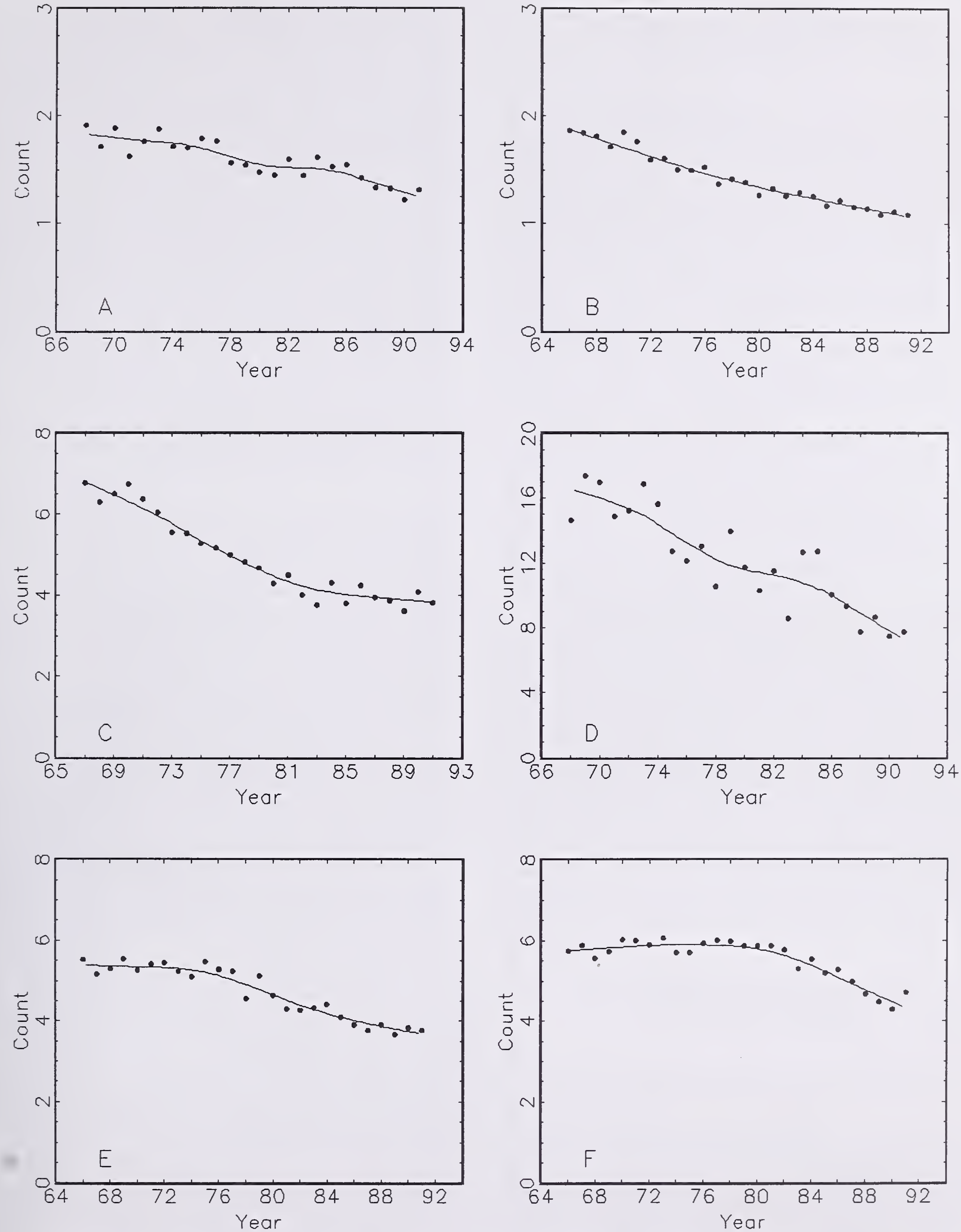


Figure 2. — Examples of long-term continental declines in four brushland and early second-growth species (A, B, C, D), representing four different portions of the continent, and short-term declines of a woodland (E) and a grassland species (F) whose populations were stable until the 1980's. A - Rock Wren, B - Prairie Warbler, C - Painted Bunting, D - Black-throated Sparrow; E - Wood Thrush, F - Bobolink.

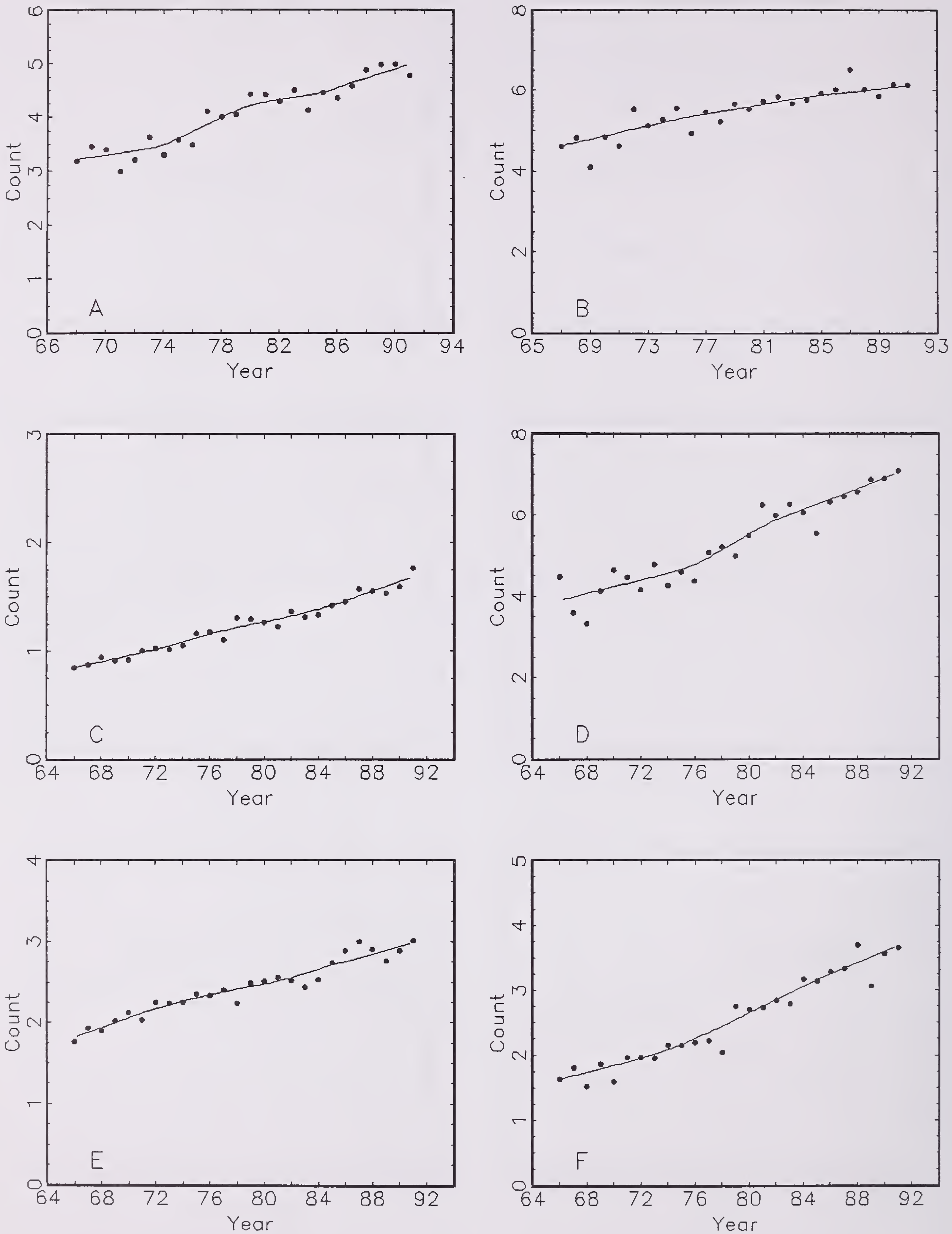


Figure 3.--Examples of long-term continental increases in six species of forest, field, or brush-nesting birds, representing all parts of North America south of the tundra. A - Ash-throated Flycatcher, B - Western Kingbird, C - Solitary Vireo, D - Magnolia Warbler, E - Blue Grosbeak, F - Lincoln's Sparrow.

population change, together with statistical probabilities, are generated by species for each state, province, physiographic region, major region of the continent, and the entire continent.

BBS adequately monitors 204 species of North American birds that have a mean abundance of more than one bird per route and a sample size such that the degrees of freedom (number of routes on which the species is recorded minus the number of state-strata units) exceeds 14. For these species a change of 3%/year over a 25-year period can be estimated. This survey has its limitations, however. Rare birds and birds of locally distributed habitats poorly sampled by roads (e.g., mountain tops and wetlands) are undersampled. Birds that breed primarily north of the road system in Canada (such as ptarmigans, jaegers, and shorebirds) or south of the U.S. border (such as trogons, becards, and tropical raptors and hummingbirds) and birds most active at night and at dusk (rails, owls, goatsuckers) are also undersampled. Habitat changes along roadsides may not be representative of the entire landscape, so changes in some bird populations may be exaggerated on the survey. On the other hand, effects of extensive clearcutting in the west are underestimated if an amenity strip of undisturbed forest is retained along roadsides.

Although survey procedures have not changed during the 26 years, analysis techniques and coverage are still being improved (Sauer *et al.* unpubl. data, Peterjohn *et al.* 19--). From the beginning, routes have been grouped by physiographic regions within states and provinces, and weighted according to the area they represent. Formerly, only routes run in consecutive years were included in the analyses, but now all routes covered at least two years by the same observer are analyzed. No two observers are identical in knowledge and identification skills, necessitating use of observer covariables in data analysis (Sauer *et al.* unpubl. data).

Even when observers are not changed, bias is likely for some species. Observers' acuity increases with experience. This positive bias, though slight, is detectible when comparing first and second years a new observer runs a route. Increased familiarity with a route may also result in higher counts, though this may be partially offset by a tendency for increasing disturbance from traffic over a period of years. After about 50 years of age, an observer's ability to hear distant high-pitched songs may decrease gradually. Hearing aids can compensate in part for loss of hearing. Unfortunately, most hearing aids are designed for assisting with comprehension of speech rather than amplifying higher frequencies. Even some hearing aids with special "bird circuits" do not live up to claims to amplify sounds higher than 6 kHz. Thus birds with high-pitched songs such as waxwings, gnatcatchers, several spruce forest warblers, and Grasshopper Sparrows, cannot be heard by most observers over 60 years of age unless birds are close at hand. In actual practice, this is only a minor problem on BBS routes as the proportion of observers unable to hear these few species is very small; the Cape May Warbler at 8-10 kHz and Blue-gray Gnatcatcher at 4-7 kHz are among the species reported as increasing. See Robbins *et al.* (1983) and Bondesen (1977) for frequency ranges of songs of North American birds.

WHY ARE SOME NEOTROPICAL MIGRANTS DECLINING WHILE OTHERS ARE NOT?

Although BBS detects population changes, it does not provide reasons that some species decline while others increase. It is up to biologists to provide hypotheses based on land-use changes on breeding and wintering grounds, increased predation and nest parasitism, weather conditions (especially extreme conditions), and environmental conditions during migration periods. If these hypotheses are tested to determine whether future changes can be predicted accurately, it may be possible to explain some observed changes. Effects of severe weather on breeding grounds are easy to document (Robbins et al. 1986). On the other hand, land-use changes usually occur so gradually that dramatic effects on bird populations seldom occur on a continental scale. Nesting and wintering habitats are being lost at the same time cowbirds are expanding their ranges, and migration casualties are increasing, making it difficult to determine from a breeding season survey whether the greatest stress occurs in the U.S. and Canada or in the tropics. Nearly all tropical American countries are losing rain forests, and no part of Latin America has been identified as showing greater declines of migrants than another, based on wintering ranges. In the U.S., however, bird population declines are more pronounced in eastern states than farther west.

In comparing species characteristics in the first two paragraphs, a few hypotheses begin to emerge. Among declining species are Wood Thrush and Kentucky Warbler, both of which need extensive forest on breeding grounds and are restricted largely in winter to mature rain forest in Latin America, where they feed on the ground. The Magnolia Warbler, however, an increasing species, nests in regenerating forest and winters commonly in citrus groves and other agricultural habitats as well as in primary forest. Common birds of grassland habitats may be in as much trouble as forest birds, though they have received less attention. Among species in trouble are the Bobolink, Dickcissel, and Vesper and Grasshopper Sparrows. We are still in the early stages of isolating specific factors that control populations of the many neotropical migrants, but we can make several recommendations for reducing pressures on these birds.

EDUCATION AND MANAGEMENT RECOMMENDATIONS

Stimulate Public Awareness of the Problem

We must stimulate public awareness of and grass roots interest in the neotropical migrant problem throughout school systems and through the media, both in North America and in the tropics. Literature and training programs are needed for land managers, together with mandates for appropriate action. The Chesapeake Bay Critical Area legislation could be used as an example of long-range land-use planning. There is also a continuing need to promote natural history education and ecotourism in tropical countries.

Improve Size, Shape, and Connectivity of Forest Habitats

Much can be done to improve forest habitats for neotropical migrants (Robbins 1979, 1991, Harris 1984, Hunter 1990). For example, land managers should keep forests in large blocks with minimum edge, maximize the interior portion of the forest (that portion farther than 100 meters from edge), minimize isolation from other forests, and promote connecting wooded corridors.

Promote Diversity of Microhabitats

A high diversity of bird life within a forest requires a high diversity of microhabitats with green vegetation at all heights. A grazed or heavily browsed forest, for example, lacks the critical ground layer of vegetation on which so many birds depend for feeding and nesting. An even-aged forest lacks the natural diversity of an uneven-aged forest.

Protect Against Exotics

Many native species of shrubs and trees cannot compete with an invasion of exotic species.

Cherish Old-growth Forest

Preservation of even small tracts of old-growth forest helps promote diversity by providing habitats not otherwise present. Where old-growth forest does not exist at present, it can be created through long-range planning.

Cluster Snags Near the Forest Edge

Dead trees are important to many species of birds and mammals for nesting sites, perches, and feeding opportunities. However, dead trees are also used as perches by cowbirds searching for songbird nests to parasitize. Many land managers are retaining dead trees, often at some prescribed rate of two or three per acre. We believe it would be more appropriate to leave dead trees in clusters, preferably close to forest edge, rather than scattered throughout the forest interior, because neotropical migrants are most heavily impacted by cowbird parasitism.

Collaborate With Neighbors

Land owners can collaborate with neighbors and community groups in maintaining the maximum amount of forest interior, in promoting wooded corridors, and pushing for tax incentives for leaving land forested.

Reduce Mowing Frequency at Nesting Season Peak

For field-nesting birds, managers can reduce mowing frequency at the peak of nesting season and increase grassland area that is more than 100 meters from other habitats. When economically feasible it helps to leave some fields fallow two or more successive years to provide habitat for sparrows such as Vesper, Lark, and Henslow's and for Dickcissels. As in forested habitats, it helps to favor native vegetation and to prevent overgrazing.

Provide Also for Early Successional Birds

For early successional species such as Prairie Warbler and Yellow-breasted Chat that do not nest in narrow hedgerows, extensive tracts of regenerating forest are needed. In some areas this habitat is provided by succession following clearcuts; in other places specific management may be needed.

Protect Wetland and Other Ground-nesting Species

For wetland birds it helps to protect shores of ponds and marshes from grazing so dense cover will be available for nest sites. Access should be restricted during the peak of the nesting season. In fact, for better breeding success of birds that nest on or near the ground, household pets should be restrained during at least the nesting season peak.

WHY ARE WE CONCERNED?

If long-term declines in neotropical migrants are limited to a relatively short list of species, why are we concerned?

We are concerned because changes detected to date may be symptomatic of much greater changes still to come. The trend toward more declines in the recent decade suggests a deterioration of habitat conditions. There is still time to slow declines and to make environmental changes to prevent these and other species from disappearing from larger and larger areas of our continent.

We are concerned over loss of species diversity for many reasons. Aside from moral considerations, there are compelling practical reasons for concern, many of which are summarized in Paul Kerlinger's paper in this symposium.

An intact ecosystem is of inestimable value for scientific and educational reasons. Although we know many component parts of our natural ecosystems, our knowledge of complex interactions between various parts is rudimentary. Birds are among the best understood members of the environment, yet we are ignorant of the complex cycles of food abundance on which they depend from week to week, and we are largely ignorant of their role as seed dispersers and pollinators here in North America and in the tropics.

By recognizing the problems, scientists, land use planners, foresters, farmers, and other land managers can work together to improve the landscape of this planet, not just for migratory birds, but for all of us who live here.

LITERATURE CITED

Bondesen, P. 1977. North American bird songs--a world of music. Scandinavian Science Press, Klampenborg, Denmark. 254 p.

Geissler, P.H., and J.R. Sauer. 1990. Topics in route-regression analysis. Pp. 54-57 *in* J.R. Sauer and S. Droege, eds. Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish and Wildlife Service Biological Report 90(1).

Hagan, J.M., III, T.L. Lloyd-Evans, and J.L. Atwood. 1992. Long-term changes in migratory landbirds in the northeastern United States: Evidence from migration capture data. Pp. 115-130 *in* J.M.Hagan and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Manomet Bird Observatory, Manomet, Massachusetts.

Harris, L.D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. Univ. Chicago Press, Chicago, Illinois.

Hunter, M.L., Jr. 1990. Wildlife, forests, and forestry: Principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, New Jersey. 370 p.

Hussell, D.J.T., M.H. Mather, and P.H. Sinclair. 1992. Trends in numbers of tropical- and temperate-wintering migrant landbirds in migration at Long Point, Ontario. Pp. 101-114 *in* J.M.Hagan and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Manomet Bird Observatory, Manomet, Massachusetts.

James, F.C., D.A. Wiedenfeld, and C.E. McCulloch. 1992. Trends in breeding populations of warblers: Declines in the southern highlands and increases in the lowlands. Pp. 43-56 *in* J.M.Hagan and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Manomet Bird Observatory, Manomet, Massachusetts.

Peterjohn, B.G., J.R. Sauer, and C.S. Robbins. 19--. The North American Breeding Bird Survey and population trends of Neotropical migrant birds. Pp. ___-___ *in* ________________ eds., Ecology and management of Neotropical migrant birds: a synthesis and review of critical issues. ______________________________.

Robbins, C.S. 1979. Effect of forest fragmentation on bird populations. Pp. 198-213 *in* R.M. DeGraaf and K.E. Evans, eds. USDA Forest Service Technical Report NC-51. Minneapolis, Minnesota.

Robbins, C.S. 1991. Managing suburban forest fragments for birds. Pp. 253-264 *in* D.J. Decker, M.E. Krasny, G.R. Goff, C.R. Smith, and D.W. Gross, Challenges in the conservation of biological resources: a practitioner's guide. Westview Press, Boulder, Colorado.

Robbins, C.S., B. Bruun, and H.S. Zim. 1983. A guide to field identification: birds of North America. Western Publishing Co., Racine, Wisconsin. 360 p.

Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The Breeding Bird Survey: its first fifteen years, 1965-1979. U.S. Fish and Wildlife Service Resource Publication 157. 196 p.

Sauer, J.R., and P.H. Geissler. 1990. Estimation of annual indices from roadside surveys. Pp. 58-62 *in* J.R. Sauer and S. Droege, eds. Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish and Wildlife Service Biological Report 90(1).

Witham, J.W., and M.L. Hunter, Jr. 1992. Population trends of Neotropical migrant landbirds in northern coastal New England. Pp. 85-95 *in* J.M.Hagan and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Manomet Bird Observatory, Manomet, Massachusetts.

Biological Diversity, Ecological Integrity, and Neotropical Migrants: New Perspectives for Wildlife Management

Brian A. Maurer[1]

Abstract — New initiatives in wildlife management have come from the realization that birds can be used as indicators of ecosystem health. Conceptually, biological diversity includes processes working at all scales in biological hierarchies that compose the natural world. Recent advances in the understanding of ecological systems suggest they are nonequilibrium systems, and must be managed as such. In a practical sense, biological diversity must be managed by devising indicators of ecosystem integrity and health. Ecological integrity, although there are difficulties in defining criteria for its measurement, provides a conceptual focus for management decisions that are intended to preserve biodiversity. More importantly, tools for devising objective measures of the ecological integrity of a community are readily available. Management of bird communities can be based on indices of ecological integrity that incorporate presence and relative abundances of neotropical migrants. Neotropical migratory birds provide an ideal focus for such management tools, since they have been shown to be highly sensitive to changes in landscapes that compromise the spatial continuity and integrity of natural ecosystems. In order to accommodate new concerns for preservation of biodiversity, wildlife managers must acquaint themselves with new tools and approaches. In particular, an expanded geographic scale perspective should permeate management activities.

INTRODUCTION

Birds have always been viewed as important indicators of ecosystem health. They are top predators, have relatively low birth rates and long lifetimes, and therefore have populations that seem to be extremely sensitive to environmental variability. Indeed, the origin of widespread concern in society today regarding environmental issues can be traced back to Rachel Carson's *Silent Spring*. Both economic development and management of natural resources have been greatly affected by this concern. Government agencies have been mandated by law to manage natural resources in a way that maximizes not only for consumption, but for uses consistent with preservation of the ecosystems containing those resources.

In this paper, I consider how management activities aimed at preserving neotropical migrants can be used as templates for preservation of the ecological integrity (Karr 1991) of ecosystems in which they reside. I will consider only one aspect of system integrity, namely, biological diversity. My approach is to ask the question "How can the diversity of neotropical migrants serve as an indicator of the ecological integrity of ecosystems?" I hope to provide an overview of how management decisions aimed at preserving habitat for neotropical migrants can have as an added benefit, the preservation of entire ecosystems and their attendant ecosystem services. I believe management for neotropical migrant biological diversity can be consistent with sustainable use of natural resources for consumption and economic development. The key word here is "sustainable", because it is abundantly clear from past experience that nonsustainable uses of natural resources ultimately lead to ecosystem degradation.

[1]*Brian A. Maurer, Department of Zoology, Brigham Young University, Provo, UT 84602.*

First, I will considering the problem of defining biological diversity. Clearly, it is important to define biological diversity in such a way that it can be used in developing and implementing management decisions. Next, I consider the problem of the integrity of ecosystems and how it can be evaluated. Finally, I discuss how specific management decisions affecting neotropical migrant habitat can be used to enhance ecological integrity of the ecosystems in which they reside.

CHANGING ECOLOGICAL PARADIGMS

Most ecological textbooks define species diversity as the number of species found in a given area (e.g., Ehrlich and Roughgarden, 1987; Begon, Harper, and Townsend, 1990; Ricklefs, 1990; Smith, 1990). This has traditionally been the basis for discussions of biological diversity. Although it is an empirically tractable exercise to count the number of species in a given area, such a procedure ignores many potentially important phenomena. A broader definition of biodiversity includes both the number of species and extent of their genetic variability (see, e.g., Office of Technology Assessment [OTA], 1987). The OTA definition explicitly includes systems of different sizes, ranging from biochemical variation in DNA to number of species in ecosystems (see also Norse et al. 1986). Hence, in its broadest definition, biological diversity is the manifestation of virtually every biological process known.

Biodiversity: A Complex Issue

In discussing biological diversity, it is important to realize that ecological systems are highly complex, and therefore, any management policies or decisions dealing with biodiversity are themselves going to be complex. A number of recent authors have focussed on the problem of how to understand the workings of complex biological systems (Allen and Starr 1982, Eldredge 1985, Salthe 1985, O'Neill et al. 1986). The common thread among these approaches is that biological systems have a hierarchical structure. Unfortunately, there are several relevant ways to construct a hierarchical ordering scheme that might be applicable to the problem of biological diversity. Biological systems participate in a number of different sets of processes. Three of the most meaningful from the perspective of biological diversity are genetical processes, ecological processes, and phylogenetic processes. Genetical processes are concerned with storage, maintenance, and transmission of information regarding biological structure. Phylogenetic processes are closely related to genetic phenomena, but emphasize and elaborate patterns of similarity of descent among species and higher taxa. Ecological phenomena involve exchanges of matter and energy among biological units and their environments.

Each of these processes affect biological diversity and should influence policies dealing with its management. Genetic processes determine the amount and kinds of variation that exist in a species that might be important to its ability to maintain viable populations. Phylogenetic information is critical in conservation because in order to assess species losses, we first have to be able to count them. Ecological processes, the traditional focus of management agencies, determine the proximate mechanisms by which populations persist, and provide many of the tools for the active management of biodiversity.

Changing Paradigms in Ecology: Attempts to Deal with Complexity

Wildlife management developed in an era when ecologists emphasized the stable nature of ecosystems and communities. The predominant models of population dynamics emphasized that populations had equilibria towards which they grew (or declined). The idea of carrying capacity is a direct translation of this idea. Habitats were thought to have limits on the abundance of each species determined by the amount of resources, competitors, and predators. Succession was thought to proceed to well defined endpoints, the so-called climax communities of Clements and others.

Because of the empirical difficulties inherent in this equilibrium view of nature, ecologists now seem to be moving away from it in favor of a new paradigm (Botkin 1990, Pickett et al. 1992). I believe that this has important implications for the way we should go about conserving biological diversity. I will attempt to characterize this new paradigm, then, in the next section will deal with how we might approach assessments of habitats in the face of these new ideas emerging in ecology.

There are three characteristics that I see as common themes in the "nonequilibrium" paradigm in ecology. The first is that emphasis is placed on dynamics rather than equilibria. Ecologists are much more interested in how communities and ecosystems change rather than attempting to explain the nature of endpoints of that change. In fact, many ecologists don't think that there are any stable endpoints towards which populations, communities, or ecosystems converge. The second idea emerging in this new approach to ecology is the hierarchical nature of populations (Morris 1987), communities (Maurer 1985, 1987; Kolasa 1989), and ecosystems (Allen and Starr 1982, O'Neill et al. 1986). This means that scale of observation and the context in which a system operates are critical components of a complete understanding of any population, community, or ecosystem process. In this view, "top down" constraints on the behavior of the system are as important as "bottom up" processes. That is, to understand the changes in population abundance of a species in a particular habitat, we need to know not only what resources and biotic interactions within the habitat affect vital rates of the population, but we need to know the geographic context (is the population near the periphery of its range?), the phylogenetic context (how has the evolutionary history of the species affected its ecological attributes?), and the landscape context (how are the rates of immigration and emigration affected by the structure of the landscape?). Finally, because of this emphasis on hierarchical structure and context sensitive processes, most ecologists explicitly emphasize the spatial context of ecological processes. For example, an enhanced understanding of the conservation of populations is emerging from studies which explicitly include the spatial structure of populations in changing landscapes (Lamberson et al. 1992, Pulliam et al. 1992).

ECOLOGICAL INTEGRITY

Current views regarding ecological systems, then, emphasize the diverse and complex nature of interactions among organisms and between organisms and their environment. This view, however, has not been integrated with wildlife management. In this section, I consider the problems of defining properties of ecosystems that can be useful in assessment of ecological change in the face of complexity.

The Ecological Context

As indicated above, traditional views of biological diversity have focussed on the idea that ecosystems will return to a predetermined stable state after a perturbation. Ecosystems are often depicted as "entities" which remain relatively unchanged if left alone. The traditional metaphor used in this context has been "the balance of nature" (Pickett et al. 1992). The balance of nature metaphor has had a powerful impact on management for biological diversity. For example, a significant amount of management by the Park Service as been centered around a "let it alone" philosophy. In many instances, human activities in ecosystems are viewed as alien influences, and sometimes value judgements are attached to them by calling them "destructive". Even the concept of a "natural" ecosystem is influenced by the equilibrium paradigm of ecology. Any system influenced by people cannot be considered "natural". The solution to management problems under such a scheme is to attempt to remove all human influences, then let the ecosystem "heal itself" through natural processes of ecological change. Oftentimes such management approaches neglect traditional habitat management practices which are deemed "artificial". This "hands off" approach is often integrated into endangered species management, even when traditional wildlife management techniques might be fruitfully applied.

This mindset on equilibrium, especially when it relates to the preservation of biological diversity, has continued despite failure of the equilibrium paradigm to provide a meaningful theoretical basis for ecosystems (Pickett et al. 1992). For example, the equilibrium models of community structure of MacArthur (1972) and his colleagues have been roundly criticized for not being adequate to explain most of what goes on in ecosystems (see, e.g., Wiens 1983, 1984, 1989 for examples pertaining to birds). Communities have been found not to converge on single equilibria, but instead to change towards multiple states by a variety of pathways (see references in Pickett et al. 1992).

Pickett et al. (1992) suggest that a better metaphor to describe natural systems might be "the flux of nature". Mounting evidence suggests ecosystems are not static, unchanging entities that can be left alone to heal themselves. Management activities to enhance biological diversity must take into account the dynamical nature of ecosystems (Landres 1992). This means that management decisions must have information from more than just the local area being managed. Managers should be aware of the functional nature of components of the ecosystems they must manage. Management decisions cannot end at convenient political boundaries, but must incorporate effects of processes occurring outside boundaries defining the unit being managed.

The ecological context in which management decisions must be made have important implications for how ecological integrity is defined. It is not enough to ask what the "natural" or "unaltered" state of the system to be managed is. Ecological integrity must incorporate the dynamic nature of ecosystems into its framework. In the next section I consider definitions of ecological integrity and how it might be measured, with special reference to birds.

Measuring Ecological Integrity: the Role of Data on Biodiversity

A widely recognized definition of ecological integrity was given by Karr and Dudley (1981), who emphasized its use in the assessment of water quality. They defined ecological integrity as the ability of an ecosystem to maintain "a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region." Note that this definition is explicitly comparative. That is, ecological integrity is a relative attribute of an ecosystem that only has meaning when compared to another ecosystem. Clearly, Karr and Dudley intended for one of the ecosystems in the comparison be "natural." The advantages of this definition is that it is operational in the sense that quantities such as species abundances, diversity, etc., have specific meanings associated with them and metrics used to calculate them. Furthermore, Karr and Dudley (1981) argued that such quantities can be used to monitor water quality, and Karr (1991) reviewed many successful applications of the approach they outlined. This is especially appealing for land managers interested in diversity of neotropical migrant birds. It suggests that using conventional ecological statistics to measure the abundance and diversity of bird communities can provide information, even if that information is indirect, about the ecological integrity of an ecosystem.

The disadvantage of Karr and Dudley's (1981) definition is that it requires a judgement as to what defines the "natural habitat" of a region. This presupposes there is an unaffected set of habitats that can be compared objectively with altered sets of habitats. The perspective described in the last section suggests that in reality, each individual landscape to be managed, whatever its size, is biologically and ecologically unique (Pickett et al. 1992). This uniqueness comes from the fact that each landscape has undergone numerous ecological changes over time on a number of different temporal scales. The number of such events that each community goes through is extremely large, and there is no guarantee that each community will respond in a similar fashion. Furthermore, virtually any landscape, including wilderness landscapes, bear, to varying degrees, the imprint of human activities, because ecosystem impacts can be transported into an ecosystem from sources many kilometers distant (Pickett et al. 1992). Defining the natural community in such landscapes will be very difficult.

Despite these difficulties, there a few guidelines used to apply the concept of ecological integrity to bird communities. First, Knopf (1992) argued that communities dominated by exotics and generalist species can be considered a sign of degradation of an ecological system (see also Gray 1989). Given the myriad of processes that change a community over time, natural communities are thought to be composed of a number of specialist species that persist due to the existence of special habitat elements resulting from disturbances and other processes. Human impacted ecosystems, on the other hand, tend to be simplified so that natural processes like fire, that create specialized habitat features, are altered or suppressed. The result is "biosimplification" (Sampson 1992), that is, ecosystems that are more uniform in species composition, physical structure, and functional organization. Exotic species and generalists tend to be favored in such systems. A second guideline is that the health or performance of individual organisms tends to be better in natural systems. In aquatic systems, it is relatively easy to assess the number of individuals that show injuries, mutations, or other abnormalities (Karr 1991). For birds, this is much more difficult. However, there are methods to assess individual performance. For example, Villard et al. (1993) have shown that pairing success for male Ovenbirds in forest fragments is lower than in continuous forest so that males in fragments have a higher likelihood of remaining unpaired during the breeding season than males in continuous forests. One could also monitor nesting success, or other measures of reproductive success, to assess individual health.

Using measures of community structure and composition as indicators of ecological health or integrity of an ecosystem can provide a powerful tool for evaluating management alternatives. Community parameters of birds are sensitive to temporal and spatial changes in ecosystems. Different parameters often reflect different ecological processes (Maurer 1985). What is missing is a formalized system of sampling bird communities and deriving indices of biological integrity (Karr 1987, 1991) from those samples. Such a protocol would necessarily go beyond the Habitat Evaluation Procedures (HEP) devised by the U.S. Fish and Wildlife Service, and used widely in environmental impact assessments. It would require intensive censuses of bird communities and detailed statistical analysis of results, both according to predetermined procedures. Success of such procedures in water quality assessment (Karr 1991) should stimulate efforts to develop a similar system for birds.

The key to carrying out an assessment of biological integrity using bird communities is the development of an index of biological integrity (IBI). To construct an IBI, a set of community characteristics are chosen, and for each, its value is ranked based on the similarity between the observed community and that expected of a "natural" community. The ranks for each characteristic are then summed, and the overall score used as an numerical estimate of how close the community is to being in a natural state. Karr (1991) lists useful characteristics for developing an IBI for a community. I used his list as a template to devise a potential list of community characteristics that might be useful for bird communities (Table 1).

Determining the "natural" state of a bird community will be difficult in many cases. The obvious approach would be to take a landscape similar to the impacted landscape being evaluated, and use it as the baseline for comparisons. This is often done in studies of forest fragmentation, where forest fragments of various sizes are compared with large, extensive forest tracts. In landscapes sufficiently altered by human activities, such opportunities may be lacking. One possible alternative is to assemble from the literature a list of those species judged to be native to the landscape of interest. It is often possible to get some idea of relative abundances from the literature. This baseline list can be used to compare to abundances obtained from intensive censuses to establish ranking criteria to calculate an IBI.

MANAGEMENT OF HABITATS FOR INTEGRITY OF BIRD COMMUNITIES

Difficulties with Applying Traditional Wildlife Management Principles

Traditional habitat management has focussed on the perpetuation of harvestable populations of game species (Leopold 1933, Peek 1986). Such efforts often leave landscapes with a high degree of "edge" habitat, because for many large game species, a number of habitat elements are required to maintain healthy populations. It has often been assumed that interspersion of habitat types created by such management is ideal for nongame species as well. If we have learned anything from studying populations of neotropical migrants it is that this is not true for many specialist species. Many neotropical migratory species of greatest concern have relatively narrow habitat requirements found only in relatively large tracts of forest (e.g., Cerulean Warbler, Robbins et al. 1992). Management practices that break up forests and create lots of edge situations are detrimental to some neotropical migrants. This was first evident from Gates and Gysel's (1978) results that showed high

Table 1. — Community characteristics and metrics that might be used in developing an index of biological integrity for bird communities which in their natural state would include a significant number of neotropical migrants.

Level of organization	Attribute and suggested metrics
Individual	Nestling growth rates, clutch sizes, & nesting success Pairing success and site fidelity Foraging behavior Parental care
Population	Density or total population size (in fragmented habitats) Incidence functions - proportion of patches occupied as a function of patch area or productivity Population variability Extinction likelihood Population age structure
Community	Species richness Relative abundances of species Number and relative abundances of neotropical migrants Number and relative abundances of habitat specialists Degree of dominance by generalist species and exotics Abundance of brood parasites and predators

rates of nest failures in artificially created edges, and has since been substantiated by a number of studies (Wilcove 1985, Askins et al. 1990, Robinson 1992).

The traditional approach to wildlife management focusses on single species. The idea is that if we create appropriate habitat elements for that species, we can maintain healthy populations for an extended period of time. In this respect, objectives of traditional habitat management are not adequate for preserving biological diversity, and some conservation biologists have been critical of traditional wildlife management activities because of this. However, the strength of the traditional approach is that it explicitly uses and enhances *natural processes* to preserve populations. In this respect, wildlife management is different from agricultural practices, which construct artificial ecosystems to perpetuate a single crop species. What is needed for preservation of biological diversity in general, and for the preservation of healthy bird communities, specifically, is a new management ethic which takes the best from traditional wildlife management and merges it with a broadened set of management objectives (e.g., Sampson and Knopf 1982). I discuss some of these new management principles in the next section.

Emerging Principles of Habitat Management for Biodiversity

Principle 1 - Diversity, *per se*, is not necessarily the best criteria upon which to build management objectives. Sampson and Knopf (1982) argued that many local scale management practices that encourage diversity within local communities ignore larger scale problems of maintaining viable populations of endemic or native species within a landscape. Often, high diversity in local communities may be associated with presence of many exotic species, such as European Starlings and House Sparrows, and of generalist species not specifically adapted to the native vegetation of the landscape, such as American Robins, Blue Jays, and Brown-headed Cowbirds. Many exotics and generalists not only are not adapted to native vegetation, but can be detrimental to native birds as competitors, predators, and nest parasites.

Principle 2 - The spatial structure of habitats in a landscape is important (Martin 1992). In complex landscapes, populations of different species are profoundly impacted by size, shape, and degree of isolation of habitat patches. This is particularly true for neotropical migrants (Villard 1991, Villard et al. 1992). Wildlife managers should be trained in principles of landscape ecology. More research is needed to determine how landscape structure affects population dynamics of species, and in turn, how this influences ecological integrity.

Principle 3 - The geographical context of a management situation must influence the management approach (Sampson 1992). It is becoming increasingly clear that attention to local details in habitat management is not enough to ensure integrity of ecosystems in managed landscapes. Conservation biologists have used island biogeographic arguments to suggest policies for maintaining communities in island-like settings. However, it is becoming increasingly clear that these approaches are too simplistic (e.g., Simberloff and Cox 1987). Small islands of natural or old growth vegetation face a situation more akin to Brown's (1971, 1978) findings on mammals on mountaintops in western North America. These communities have suffered profound declines in diversity of nonvolant mammal species after being separated from one another after the climate warmed in the late Pleistocene. Likewise, reserves and other isolated patches of habitat can be expected to experience profound losses of diversity. In effect, the old connections that these habitats had with similar habitat are being replaced with new connections to the surrounding landscape matrix. Geographically, this appears to be increasing the degree to which neotropical migrant geographic ranges are becoming fragmented (Maurer and Heywood 1993). Integrity of ecological islands should be reflected in extinctions of species typical of historical vegetation of the area and in colonization of exotic and generalist species (Karr 1987, Gray 1989).

Principle 4 - Management objectives must account for natural levels of environmental variability (Landres 1992). Ecosystems should not be thought of as equilibrium systems when making management decisions. Managers should try to base management plans with change in mind. This will usually require more conservative approaches to preservation of key habitats. Since population persistence is closely tied to habitat size, larger tracts of important habitat should be preserved than would be needed under the assumption of equilibrium.

Principle 5 - Wildlife management must become a global discipline. Problems faced by virtually all wildlife extend beyond traditional political boundaries. This is particularly true for neotropical migrants, where problems cross national borders. Management objectives need to consider how management activities at one place will impact or affect other ecosystems and landscapes beyond the boundaries defined by traditional wildlife management.

CONCLUSIONS

It is clear that agencies responsible for management of habitats are facing new challenges defined in part by a better understanding of how ecosystems work, and in part by increased awareness by the public of environmental concerns. Expanding human populations and increased rates of consumption of natural resources have created increasingly intense pressures that continue to transform natural ecological systems into human dominated ecosystems at alarming rates. In human dominated landscapes, biological diversity is much lower than in natural landscapes.

Defining what biological diversity is has been difficult since the term in its broadest meaning encompasses nearly every biological process known. Traditional wildlife and natural resource management interfaces with biological diversity through ecological integrity, that is, the degree to which a community resembles a natural, relatively undisturbed (by human activities) community. Despite the problems of defining exactly what the natural state of a community is, it is important that management decisions incorporate biological integrity of the community being managed as a prime consideration in management objectives and decisions.

In this volume, contributions will be centered around defining those specific attributes of bird communities that should define what a "healthy" bird community should look like. The presence and relative abundances of neotropical migratory species figure prominently in these definitions. These species are sensitive to a number of changes in ecosystem health, and it is likely that we will be able to develop specific protocols that can be used to evaluate the health and integrity of an ecosystem by examining IBI's constructed for bird communities.

Habitat management techniques that encourage natural processes, such as succession, fire, etc., should continue to be a part of the repertoire of land managers seeking to preserve biological diversity. But our experience with neotropical migrants has taught us that managers will need an expanded toolbox. Considerations of habitat size, shape, and connectivity must be taken into account in management decisions. In many instances, necessary management activities may include establishing networks of reserves within an intensively managed landscape that provides for the preservation of a significant proportion of the landscape in native, or "old growth", vegetation.

The implementation of such management activities requires a "top-down" approach (Sampson and Knopf 1982), that is, managers must be aware of vegetation and associated animal communities native to an entire biotic region (Sampson 1992). These associations of plants and animals have had a long history of evolutionary interactions, and such continued evolution cannot occur in small, isolated fragments of habitats. Successful preservation of biological diversity ultimately means preservation of entire ecoregions and biogeographic units across continents such that landscapes within these regions serve as sources and corridors for species native to the region. This in turn requires a sufficient amount of habitat within landscapes are capable of maintaining viable populations of native species for a long period of time. Wildlife management can no longer be carried out by isolated state and federal agencies, each tending to its own affairs.

LITERATURE CITED

Allen, T.F.H., and T.B. Starr. 1982. Hierarchy. University of Chicago Press, Chicago.

Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7:1-57.

Begon, M., J.L. Harper, and C.R. Townsend. 1990. Ecology, individuals, populations, and communities. Blackwell Scientific, Boston.

Botkin, D.B. 1990. Discordant harmonies: a new ecology for the twenty-first century. Oxford University Press, New York.

Brown, J.H. 1971. Mammals on mountaintops: nonequilibrium insular biogeography. Am. Nat. 105:467-478.

Brown, J.H. 1978. The theory of insular biogeography and the distribution of boreal birds and mammals. Great Basin Nat. Memoirs 2:209-227.

Ehrlich, P.R., and J. Roughgarden. 1987. The science of ecology. MacMillan, New York.

Eldredge, N. 1985. Unfinished synthesis. Oxford University Press, Oxford.

Gates, J.E., and L.W. Gysel. 1978. Avian nest dispersion and fledgling success in field forest ecotones. Ecology 59:871-883.

Gray, J.S. 1989. Effects of environmental stress on species of rich assemblages. Biological J. Linnean Society 37:19-32.

Karr, J.R. 1987. Biological monitoring and environmental assessment: a conceptual framework. Environmental Management 11:249-256.

Karr, J.R. 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1:66-84.

Karr, J.R., and D.R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5:55-68.

Knopf, F.L. 1992. Faunal mixing, faunal integrity, and the bio-political template for diversity conservation. Trans. North American Wildl. Nat. Res. Conf. 57:330-342.

Kolasa, J. 1989. Ecological systems in hierarchical perspective: breaks in community structure and other consequences. Ecology 70:36-47.

Lamberson, R.H., R. McKelvey, B.R. Noon, and C. Voss. 1992. A dynamic analysis of norther spotted owl viability in a fragmented forest habitat. Conservation Biology 6:505-512.

Landres, P.B. 1992. Temporal scale perspectives in managing biological diversity. Trans. North American Wildl. Nat. Res. Conf. 57:292-307.

Leopold, A. 1933. Game management. Charles Scribner, New York.

MacArthur, R.H. 1972. Geographical ecology. Harper and Row, New York.

Martin, T.E. 1992. Landscape considerations for viable populations and biological diversity. Trans. North American Wildl. Nat. Res. Conf. 57:283-291.

Maurer, B.A. 1985. Avian community dynamics in desert grasslands: observational scale and hierarchical structure. Ecological Monographs 55: 295-312.

Maurer, B.A. 1987. Scaling of biological community structure: a systems approach to community complexity. Journal of Theoretical Biology 127:97-110.

Maurer, B.A., and S.G. Heywood. 1993. Geographic range fragmentation and abundance in neotropical migratory birds. Conservation Biology, in press.

Morris, D.W. 1987. Ecological scale and habitat use. Ecology 68:362-369.

Norse, E.A., K.L. Rosenbaum, D.S. Wilcove, B.A. Wilcox, W.H. Romme, D.W. Johnston, and M.L. Stout. 1986. Conserving biological diversity in our national forests. The Wilderness Society.

Office of Technology Assessment. 1987. Technologies to maintain biological diversity. OTA-F-330. U.S. Government Printing Office, Washington, D.C.

O'Neill, R.V., D.L. DeAngelis, J.B. Waide, and T.F.H. Allen. 1986. A hierarchical concept of ecosystems. Princeton University Press, Princeton, New Jersey.

Peek, J.M. 1986. A review of wildlife management. Prentice-Hall, Englewood, N.J.

Pickett, S.T.A., V.T. Parker, and P.L. Fiedler. 1992. The new paradigm in ecology: implications for conservation above the species level. Pages 65-88 in P.L. Fiedler and S.K. Jain, eds. Conservation biology. Chapman and Hall, New York.

Pulliam, H.R., J.B. Dunning, Jr., and J. Liu. 1992. Population dynamics in complex landscapes: a case study. Ecological Applications 2:165-177.

Ricklefs, R.E. 1990. Ecology, 3rd ed. Freeman, New York.

Robbins, C.S., J.W. Fitzpatrick, and P.B. Hamel. 1992. A warbler in trouble: *Dendroica cerulea*. Pages 549-562 in Hagan, J.M., III, and D.W. Johnston, eds. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C.

Robinson, S.K. 1992. Population dynamics of breeding neotropical migrants in a fragmented Illinois landscape. Pages 408-418 in Hagan, J.M., III, and D.W. Johnston, eds. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C.

Salthe, S.N. 1985. Evolving hierarchical systems. Columbia University Press, New York.

Sampson, F.B. 1992. Conserving biological diversity in sustainable ecological systems. Trans. North American Wildl. Nat. Res. Conf. 57:308-320.

Sampson, F.B., and F.L. Knopf. 1982. In search of a diversity ethic for wildlife management. Trans. North American Wildl. Nat. Res. Conf. 47: 421-431.

Simberloff, D., and J. Cox. 1987. Consequences and costs of conservation corridors. Conservation Biology 1:63-71.

Smith, R.L. 1990. Ecology and field biology, 4th ed. Harper and Row, New York.

Villard, M.A. 1991. Spatio-temporal dynamics of forest bird patch populations in agricultural landscapes. Ph.D. Dissertation, Carelton University, Ottawa, Ontario.

Villard, M.A., K. Freemark, and G. Merriam. 1992. Metapopulation theory and neotropical migrants in temperate forests: an empirical investigation. Pp. 474-482 in J.M. Hagan, III, and D.W. Johnston, eds. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C.

Villard, M.A., P.R. Martin, and C.G. Drummond. 1993. Habitat fragmentation and pairing success in the ovenbird (*Seiurus aurocapillus*). Auk, in press.

Wiens, J.A. 1983. Avian community ecology: an iconoclastic view. Pp. 355-403 in A.H. Brush and G.A. Clark, Jr. Perspectives in ornithology, Cambridge University Press, Cambridge.

Wiens, J.A. 1984. On understanding a non-equilibrium world: myth and reality in community patterns and processes. Pp. 439-457 in D.R. Strong, Jr., D. Simberloff, L.G. Abele, and A.B. Thistle. Ecological communities: conceptual issues and the evidence. Princeton University Press, Princeton.

Wiens, J.A. 1989. The ecology of bird communities, Vols. 1 & 2. Cambridge University Press, Cambridge.

Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1214.

Birding Economics and Birder Demographics Studies as Conservation Tools

Paul Kerlinger[1]

Abstract — Birders are the primary user-group of neotropical migratory birds. In the United States, birders number in the tens of millions and spend upwards of $20 billion dollars per year on bird seed, travel, and birding paraphernalia. Average yearly spending by active birders averages between $1,500 and $3,400, with travel being the major expenditure. Research needs include studies of birder demographics and birding economics at the national and state levels, as well as at specific birding sites. In addition, we must learn more about birder knowledge of how wildlife programs are funded and their attitudes toward new means of funding such programs. The meager information available on these topics is reviewed. With funding for nongame wildlife programs floundering, the need for new funding sources is acute. As the primary user-group of neotropical migrant birds, birders represent a large, dependable source of revenue for nongame programs just as hunters and fishermen have funded game programs.

As evidence for the decline of neotropical migrant birds accumulates, government agencies and nongovernment organizations have responded. We now recognize the need to understand why these birds are declining and the need to develop comprehensive strategies to ameliorate the declines. Unfortunately, we do not have the infrastructure or staffing necessary within government and nongovernment sectors to undertake this enormous task, nor do we have funding for such programs. Unlike consumptive wildlife, neotropical migratory birds do not have a recognized user-group to advocate and lobby for them, as well as to help fund recovery efforts. Until this problem is resolved, recovery will not be achieved.

Past responses to declining wildlife populations have been varied. As game species disappeared, federal and state fish and game agencies were created. These agencies are now entrusted with preserving land for wildlife, reintroducing wildlife, monitoring wildlife populations, setting limits on taking of wildlife, and enforcing laws that pertain to wildlife. In addition, funding sources were created that resulted in dependable and substantial revenues for game programs. These include excise taxes on hunting and fishing paraphernalia, various wildlife (hunting and fishing) stamps, and other harvesting permits that fund a sizeable portion of state and federal programs.

The reason for the enormous success of fish and game agencies is that consumptive wildlife users are easily defined and regulated. For the most part, recreational consumptive wildlife users have been hunters and fishermen who now have enormous input into the workings of federal and state agencies that regulate these activities. Hunters and fishermen also have lobby and advocacy groups that exert enormous power within government and various agencies. These include the National Rifle Association among others.

In the 1950's through 1970's the need to protect a few nongame species approaching extinction was recognized. Endangered species laws and programs at both state and federal levels resulted. Because a paucity of funds has precluded broader efforts, the focus of these programs has been a selected group species of endangered species. Eventually, need for programs that focused on nongame and nonendangered species was recognized. Funding was meager at first, but as state tax-checkoff programs for wildlife were implemented a new wave of programs emerged whose focus included all species not included under the umbrella of game. At this time, state wildlife tax-checkoff funds are no longer growing, and nongame and endangered species programs are languishing as funds become more limited. The need for a broad-based and dependable source of funds is obvious, but that source has not been identified.

Birders, numbering in the tens of millions here in the U. S., represent the primary user- group of neotropical (and other) birds. To date, they have not been recognized as such, nor have

[1]*Paul Kerlinger, Cape May Bird Observatory, New Jersey Audubon, P.O. Box 3, Cape May Point, NJ 08212.*

they been considered seriously as a source of revenue for nongame programs. This group, constituting a majority of nonconsumptive wildlife users, would seem an obvious source of funding and advocacy or lobbying efforts. However, we know relatively little about this group; their numbers, demographics, and spending patterns. Before strategies for funding and management programs can be devised, we must understand this user-group in the same way we have come to know hunters and fishermen. The remainder of this paper details types of information we need to gather, research that is needed, and reviews results of research already conducted.

RESEARCH NEEDS

Birding has traditionally been overlooked in studies of nature tourism, both in the U. S. and abroad. There are many examples of this oversight. In a recent compendium on nature tourism (Whelan 1991), neither the term "bird watcher" or "birder" was listed in the index, nor could references to birding ecotourism be found in the entire volume! A similar lack of attention to the importance or potential of birders was obvious in the Manomet Bird Observatory volume devoted to neotropical migratory bird conservation, where the term "bird watcher" seems to have been used only once. This may be understandable in a scientific volume, although my opinion is that it is short-sighted to ignore birders in any discussion of neotropical migratory bird conservation. It is also my opinion that the success of conservation programs for neotropical migratory birds depends, in the long-term, on advocacy and financial support of birders.

The oversight is magnified when other major projects or references are examined. The (USFWS) National Survey of Fishing, Hunting, and Wildlife-Associated Recreation has been conducted at five-year intervals for several decades (U.S.D.I. 1989). The survey separates wildlife users into consumptive and nonconsumptive groups and further dichotomizes consumptive users into fishermen and hunters. (Trapping is also noted, but consists of a relatively small group.) Thus, in most economic and demographic analyses, birding is lumped with all other nonconsumptive, recreational wildlife uses, thus obscuring the actual number and economic impact of American birders. Luckily, most questionnaires used by USFWS contained questions that allow researchers to reanalyze nonconsumptive data for birders, separately. Because this data set has been gathered rigorously and for such a long time, it offers vast insight into the changing role of the birder as a wildlife user-group. The Survey should be the starting point for a programmatic and integrated approach (Table 1) to the study of

Table 1. — Schematic diagram of a proposed multi-level approach to the study of birder demographics and birding economics.

Level I - National Studies of Birders

1. Demographics - age, sex, income, education, activity level
2. Economics
   a. Total economic impact - total number of dollars per year
   b. Specific types of expenditures - travel, optics, bird seed, clothing, field guides, books, cassettes, VCR tapes and equipment, recording equipment, artwork, insect repellent and sunscreen, contributions to conservation organizations (membership and otherwise), magazines, photographic equipment and supplies, ...
3. Knowledge of how wildlife programs are funded
4. Attitude towards new or proposed funding methods

Level II - International Studies of Birding Tourism

1. Demographics - numbers of birding visitors, age, sex, income, education, activity level, place of origin (distance traveled and mode of travel), seasonal pattern of visitation
2. Economics
   a. Total economic impact on a country or local economy
   b. Birder expenditures during visit - food, lodging, travel, field guides, tour guides, gifts ...
3. Attitude towards user-fees or exit-fees for preserving open space
4. Marketing research to learn more about how a destination can be developed

Level III - Site Specific Studies at Domestic Birding Hotspots

1. Demographics - numbers of birding visitors, age, sex, income, education, activity level, place of origin (distance traveled and mode of travel), seasonal pattern of visitation
2. Birder expenditures during visit - food, lodging, travel, field guides, tour guides, gifts ...

birder demographics and birding economics. Furthermore, the Survey offers the opportunity to conduct in-depth follow-up studies of birders so a wider array of questions can be asked.

Perhaps the most important question that we need to ask is, "How many birders are there in the U. S.?" The range of activity among these recreational, non-consumptive wildlife users is vast. Some people bird only in city parks, which includes feeding pigeons and starlings. Many "birders" do not even own binoculars. These are birders in the broadest sense of the avocation and should not be considered among the ranks of American birders. The next step up in activity are those who maintain yard feeders. These people usually own binoculars but do not venture forth to different locations to observe their quarry. At the other end of the spectrum are those who pursue their pastime during more than 50-100 days of the year. Between these extremes are an amazing range and variety of recreational users.

In Table 1, I propose a three-leveled structure for programmatic research that will lead to better understanding of birders and their economic impacts. Three major areas of research are proposed, each focusing on a different geographic scale and each contributing information about birders as a user-group that can be used for different purposes. The data for national economic and demographic studies have already been collected as part of the United States Fish and Wildlife Service National Survey.

A primary goal (Level I in Table 1) of (my) research on birder demographics and birding economics from the Natural Survey is acquisition of data to be fitted to an asymptotic curve as shown in Figure 1. Instead of giving us one number to cite when asked how many U.S. birders there are, we will determine how many people go birding for more than 100, 50, 25, 5, etc. days per year; how many spend more than $2,000, $1,000, $500, $100, etc. per year. Thus, we will characterize the continuum of birder activity and total dollar value spent (economic impact) of the group as a whole or by any defined portion of the birding population.

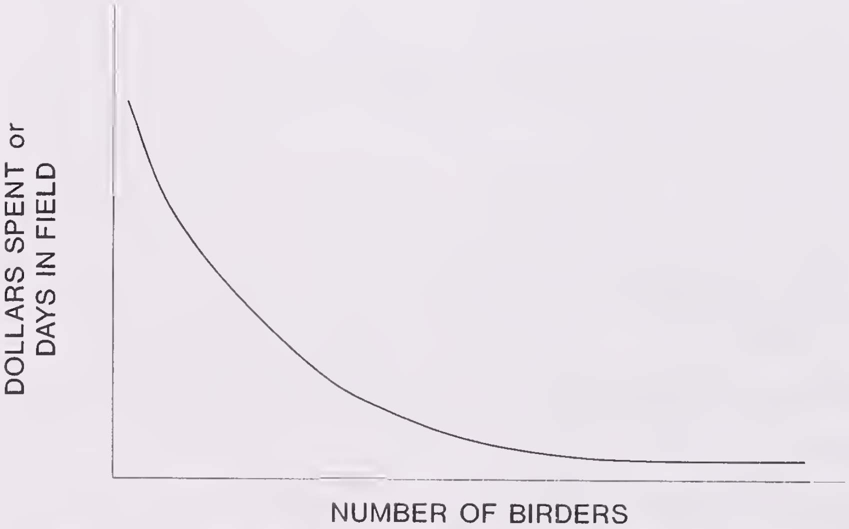


Figure 1. — Theoretical curve showing the activity or spending of birders along a continuum of high to low activity.

Of the remaining proposed research in Table 1, some data exist, but is outdated or exists for only a portion of what is needed. One of the most pressing needs in birding/birder research is a study of birder knowledge of how wildlife programs are funded and a study of birder attitudes toward new means of funding nongame wildlife programs (Table 1; National Studies numbers 3 and 4). Many hunters and fishermen seem to be aware that they "pay" for wildlife through various types of excise taxes, hunting or fishing licenses, wildlife stamps, and other means. It would be interesting to determine how much birders know about funding of state and federal wildlife programs, both game and nongame. It also would be interesting to compare their knowledge with that of hunters and fishermen. The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation would be an ideal vehicle for such studies. (As a further study, the knowledge and attitudes of non-users of wildlife should also be determined.)

Although I am suggesting that comparisons between birders, hunters, and fishermen be made, these data need to be presented carefully. With the volatility of anti-hunting issues and unscrupulous practices of some animal rights groups, data could be used as a divisive tool to polarize consumptive and nonconsumptive users. This would detract from any positive efforts to conserve open space. Information on hunting and fishing from the National Survey should serve as a standard from which we evaluate the true potential of birders as a source of future funding for nongame/neotropical migratory bird programs.

A brief perusal of magazines such as *Bird Watcher's Digest* shows birding travel is big business. The number of advertisements for foreign birding trips and the number of tour companies that lead such trips has increased dramatically in the past decade. The market may now be saturated after geometric growth in the 1980's. This growth reflects broader interest in birding tourism and ecotourism in general.

Birding is just one form of ecotourism touted as a conservation tool by many experts. Birding economic studies for entire neotropical countries (Level II in Table 1) and for specific sites (Level III in Table 1) within those countries would provide information used to argue for open space conservation. In addition to standard economic studies, cost-benefit relations weight alternative forms of economic development. A few cost-benefit analyses have been done, but they are still rare. In the case of ecotourism in Palawan, Philippines (Hodgson and Dixon 1988), a cost-benefit analysis showed a greater economic benefit to the community resulted from scuba diving than logging. Further, the analysis showed that siltation of nearshore waters from logging resulted in fewer ecotourism dollars. Similar analyses might reveal analogous patterns at birding hotspots (often biodiversity centers) in the neotropics. This information is desparately needed by policy makers so that long-term economic planning is possible. The types of tourist destinations that should be targeted include places such as Asa Wright Nature Center in Trinidad and Tobago; Monte Verde in Costa Rica; and Quintana Roo in Yucatan, Mexico, to name a few.

Studies that attempt to examine economic impacts of birding tourism on entire neotropical nations will be difficult to conduct and will probably not result in significant expenditures when compared with broader-scale, less environmentally sensitive industries such as logging or ranching. In many countries there are several different birding destinations such that multiple trips are needed for a birder to sample all major birding opportunities. That is why in most countries site specific studies are needed, along with research to trace the flow of dollars from tourists into the local community. This latter point is important because many ecotourist dollars never enter the local economy. Ecotourism planners need data to determine how much can feasibly be directed to locals who "manage" the actual resource (in this case the birds).

The third level proposed in Table 1 are domestic studies of birding tourism at specific destinations. Recent research has identified some major birding hotspots in the U. S. and Canada (Table 2). These sites are frequently critical stopover sites or breeding locales, most often for neotropical migrants, and should be targeted for in-depth studies. How many birders visit the site, where they stay, how much they spend, why they are there (type of birds, facilities), and much more can be learned. Most importantly, studies should be done in a standardized way so that comparisons can be made and a follow-up can be conducted at 5-10+ year intervals.

In the review of past research that follows, I attempted to follow the structure provided in Table 1.

PAST RESEARCH

Studies of wildlife use in the U. S. have been conducted at many levels. The literature is diffuse and difficult to summarize. Furthermore, it is difficult to compare studies mostly because research methods vary greatly. The following paragraphs include selected information and should not be construed as an exhaustive review of the birding economics/demographics literature.

Table 2. — America's dozen favorite birding sites in descending order of choice along with the nearest federal/state land holdings or private preserve (unpublished data from Wiedner and Kerlinger 1990).

1. Southeastern Arizona (Ramsey Canyon/Mile-Hi Ranch [The Nature Conservancy])
2. Rio Grande Valley, Texas (Rio Grande Valley National Wildlife Refuge)
3. Everglades National Park, Florida
4. Texas Coast (Anuhuac National Wildlife Refuge and others)
5. Cape May, New Jersey (Cape May National Wildlife Refuge)
6. Point Pelee, Ontario (Point Pelee National Park)
7. Big Bend National Park, Texas
8. Point Reyes, California
9. Forsythe (Brigantine) National Wildlife Refuge, New Jersey
10. High Island, Texas
11. Hawk Mountain Sanctuary, Pennsylvania
12. Cheyenne Bottoms, Kansas (Quivera National Wildlife Refuge)

Birder Demographics

In 1970 only about 4% of Americans were considered birders (USDI 1970). By the mid-1980's independent samples suggested about one out of four Americans could be considered birders and 11% watched birds during at least 20 days per year (Kellert 1985). One estimate of the number of people who watched birds in the late 1980's was 61 million (Hall and O'Leary 1989), although this estimate seems high. The problem with estimating number of birders is that activity and proficiency levels vary greatly. There are certainly different levels of birding activity, but defining these levels is problematic. Kellert's definition of a "committed" birder was one who could identify more than 40 species. "Casual" birders were those who could identify fewer than 10 species. "Active" birders defined by Wiedner and Kerlinger (1990) were participants in the 1988-1989 National Audubon Society Christmas Bird Count (CBC). In a study of birding tourism at a specific destination, Kerlinger and Wiedner (1991) identified birders as those who wore binoculars and identified themselves as such when asked.Birders are not a random sample of the American population and statistics from different studies vary. Wiedner and Kerlinger (1990) reported that active birders were primarily male (63% of the sample), although in a study of birding tourists at Cape May, New Jersey, (Kerlinger and Wiedner 1991), the sex ratio was nearly equal (49% female). One statistic that does not seem to vary among studies is that the age of the average birder is in the mid-forties (Kellert 1985, Kerlinger and Wiedner 1991, Wiedner and Kerlinger 1990).

The income levels of birders has been repeatedly shown well above the national average. Income for American Birding Association (ABA) members was nearly three times the national average (Wauer 1991). For the CBC group studied by Wiedner and Kerlinger (1990), less than 30 percent had incomes less than the national average, even when students were included. As expected, active birders are highly educated. Wiedner and Kerlinger (1990) demonstrated that about three-quarters of the respondents in their study held degrees from four-year colleges and 98% graduated from high school. Results reported in the ABA study were similar as was the case with the Kellert (1985) study.

Birding Economics - National Level

Some very large dollar values have emerged from studies of birders and other nonconsumptive wildlife users. Birding was suggested to be a $20 billion industry in the mid-1980's for all of North America. An earlier estimate in 1980 using the National

Survey was $15 billion for just the U.S. (USDI 1982) for all nonconsumptive wildlife use. A better estimate will be available when the 1990 National survey is analyzed.

It is probable that the amount of money spent by American birders parallels the spectrum of birding activity from active (dedicated) to casual birders. Some birders spend thousands of dollars and others spend very few dollars (Figure 1). The most active of birders probably spend the most. In 1990, Wiedner and Kerlinger reported that "active" birders spend $1,850 per year. A study by Wauer (1991) of the membership of the ABA revealed average yearly expenditures of nearly twice this amount ($3,400). Currently, 10,000 ABA members are some of the most active birders in the world. Travel is the largest expenditure in a birder's yearly budget, accounting for more than 70% of total expenditures. A detailed breakdown of an active birder's annual expenditures may be found in Wiedner and Kerlinger (1990) and Wauer (1991).

Studies of active birders focus only on the left side of Figure 1, the relatively small number of very active birders. Unfortunately, we do not know have robust estimates for the entire area under the curve, which would include a heterogeneous group of birders with varying activity levels.

Birding Economics - Site Specific Level

Site specific studies of birders and birding economics have now been completed, probably at fewer than 10 locations in the world (Table 3). Site specific studies refer to a geographic site that attracts birders from a much larger area. Area size can vary. For example, Forsythe National Wildlife Refuge, a birding destination for more than 175,000 people per year, most of whom are birders, is small when compared to the neighboring Cape May peninsula. It could be considered as separate from Cape May. This becomes problematic, because many birders stop at Forsythe on their way to or from Cape May. According to USFWS about 90,000 birders visit the peninsula each year. Other examples of sites include Hawk Mountain Sanctuary, Pennsylvania, and the Everglades (National Park) in Florida. Each differs in size and the area surrounding the site. Thus it is often difficult to identify or delineate the geographic area that reaps the economic benefits. Some sites frequented by traveling birders have virtually no businesses within them that could benefit from birding ecotourism. The Pawnee National Grassland in Colorado has few services, so birders cannot even spend money there. Instead they must find lodging and restaurants dozens of miles away. Studies of these areas must include communities that may be 100 km or more from the actual birding sites.

The input of birders to other local economies is similar. How many sites in the U. S. benefit from birding tourism is not known. A national study of active birders by Kerlinger and Wiedner conducted in 1988-1989 revealed that birders visit a large number of sites in this country. When asked to list their 5 favorite birding locales in North America, the 1,130 respondents gave the names of more than 900 sites! That different names may have been used for the same sites, or that some sites were very close to each other reduces the actual number. But the number is still impressive.

What happens at other sites listed in Table 2? What happens at the Bald Eagle Days festival in Illinois/Iowa each winter? the hummingbird festival in Texas each autumn? the waterfowl/carving attractions on the eastern shore of Maryland? How many birding events are held in the U. S. each year? How much do birders spend and what do they purchase at these events? The answers have profound implications for conservation.

Only three detailed, site-specific studies have been reported in the literature, although dependable economic estimates of economic impact are available from several other areas. Kerlinger and Wiedner (1991) working in Cape May, New Jersey, demonstrated a conservative $6 million coming into the local economy. An updated estimate suggests more than $10 million are injected in the Cape May economy as of 1991-1992. Hvenegaard et al. (1988) showed a similar economic input into the Point Pelee/Leamington, Ontario economy, as did Lingle (1991) for the Platte River area of Nebraska. These sites differ greatly. Point Pelee attracts 50-60,000 birders per year, mostly in April-June to observe neotropical songbird migrants on their way to northern breeding grounds. The Platte River attracts some

Table 3. — Selected summary of sites where birding economic studies have been conducted along with the numbers of birders and the amount they spent.

Site	Number of Visitors Per Year	Dollars Spent
Cape May, New Jersey	100,000	$ 10 million[1]
Hawk Mountain Sanctuary, Pennsylvania	50,000	$ 2-4 million[2]
Platte/North Platte Rivers, Nebraska	80,000	$ 40 million
Point Pelee, Ontario	57,000	$ 3.2 million
Pembroke, Ontario	10,000	$ 0.5 million

[1] *The $10 million dollar statistic is an upgraded estimate 4 years after the original survey was conducted.*

[2] *This dollar value is estimated from a preliminary analysis of data collected in 1990 by Kerlinger and J. Brett.*

40,000 people who wish to view the spectacle of cranes that stopover during their autumn migration. Cape May is an autumn migration site. Both are excellent birding sites and also have superb general tourist visitation. Birders tend to visit these sites during the off-season for general tourism. This makes birding tourism very special for the local communities because birders inject revenue when general tourism dollars do not.

THE USE OF BIRDING ECONOMICS AND BIRDER DEMOGRAPHICS STUDIES

Of what use are birding economic studies conducted at the national level? Once the user-group is identified and their spending patterns characterized, the information can be used for many purposes. Policy makers and legislators in the government and private sector, who need to know the demand for open space and how much funding should be appropriated for acquisition and management are a key group.

Birders constitute a major user group of open space, especially in the federal refuge and park system. The same is true of state wildlife management areas, parks, and municipal parks. Although hunters and fishermen use public open space, they usually do so during limited (open) seasons. There are no seasons on birding, so it can occur on more days during the year than consumptive activities. This means greater potential for use by birders (and other nonconsumptive users). It also means that consumptive and nonconsumptive activities can be easily partitioned to avoid the potential for negative interaction between groups. Decisions to acquire open space in a particular refuge or management area is based on need for greater area for wildlife and need for more areas for users. Information that characterizes a large number of well educated, upper income, tax-paying, voters as primary users of public open space is very meaningful, especially to legislators.

A group that should be just as interested are businesses that benefit directly and indirectly from birding. These include airlines, optics, wild bird food, publishers, tour companies, travel agents, lodging, and manufacturers of birding related paraphernalia. Because the birding optics industry and other businesses stand to benefit economically, they should be supporting birding economics studies. If manufacturers support such studies, they can be economically justified by including marketing questions (piggy-back research) that will benefit the manufacturer through helping design more saleable items or providing new advertising ideas or identifying places to advertise.

Lest the user-group be forgotten, I must emphasize the importance of information **about** birders **to** birders. There are many of us (birders) who wish to see birding reach its full potential for conservation. Birders need to know their own numerical and economic strength. There is no advocacy or loggying group currently serving birders as is the case for fishermen and hunters. Dozens of national and state organizations serve birders to some degree, but none are completely dedicated to this end. For birders to have power that is commensurate to their numbers, they must have an organization that serves in a lobbying capacity. Advocacy is good, lobbying is stronger.

Economic studies of birding at specific birding destinations are useful in a different way from national studies. Information collected as a result of site-specific birding economic studies can be an invaluable tool for open space conservation and, therefore, for neotropical migrants as well as other bird species. Its first use should be as a general education tool. The information should be disseminated widely in the area concerned. Newspaper and magazine articles, television and radio "spots" all help to educate a public that has no knowledge about how birders and birding affect their community.

Planning boards, chambers of commerce, park managers, refuge managers and superintendents, and others need to be informed about the numbers of birders that visit their area or use their open space. Such information is invaluable for constructing new refuges, not to mention managing existing refuges. For example, the recently established Cape May National Wildlife Refuge has been accepted by many area planners as having an economic potential for the community.

Another result of the Cape May birding economic study is that Cumberland County (adjacent to Cape May County) Planning and Economic Development Board applied for and was awarded a Delaware Estuary Program (U. S. Environmental Protection Agency) grant to produce a site guide to birding in Cumberland County. Their hope is that the abundant wildlife of Cumberland County will be the basis for ecotourism to bring revenue to the county without resorting to development of environmentally sensitive areas. Cumberland County has more (undevelopable) freshwater and tidal wetlands than any county in New Jersey. The county also has a large forested area (much lowland) that hosts many neotropical birds. This enlightened, pioneering effort by a county that is one of the poorest in New Jersey is exemplary. The success (or failure) of these efforts will weigh heavily on future development and environmental plans for Cumberland County and other areas.

More specific uses include fund raising for nonprofit organizations; a tool for reducing or eliminating taxes on wetlands or other open space; and even in court cases where development threatens important habitat. Economic arguments are often more potent than aesthetic arguments, because they appeal to "bottom line," budget conscious planners.

Birding economic studies as a fund-raising tool has been used successfully in several areas. As a result of an economic study of birding tourism in Cape May, the Cape May Bird Observatory was able to add dozens of motel, hotel, restaurant, and campsite owners, as well as realtors, to its membership. All of these new members entered at higher rates than individual or family members. The money derived from these memberships is used for education and research (not to mention paying lawyers to sue the state of New Jersey on wetlands issues and expert witnesses to testify in environmental cases). Without the economic study done by Kerlinger and Wiedner (1991), these businesses would not have known about how much birders contribute to the Cape May economy, nor would they have supported the Bird Observatory. Furthermore, many owners subsequently became more outspoken regarding environmental issues in their own backyard knowing that environmental degradation would be bad for business. The same sort of environmental-economic issues can be raised in other areas where birders provide a significant economic input to a community. This is most important for grass-roots environmental organizations, nature centers, private refuges, etc. Open space and the birds that occupy that space should be viewed as economic attractors. The issue of jobs vs the environment is a frequently used ruse to avoid long-term solutions to environmental or economic problems. The alternative argument of a clean environment promoting long-term economic stability should be emphasized.

CONCLUSIONS

I introduce the reader to a relatively new field of study that focuses on a previouisly under recognized user-group. Birders are the major, perhaps only, user-group of neotropical migratory birds. Birders, like hunters and fishermen, are easily identified and when their economic and numerical strength is characterized, they will emerge as a powerful group. Most importantly, we need to characterize the group through demographic and economic studies at several different levels (Table 1). The points I made regarding need for studies of birder demographics and birding economics are not new. Diamond and Filion (1987) reported several studies that touted the economic importance of birding and birding tourism, but few studies presented data to substantiate their claims and fewer provided cost-benefit analyses of the sort outlined above. Kellert (1985) drew some of the same conclusions nearly a decade ago, as did several other authors. Kellert found that 78% of committed birders favored "entrance fees to wildlife refuges and other public wildlife areas," but that only about half supported a sales tax on birding equipment. The need for a funding source for nongame wildlife programs, especially neotropical migratory birds, is acute. Birders represent a viable source of long-term and dependable funding for nongame programs, including those for neotropical migratory birds.

ACKNOWLEDGMENTS

Funding during my initial birding economic studies came from Humphrey Swift of Swift Instruments, Inc. The remainder of the funding has been provided by members of New Jersey Audubon Society and Cape May Bird Observatory, as well as a major contribution by Robert and Jane Engel. The Bernice Barbour Foundation is providing funds for the research facility in which future birding economic studies will be conducted. I thank C. Kerlinger, David Wiedner, Pete Dunne, Joan Walsh, David Rockland, Rob Southwick, Dick Payne, Peter Stangel, and R. Widmer for thought provoking discussions and suggestions.

LITERATURE CITED

Clark, W. R. 1987. Economics and marketing of "Canada's Capistrano." ICBP Tech. Publ. No 6:31-48.

Diamond, A. W., and F. L. Filion (Eds.) 1987. The value of birds. ICBP Tech. Publ. No. 6. ICBP, Cambridge.

Hall, D. A., and J. T. O'Leary. 1989. Highlights of trends in birding from the 1980 and 1985 national surveys of non-consumptive wildlife-associated recreation. Human Dimensions in Wildlife Newsletter 8(2):23-24.

Hvenegaard, G. T., J. R. Butler, and D. K. Krystofiak. 1988. Economic values of bird watching at Point Pelee National Park, Canada. Wildl. Soc. Bull. 17:526-531.

Hodgson, G. and J. A. Dixon. 1988. Logging versus fisheries and tourism in Palawan: an environmental and economic analysis. EAPI Occas. Pap. No. 7. Honolulu, HA: East-West Center.

Kellert, S. R. 1985. Bird watching in American society. Leisure Sci. 7:343-360.

Kerlinger, P. and D. S. Wiedner. 1991. The economics of birding at Cape May, New Jersey. in Ecotourism and Resource Conservation: a collection of papers. J. A. Kusler, ed. Proceedings of the 2nd International Symposium: ecotourism and resource conservation. pp. 324-334.

Lingle, G. R. 1991. History and economic impact of crane-watching in central Nebraska. Proc. North Am. Crane Workshop 6:25-29.

United States Department of the Interior. 1970. National survey of hunting and fishing. U. S. Fish and Wildlife Service, Washington, D.C.

United States Department of the Interior. 1982. The 1980 National Survey of Fishing, Hunting, and Wildlife-associated Recreation. Fish and Wildlife Service, Washington, DC.

United States Department of the Interior. 1989. The 1985 National Survey of Fishing, Hunting, and Wildlife-associated Recreation. Fish and Wildlife Service, Washington, DC.

Wiedner, D. S. and P. Kerlinger. 1990. Economics of birding: a national survey of active birders. American Birds (ICBP Section) 44:209-213.

Wauer, R. 1991. Profile of an ABA birder. Birding 23:146-154.

Whelan, T. 1991. Nature Tourism: managing for the environment. Island Press, Washington, DC.

Cooperative Partnerships and the Role of Private Landowners

T. Bently Wigley[1] and James M. Sweeney[2]

Abstract — Because most land, including forest land, in the United States is privately owned, it is clear the private sector should be a major cooperator in "Partners in Flight" efforts to conserve neotropical migratory birds. The "private sector" is more than forest landowners, whether corporate or noncorporate; it includes agricultural landowners, mining interests, housing and commercial land developers, and others. The private sector also includes the general public as users of products generated from private lands and as stockholders in corporate landowners. Private landowners are extremely diverse and vary considerably in their land ownership objectives. With that diversity comes a unique opportunity for cooperation in addressing natural resource issues, or controversey and conflict. We present a case study of one successful cooperative partnership, the Black Bear Conservation Committee, and identify reasons it has succeeded. Examples of other successful partnerships between private landowners and other non-governmental organizations, state agencies, and federal agencies are described. Successful partnerships will require all partners leave "hidden agendas" behind, respect the objectives of each other, and contribute something to the partnership. We propose that the challenge to Partners in Flight members is to help private landowners define their role in neotropical migratory bird conservation within the context of their land ownership and management objectives, and help them fulfill that role.

Most efforts to conserve neotropical migratory birds have focused on federal agencies and federal lands. Most land, however, is not owned by federal, state, or local government. Rather, it is owned by private individuals, partnerships, and corporations, much of it in small parcels. About 66% of all land in the United States is owned by families and individuals; nonfamily corporations and partnerships own another 13% of all land (Gustafson 1982). Half of all land is owned in parcels smaller than 500 acres and about 20% is in parcels larger than 5,000 acres. The average landholding is 40 acres (Gustafson 1982).

Forested land is important to many species of neotropical migrants. The United States is about 21% forested (Table 1); the Northeast region is most heavily forested, followed by the South, North Central, and West. Most forested land also is owned by noncorporate individuals or families (Table 2). Nationally, noncorporate private landowners own almost 3 times more forested land than the public owns through the federal government. The forest products industry owns about 15% of all forested land, or roughly 3/4 as much as is owned by federal agencies.

The potential importance of private forest lands to neotropical migrants is particularly salient in the eastern United States. In the Northeast and South, corporate and noncorporate private landowners own about 90% of all forested lands. Federal ownership is % in the Northeast, and % in the South. Thus, few efforts to enhance habitat for neotropical migrants, particularly those associated with forests, will be complete without involving private landowners. The Departments of Interior and Agriculture recently acknowleged that "because they own the majority of the U.S., the involvement of millions of private parties and landowners is critical to the overall success of conservation efforts" (Goklany 1992).

[1] *T. Bently Wigley, National Council of the Paper Industry for Air and Stream Improvement, Inc., Department of Aquaculture, Fisheries, and Wildlife, Clemson University, Clemson, SC 29634-0362*

[2] *James M. Sweeney, National Forest Products Association, 1250 Connecticut Avenue, NW, Suite 200, Washington, DC 20036*

Table 1. — Total and forested land area (1,000 acres) in the United States (after Waddell et al. 1989).

Land area	Region				
	Northwest	South	North Central	West	United States
Total land	103,621	557,298	480,284	1,116,413	2,257,616
Forested land	63,453	210,033	78,113	129,720	483,319
Percent forested	63.2	37.7	16.3	11.6	21.4

[1]**Northeast** *includes: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.* **South** *includes: Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.* **North Central** *includes: Michigan, Minnesota, Wisconsin, Illinois, Indiana, Iowa, Missouri, Ohio, Kansas, Nebraska, North Dakota, and South Dakota.* **West** *includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.*

Table 2. — Percentage of forested land by landowner type (after Waddell et al. 1989).

Landowner type	Region				
	Northeast	South	North Central	West	United States
Federal	2.8	8.1	11.5	53.3	20.1
State	8.1	1.6	9.8	8.0	5.5
County and municipal	1.3	0.4	6.3	0.4	1.5
Indian	0.2	0.1	1.2	3.4	1.2
Forest products	17.4	18.8	5.6	11.9	14.6
Noncorporate private	70.1	71.1	65.7	23.0	57.2

[1]**Northeast** *includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.* **South** *includes Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.* **North Central** *includes Michigan, Minnesota, Wisconsin, Illinois, Indiana, Iowa, Missouri, Ohio, Kansas, Nebraska, North Dakota, and South Dakota.* **West** *includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.*

LANDOWNER OBJECTIVES

Private noncorporate landowners represent a cross-section of occupations, interests, and reasons for owning land (Shaw 1981), thus they vary considerably in their ownership objectives. Most noncorporate private landowners have multiple reasons for owning their land. And, ownership objectives are constantly changing because annual turnover in ownership of private noncorporate land is about 12% (Shaw 1981).

In Mississippi, Nabi et al. (1983) found that 63% of nonindustrial private landowners had "multiple-use" as the goal of owning their forestland. However, timber production was the most important of the multiple uses, followed by wildlife, residence, and grazing. Likewise, 28% of private landowners in South Carolina owned their land (43% of the private land) for timber production purposes (Marsinko et al. 1987). Other uses in rank order were investment, part of farm, place of residence, no plans yet, aesthetics, future farming, recreation, and hunting. In New England, private landowners primarily use their forests for woodlot, open-space, recreation, scenery, wildlife habitat, part of farm, hunting, and privacy (Alexander 1986). Fuelwood cutting is the most important commodity use of private noncorporate forest land in New England, but landowners value their land primarily for intangible benefits and satisfactions associated with scenery, open-space, and pride-in-ownership. Despite interest in wildlife and commodity uses, few noncorporate landowners actively manage their lands to enhance habitat suitability (Alexander 1986) or timber production (Greene and Blatner 1987). Rather, they tend to harvest when income or fuelwood is needed.

The forest products industry is an equally diverse group of landowners. It is composed of small to large corporate landowners. Some corporations are owned by individuals or families; others are owned by stockholders. Some corporations own and operate on their own lands. Others are dependent in part or whole on timber from public lands. Most companies differ in products they make from timber they harvest. For example, they may emphasize glossy magazine paper; dimension products such as lumber or poles; paper cups, towels, and napkins; some combination of these products; or something entirely different. The products a company makes influences how they will manage their forests. For example, pulp/paper companies may be on a shorter rotation than producers of timber, and they may emphasize different tree species.

Despite their differences, there are at least 3 factors that corporate landowners have in common. One is they hold their lands to provide the company's owners with a return on their investment. Many forest products companies are owned by stockholders who purchased their stock in anticipation of a reasonable return for their investment. A second commonality is they harvest timber because there is demand for forest products. And, that demand is projected to increase. By the year 2040, annual lumber consumption is expected to increase by 23% to 70 billion board feet, consumption of plywood is expected to increase by 50%, and consumption of paper and allied products is expected to double (Schallau 1991). A third factor companies have in common is they compete with each other. By law, no company monopolizes any market. But, the most efficient company will often acquire the largest market share for which it is competing. Thus, the ability of companies to alter forest management activities for noncommodity reasons is usually tempered by the competitive nature of American industry.

WORKING WITH PRIVATE LANDOWNERS

Despite these constraints, companies within the forest products industry have historically worked on their own and through cooperative partnerships with many other organizations and agencies to promote responsible stewardship of forest resources (Owen and Heissenbuttel 1990). In a speech to the 56th North American Wildlife and Natural Resources Conference in March 1991, U.S. Fish and Wildlife Service Director John Turner called for such public and private sector partnerships and involvement in making resource management decisions. Turner suggested that "partnerships may be the best and surest vehicle yet to carry forth a full and rich biological community into the 21st century" (Bullock 1992).

The Black Bear Conservation Committee: A Case Study

There are a variety of ways in which cooperative partnerships may be formed. The most important commonalities in partnerships seem to be a mutual interest in some issue and a desire to work together in a positive, cooperative manner. One excellent case study of a successful cooperative partnership is the Black Bear Conservation Committee (BBCC). Although the BBCC does not focus on neotropical migrants, the management practices they advocate also will enhance habitat for many neotropical migrants. Additionally, the BBCC provides some powerful lessons for developing partnerships; similar partnerships also may work for neotropical migrants.

Declining numbers of the Louisiana black bear (*Ursus americanus luteolus*) throughout Mississippi, Louisiana, and east Texas was the impetus for forming the BBCC. The Louisiana Forestry Association arranged the initial meeting of organizations, agencies, and individuals interested in status of bear populations in the tri-state area, and invited Dr. Michael R. Pelton of the University of Tennessee as a speaker. Dr. Pelton captured thoughts of those present when he said "The primary responsibility for insuring the future survival and viability of present black bear numbers in the Southeast Coastal Plain, and Louisiana specifically, shall fall on a number of public and private agencies that control the lands containing black bear habitat or potential habitat." Although some Louisiana black bears are on federally owned lands, most bears are on private lands (Nielsen 1992). Thus, participation of private landowners is critical to bear recovery. To date, 37 organizations have signed the memorandum of understanding committing them to the goals of the BBCC. Members include forest products companies, forestry and agricultural trade associations, federal and state natural resource agencies, local chapters of environmental groups, and universities.

Through the BBCC, these entities have come together to address management and restoration of a wildlife species. Some BBCC accomplishments include increasing awareness of the public in Mississippi, Louisiana, and east Texas about the black bear and its status; securing funding for a full-time coordinator who serves in administrative and extension capacities; coordinating research on black bear and helping secure over $500,000 in research funds; and developing management guidelines for landowners. At the time of this writing, the BBCC is approaching completion of its "Restoration Plan" for the black bear in the tri-state area. The BBCC was honored by the Louisiana Wildlife Federation as its choice for 1991 Conservation Organization of the Year.

We attribute the BBCC's success to several things. First, the BBCC requires that all members of the partnership "leave-at-the-door" any agendas except that of restoring the bear. This helps BBCC members focus on their common goal. Second, there has been mutual respect among BBCC members for objectives of each individual partner. Partners have allowed each other to contribute what they can within the limits of their organization's objectives and capabilities. Third, all BBCC partners make some contribution to the partnership's efforts. Contributing only opinions and demands to a partnership will quickly destroy trust and respect. In the BBCC no organization gives the same thing or same amount, but they all give something. This truly qualifies them as "partners" and makes their fellow partners much more willing to communicate about issues. Fourth, BBCC partners began by cooperating in a positive way on issues where there was much common ground. This "good start" helped them learn about each other and develop mutual trust. Using this solid foundation, the BBCC has begun successfully dealing with issues that sometimes divided groups such as industry and environmental organizations. Fifth, the BBCC has provided an environment in which its members can informally socialize and come to know each other as individuals. It is much easier to communicate, find common ground, and work together when partners know each other personally. Finally, the BBCC has relied on the "best" available, scientifically-derived information as an arbiter.

Other Types of Partnerships

These same principles can work equally well for smaller partnerships such as those between individual companies and state wildlife agencies. These partnerships are virtually unknown outside the South where state wildlife agencies often have agreements with forest products companies to provide public access on their lands (Owen and Heissenbuttel 1990). In Tennessee, for example, the Tennessee Wildlife Resources Agency (TWRA) has signed agreements with 5 forest products companies, giving hunters access to 600,000 acres. The landowner sets and collects permit fees and TWRA enforces the rules and regulations governing the lands. In Arkansas, the Arkansas Game and Fish Commission (AGFC) pays landowners a flat per-acre fee for lands enrolled in an access program. The state then sells access permits to the public. To be successful, such partnerships call for a close working relationship between partners.

Sometimes parnerships can involve companies and other non-governmental organizations (NGOs). For example, Mead Corporation and Menasha Corporation have joined the Michigan Wildlife Habitat Foundation (MWHF) and Ruffed Grouse Society to encourage private landowners to place their woodlands under professional management by emphasizing the wildlife benefits of forest management (Owen and Heissenbuttel 1990). A wildlife biologist has been hired by MWHF to administer the project in the 14-county area. He prepares management plans that incorporate landowner objectives, and actual forest management work is provided by a private consultant or a forest products company.

In Louisiana, International Paper Company and The Nature Conservancy have formed a cooperative parnership to maintain a unique Black Hills ecosystem owned by the company. International Paper Company has restricted human and livestock access to the area and has modified their timber management activities; the Nature Conservancy advises the company regarding activities necessary to maintain the ecosystem, such as prescribed burning. In Florida, Champion International Corporation has entered a cooperative agreement with The Nature Conservancy to protect a population of a rare perennial herb.

Private landowners also can form cooperative partnerships with federal agencies; sometimes these are quite informal. For example, Georgia-Pacific Corporation supplied the expertise, equipment, and manpower to conduct a prescribed burn on 100 acres of the Congaree National Monument in South Carolina. The goal was to reduce hardwood midstory and improve habitat for the red-cockaded woodpecker (*Picoides borealis*). In North Carolina, the Weyerhaeuser Company used their heavy equipment to help construct dikes on the Alligator River National Wildlife Refuge. Such informal partnerships usually are the result of personal working relationships between local landowners (or their employees) and agency personnel.

More formal relationships between private landowners and agencies also can exist. In 1989, Scott Paper Company executed the first major private landowner agreement under the North American Waterfowl Management Plan. Under the agreement, Scott has altered forest management practices on 27,000 acres of Mobile River delta in south Alabama to benefit waterfowl. And, Scott has donated lumber for constructing wood duck nesting boxes. In California, Simpson Timber Company and the U.S. Bureau of Indian Affairs operate a fish hatchery on company lands. Each year, they release 500,000 young fish into Cappell Creek. Simpson Timber Company also is very close to completing a Habitat Conservation Plan for the management of northern spotted owls (*Strix occidentalis caurina*) on their lands.

There is perhaps no better example of cooperative partnerships than those focused on research. Over the decade of the 1980's, the forest products industry spent more than $100 million on wildlife and environmental research (Owen and Heissenbuttel 1990). Much of that funding went to support cooperative research; and that trend continues. For example, through the National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI) and with matching funds from the National Fish and Wildlife Foundation, the forest products industry is partially funding Manomet Bird Observatory (MBO) to conduct a study of neotropical migratory birds in Maine. Three forest products companies also are participating in the study by allowing MBO and the U.S. Forest Service access to their lands, and by providing Geographic Information System and stand inventory data to the researchers. In the Pacific Northwest, NCASI has developed several cooperative partnerships individually with the U.S. Forest Service and Bureau of Land Management to conduct research on northern spotted owls (*Strix occidentalis caurina*) and elk (*Cervus canadensis*). Each partner provides about one-half of the funding and shares equally in the research responsibilities such as data collection. Weyerhaeuser Company and the U.S. Forest Service are partners in funding and conducting a project in Arkansas to investigate bird and small mammal use of streamside management zones. Anderson-Tully Company is cooperating with the Tennessee Conservation League and the USDA Forest Service in a study of cerulean warblers (*Dendroica cerulea*) by providing study sites and helping with data collection.

Cooperation Versus Regulation

To private landowners, cooperation is almost always a more desirable approach than regulation for addressing natural resource issues. Agencies and NGOs can work cooperatively with private landowners through mechanisms such as informal agreements, memoranda-of-understanding, and leases. Each of these mechanisms, however, requires personal contact between partners and mutual respect; a good relationship does not happen by itself.

Land exchanges are sometimes viewed as cooperation. However, they are not always desirable from the private landowner's viewpoint. Usually, the landowner needs the land and its associated resources to meet his/her objectives. Often, property offered for exchange is not strategically located for the private landowner or of comparable quality. And, exchanges may not be the best long-term solution to resource issues. Ironically, the unique plant and animal communities on private land being sought in exchanges are usually there as a result of past management practices by the owners. Yet, private lands are sometimes categorized as "at-risk" or "unprotected." In reality, private ownership does not mean "at-risk," and simply transferring ownership of private lands to a governmental agency will not ensure that they will be categorically "protected."

Incentive Programs

Sometimes, *de facto* cooperative partnerships can be developed through incentives. There are a number of incentive programs offered through state and federal natural resource agencies for owners of private lands. The programs can be used to encourage landowners to enhance habitat for neotropical migrants. For example, state forestry agencies administer the Forest Stewardship Program (FSP), authorized by the 1990 Farm Bill. The FSP offers technical assistance to private landowners in developing multiple-use management plans for their forests. Cost-sharing for management activities recommended through FSP is possible through the Forest Stewardship Incentive Program and some state incentive programs. The Agricultural Stabilization and Conservation Service administers a number of incentive programs including the Conservation Reserve Program, the Wetland Reserve Program, the Agricultural Conservation Program, and the Forestry Incentives Program (commonly known as FIP). Each of these programs offers some form of incentive to enhance wildlife habitat on lands now in agricultural production.

CONCLUSIONS

Many private landowners already are involved in Partners in Flight. Landowners within the forest products industry are charter members of Partners in Flight and actively participate in all working groups. Wherever possible, they are supporting research and considering the needs of neotropical migrants in their management strategies. For example, member companies of the American Paper Institute have adopted a comprehensive set of environmental and forestry principles which require a commitment to integrating the growing, nurturing, and harvesting of trees with conservation of habitat for wildlife (McMahon 1992), including neotropical migrants.

Many other private landowners, however, such as noncorporate individuals and small commercial operators are not involved in Partners in Flight and they rarely belong to trade associations such as the American Paper Institute. Organizations such as the Cooperative Extension Service and the U.S. Forest Service State and Private Forestry often are the best mechanisms for assisting these diverse landowners. The challenge for all Partners in Flight members is to help these private landowners define their role in neotropical migrant conservation within the context of their land ownership and manangement objectives, and help them fulfill that role.

Agencies and NGOs should not expect private landowners to dramatically alter their ownership objectives to accomodate neotropical migrants. For example, the provision of extensive areas of late-successional stands is economically unfeasible on many industrial lands (Rochelle and Hicks 1992). However, forest products companies often are able to provide some characteristics of older forests such as snags, dead and down wood, and leave-trees. Likewise, a farmer should not be expected to abandon agriculture on his lands. Instead, through cooperation, farmers may be encouraged to modify certain practices, reforest a portion of his/her farm, or provide grassland or shrubland habitat.

Private landowners may have particularly useful contributions they can make to neotropical migrant conservation through research. Successful neotropical migratory bird conservation will require developing an understanding of how to accomodate these species in managed landscapes; obviously, there is a limit to the amount of land that can be reserved from management. Understanding how neotropical migrants can be conserved in managed landscapes will require including private lands in landscape-scale research that applies principles of adaptive management (Walters 1986, Walters and Holling 1990).

Building cooperative partnerships with private landowners, though, requires that an agency or NGO contribute something to the partnership. Too often, landowners are asked to give something and receive nothing in exchange. Individuals and companies usually perceive such one-sided offers of cooperation as demands. Agencies and NGOs also can enhance partnerships by demonstrating an acceptance of the landowner's objectives and a willingness to work within that framework. Built on such mutual respect, cooperative partnerships can indeed be the conservation vehicles that carry us into the 21st century.

LITERATURE CITED

Alexander, L. 1986. Timber-wildlife management from the forest landowner's perspective. Pages 269-279 *in* J. A. Bissonette, ed. Is good forestry good wildlife management? Maine Agric. Exp. Sta. Misc. Publ. No. 689.

Bullock, J. 1992. Working together for the resource: the Black Bear Conservation Committee. TreeTalk (Winter):4-6,20.

Goklany, I. 1992. America's biodiversity strategy: actions to conserve species and habitats (fact sheet). USDI Office of Program Analysis and USDA Natur. Resour. and Manage. Washington, D.C.

Greene, J. L., and K. A. Blatner. 1987. Woodland owner characteristics associated with timber management. Ark. Farm Res. 36(1):11.

Gustafson, G. C. 1982. Who owns the land? A state and regional summary of landownership in the United States. USDA Econ. Res. Serv. Staff Rep. No. AGES830405. 46pp.

Marsinko, A., H. Stevens, and S. Nodine. 1987. Nonindustrial private forest lands and landowners in South Carolina. Clemson Univ. Dept. For., For. Res. Series No. 43. 36pp.

McMahon, J. P. 1992. Forest industry's commitment to the public. J. For. 90(10):38-40.

Nabi, D. H., D. C. Guynn, Jr., T. B. Wigley, and S. P. Mott. 1983. Forest resource values of Mississippi nonindustrial private forest landowners. Pages 338-342 *in* J. P. Royer and C. D. Risbrudt, eds. Nonindustrial private forests: a review of economic and policy studies. Duke Univ. Sch. For. and Env. Studies. Durham, N.C.

Nielsen, B. 1992. Swamp bear. Wildl. Conserv. 95(4):7.

Owen, C. and J. Heissenbuttel. 1990. Wise use of the forest resource: the conservation record of the forest products industry. Am. For. Found., Washington, D.C. 39pp.

Rochelle, J. A., and L. L. Hicks. 1992. The role of private industrial forestlands in the management of biological diversity. Biodiversity in managed landscapes: theory and practice. USDA For. Serv. Gen. Tech. Rep. In press.

Schallau, C. H. 1991. "Where are we in the carbon cycle?" and related questions. Pages 259-266 *in* Environmental Conference, TAPPI, Technology Park, Atlanta, Ga.

Shaw, S. P. 1981. Wildlife management on private nonindustrial forestlands. Pages 36-41 *in* R. T. Dumke, G. V. Burger, and J. R. March, eds., Proc. symp. wildl. manage. on private lands. Wisc. Chapt. of The Wildl. Soc., Madison, Wisc.

Waddell, K. L., D. D. Oswald, and D. S. Powell. 1989. Forest statistics of the United States, 1987. USDA For. Serv. Resour. Bull. PNW-RB-168. 106pp.

Walters, C. J. 1986. Adaptive management of renewable resources. MacMillan Publishing Company, New York. 374pp.

Walters, C. J., and C. S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71:2060-2068.

Involving the Private Sector in Georgia's Conservation Initiatives for Neotropical Birds

Terry W. Johnson[1]

Abstract — Faced with major financial and manpower restrictions, the Georgia Department of Natural Resources' (DNR) Nongame-Endangered Wildlife Program (NGEWP) is aggressively encouraging the private sector to participate in a broad spectrum of innovative neotropical bird-related research, survey, fund raising, management and educational activities. A key element in this initiative was the passage of landmark legislation that permits the purchase of low cost liability insurance for volunteers.

The implementation of *Partners in Flight* in Georgia, the largest state east of the Mississippi River, is a monumental task. Success of this initiative is closely linked to the strength and diversity of partnerships forged between governmental agencies, businesses, private citizens, as well as civic and conservation groups. Realizing its manpower and financial limitations, NGEWP is actively encouraging involvement of the private sector in a broad spectrum of neotropical migratory bird initiatives including fund raising, research, survey, education, and management.

The problem of volunteer liability has long hampered state and federal volunteer efforts. During the 1992 legislative session the Georgia General Assembly passed a bill (SB 272) that provided for volunteers to be covered under a special liability insurance program. This cost of this insurance is less than four (4) dollars per volunteer.

In response to this landmark legislation, the Georgia DNR has moved swiftly to expand volunteer opportunities. Each division and program has been given the opportunity to administer its own volunteers in a manner that best serves its needs. The NGEWP, which will direct the DNR's neotropical migratory bird-related projects, has chosen to utilize volunteers through a formal volunteer network. The coordinator of this network will herself be a volunteer with many years of volunteer experience with a number of organizations.

Volunteers will be solicited by means of news releases and an attractive information brochure. Applicants will be sent a catalog of projects. Each project description will include the following pertinent information: objectives of the project; geographic location of the study area; duration of the project; time commitment needed to participate in the project; and what special skills are necessary to satisfactorily perform the work.

All applicants will be carefully screened and required to successfully complete an orientation and training regime before being assigned to a project. This will help insure that volunteers will be fully trained when they enter the field as representatives of NGEWP. The training regime will be designed to reinforce the concept that each volunteer is making a significant contribution to the conservation of Georgia's wildlife resources.

Each year NGEWP will hold an annual volunteer appreciation banquet. At such time, awards will be given to those volunteers that have distinguished themselves in the volunteer program.

Like most states, the NGEWP budget is far from adequate to meet conservation needs of states nongame wildlife resources. Concomitantly, one of the most important ways that volunteers are currently aiding NGEWP's initiatives for neotropical birds is fund raising. Volunteers are actively promoting the tax checkoff through distribution of promotional material, appearing on television and radio programs, and making oral presentations to civic and conservation groups. All public appearances are coordinated through a speaker's bureau.

One of our most lucrative fund raising activities is the annual Weekend For Wildlife. This fund raiser, conceived by two volunteers--- Emmy and Al Minor, has raised approximately $225,000 for NGEWP in just three years.

Weekend For Wildlife is held each February at the Cloister, a five-star hotel situated on the Georgia coast. Guests are offered a cornucopia of nongame wildlife-related talks, field trips, a banquet, and auction. The event is staged through combined

[1] *Terry W. Johnson, Georgia Department of Natural Resources Game and Fish Division, Nongame-Endangered Wildlife Program, Forsyth, Georgia 31029*

efforts of volunteers and staff members representing all four Georgia DNR divisions. Volunteers serve in practically every aspect of preparation and staging of the event. For example, volunteers help decorate the banquet halls and meeting rooms, serve as statewide auction chairmen, solicit auction items, guides for field trips, and lecturers. This involvement greatly reduces the number of DNR staff members needed to stage the event.

Another volunteer, Eva Persons, has recently organized a NGEWP friend's organization called TERN, INC. One of the primary objectives of this organization is to provide a dependable supplemental funding source for NGEWP.

NGEWP is also developing a plan to provide Georgia's business community with the opportunity to financially support its neotropical migratory bird and other wildlife projects. Corporations will be given the opportunity to provide long-term funding for nongame-related projects. Each corporation will be provided with a list of projects and their costs. For example, one project will be development of a breeding bird atlas for Georgia. If one or more corporations are willing to fund this project for the anticipated five years needed to complete the effort, they will be able to use their sponsorship in corporate advertising campaigns. In addition, NGEWP will acknowledge each corporation's generous support.

Education is the cornerstone of Georgia's NGEWP. Currently volunteers are supporting the program's educational efforts by assisting with the presentation of workshops and field days for property owners, conducting field trips, visiting classrooms, development of demonstration areas and writing brochures.

The extremely small NGEWP staff, three biologists (including the program director), severely limits the type, scope, and number of survey and research projects initiated. However, volunteers have proven to be invaluable to several nongame survey and research endeavors. For example, volunteers routinely assist in shorebird and cavity nesting bird surveys. Others are helping develop bird lists for Georgia's parks and wildlife management areas. It is hoped that, in the future, volunteers will play key roles in carrying out breeding bird surveys and preparation of a breeding bird atlas.

Since 1989, NGEWP has been conducting annual hummingbird surveys. These surveys have proven to be extremely popular. Well over 2000 participants, named Hummingbird Helpers, have taken part in the survey during the past three (3) years. The survey is designed to monitor hummingbird populations and evaluate management techniques. For example, already over 120 plants have been identified by landowners as being used by hummingbirds in their yards. In addition, during the past three years, heightened public awareness has played a key role in two new species of hummingbirds, the black chinned (*Archilochus alexandri*) and magnificent (*Eugenes fulgens*) being discovered and identified in Georgia.

It is obvious that Georgia must successfully address problems associated with managing private lands for neotropical migrants, if its Neotropical Migratory Bird Conservation Program is going to enjoy any degree of success. Currently, management of privately-owned woodlands and other habitats for neotropical migrants is being promoted through the Georgia Acres For Wildlife and Forest Stewardship Programs.

One of the fastest growing habitats in Georgia is urban/suburban habitat. In response to the realization that a wide variety of wild plants and animals occupy this habitat type, the NGEWP will shortly launch a new program called ***The Community Wildlife Project***. This initiative is designed to heighten awareness of private citizens, as well as civic and governmental leaders, to values of managing public an private property within urban/suburban settings for wild plants and animals. Communities desiring official certification as a Certified Wildlife Community must meet stringent guidelines established by NGEWP. Included in these guidelines will be parameters designed to enhance habitats for neotropical migrants.

This project is being cosponsored by the Garden Club of Georgia, Inc. NGEWP will establish certification guidelines and provide communities with technical assistance. Members of the Garden Club of Georgia, Inc. will serve as advocates of the project within their respective communities.

Finally, Georgia's new land acquisition program entitled, ***Preservation 2000***, is providing the private sector with a unique opportunity to nominate tracts of land that represent the best of Georgia's remaining wildlife and plant habitats. Birding groups throughout the state have been encouraged to nominated sites important to breeding birds and neotropical migrants.

The problems facing our neotropical migratory birds are not insurmountable. They should simply be viewed as exciting new challenges. The solutions to this conservation crisis lay in our ability to balance our economic and human growth with the needs of our wildlife resources. This will require the aggregate skills of a veritable army of professional biologists and technicians, private citizens, legislators, educators, planners, economists, and others. It will necessitate forging new alliances between the private sector, federal, state, and local governments. We must develop new ideas, and be willing to discard time worn concepts that have guided our resource management efforts in the past. The neotropical migratory bird conservation initiatives involving the private sector presented in this paper represent Georgia's first steps toward solving these complex problems.

Are Populations of Neotropical Migrant Birds Limited in Summer or Winter? Implications for Management

Thomas W. Sherry[1] and Richard T. Holmes[2]

Abstract—Understanding where in their annual cycle Neotropical-Nearctic migrant bird populations are limited is essential for developing effective management and conservation policies. A review of currently available information indicates that these long-distance migrant species may be limited by events and circumstances in both summer and winter, and possibly on migration as well. This has broad implications for management, which must take into account both the quantity and quality of habitat for these species at various times of year. Thus, the maintenance of viable populations of long-distance migrant species will require extraordinary communication, coordination, and effort involving resource managers, scientists, and the public across international boundaries.

INTRODUCTION

Recent evidence suggests that many songbird populations that migrate each year between temperate breeding areas and tropical winter quarters are declining and that these declines have accelerated in recent years (Robbins et al. 1989, Askins et al. 1990, Finch 1991). Potential causes for the declines are diverse, and may involve environmental changes and deterioration in breeding areas, in winter quarters, or even during migration. Understanding the relative importance of limiting or regulatory factors for these long-distance migrants, and when they operate during the annual cycle, is essential to the development of sound management plans, to avoid wasting limited financial and human resources in one area or season that may not safeguard a population. Thus, whether migrant species are more limited by events on their breeding grounds, on migration, in winter, or during a combination of seasons will determine where and what to manage. In this paper, we review briefly current knowledge about where and how migrant bird populations are limited, with emphasis on the implications for management. A more comprehensive treatment, with full literature review, is presented elsewhere (Sherry and Holmes MS).

[1]Department of Ecology, Evolution, and Organismal Biology, Tulane University, New Orleans, LA 70118.

[2]Department of Biological Sciences, Dartmouth College, Hanover, NH 03755.

POPULATION LIMITATION IN SUMMER, WINTER, OR BOTH? AN OVERVIEW

During what phase of the annual cycle are populations of long-distance migratory passerine birds limited, and what are the ecological causes of these population dynamics? This topic is poorly understood because of the global scales over which these migrants travel annually, their long distance dispersal, their diverse responses to seasonal resources or habitats, and the many possible causes of population changes. As a result, we still do not know for any Neotropical migrant bird population how age-specific mortality is distributed across the annual cycle or what combination of factors limits a population in any one or more parts of its range. Nor do we know the relative importance of wintering, breeding, or migratory areas for any single migratory species. Nevertheless, enough information does exist to suggest that all three phases in the annual cycle are potentially important for many species.

Evidence for Limitation in Winter

Some biologists have proposed that long-distance migrant bird populations must be limited principally by events affecting overwintering survival (Fretwell 1972, 1986, Morse 1980, Alerstam and Hogstedt 1982, Baillie and Peach 1992, Rappole et al. 1992, Morton 1992). Evidence for this view, until recently, has been largely indirect. First, non-migratory species, mostly resident in the temperate zone, tend to be limited mainly by winter mortality (e.g., Perrins 1980, Ekman et al. 1984, Arcese et al. 1992). Second, theoretical arguments (e.g., Fretwell and Lucas 1970, Fretwell 1972) and mostly circumstantial observations suggest that events where migratory birds winter in some cases influence the numbers breeding in subsequent summers (e.g., Winstanly et al. 1974, Morse 1980, Baillie and Peach 1992). And, third, studies in the temperate zone, where resource limitation either does not occur or does so infrequently (Wiens 1977, 1989, Pulliam and Dunning 1987), suggest that breeding habitats are unsaturated, breeding densities are below carrying capacity, and thus that populations must be limited by events occurring at other times, i.e., in winter. Finally, this view is supported by the observation that population declines have occurred in recent decades as tropical deforestation has been accelerating, suggesting that winter habitat loss is not just coincidental to, but is the major factor causing the declines (Terborgh 1989, Morton and Greenberg 1989, Morton 1992). Although these arguments for winter limitation are hard to refute, it is also difficult to test or provide supporting data. Robbins et al. (1989), however, noted that the migrant species showing the most significant population declines were those that depend on forest habitat in winter but breed in non-forested habitats, implying that forest loss in winter is a critical factor.

More recently, demographic, experimental, and distributional studies have begun to show that migrants often compete for winter habitat, which implies potentially limiting conditions during winter. Evidence for such habitat limitation is based on (1) the pattern of even (rather than random or aggregated) local dispersion of individuals, presumably via territorial interactions (Elgood et al. 1966, Sliwa and Sherry 1992), (2) frequent winter site fidelity, i.e., a tendency to return to a territory held in a previous winter (Price 1981, Holmes et al. 1989, Holmes and Sherry 1992, Winker et al. 1990), (3) the occurrence of intraspecific aggressive interactions (e.g., Morton 1980, Schwartz 1980, Holmes et al. 1989, Kelsey 1989, Stacier 1992), or some combination of the above (see Greenberg 1986). Perhaps the best evidence that winter habitat may limit populations comes from experimental studies in which Neotropical migrants that were removed from winter habitat were replaced by other individuals almost immediately, suggesting competition for preferred sites and perhaps saturation of certain habitats (Rappole and Warner 1980, Morton et al. 1987, Marra et al. MS). The occurrence of apparently widespread sex- and age-segregation of migrants among winter habitats (Lopez Ornat and Greenberg 1990, Wunderle 1992, Sliwa and Sherry in prep.) also suggests behavioral dominance, and thus competition for highest quality habitats. The hypothesis that Neotropical migrants compete intraspecifically for limited winter habitat would be supported by variation in winter fitness associated with different habitats, and only Greenberg (1992) has provided suggestive evidence for such variation. Further research is needed to assess the degree to which differences in winter habitat quality influence survivorship.

Evidence for Limitation in Summer

An alternative view of population limitation in these migrant species is that events on the breeding grounds may be at least as important, if not more so, than those in winter (e.g., Probst 1986, Holmes et al. 1986, Martin 1987, Hutto 1988, Sherry and Holmes 1992). Fragmentation of forest habitats in eastern North America, for instance, has been strongly implicated as one cause of reduced breeding success and consequently lowered breeding densities of some songbird species (e.g. Whitcomb et al. 1981, Ambuel and Temple 1983, Lynch and Whigham 1984). Reduced breeding success has been attributed mostly to decreased area of undisturbed forest breeding habitat or to increased nest predation and nest parasitism along forest edges (see Askins et al. 1990, Finch 1991, Martin 1992, papers in this volume). Variable food abundance, however, even within unfragmented landscapes (Enemar et al. 1984, Holmes et al. 1986, 1991, Tomialojac and Wesolowski 1990, Rodenhouse and Holmes 1992) can also significantly affect bird reproductive success, survivorship, and ultimately recruitment of new individuals into these populations. Recruitment is particularly crucial, and four studies have now shown that recruitment into breeding populations of long-distance migrants is significantly and positively correlated with nesting success in the previous summers (Fig. 1, see Nolan 1978, Virolainen 1984, Sherry and Holmes 1992, Holmes et al. 1992). The importance of this relationship is that factors affecting reproductive output appear to have a major impact on subsequent population dynamics and abundance and, indeed, may override the impact of events on migration or in winter (Sherry and Holmes 1992). If this holds more broadly, breeding season events may emerge as the major driving force in determining the abundances of these species.

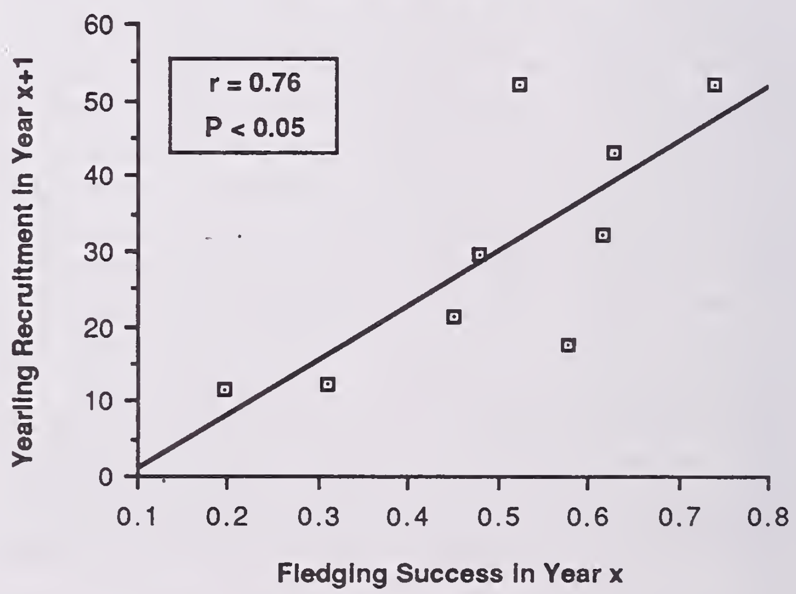


Figure 1. — Relationship between annual breeding productivity of American Redstarts in the Hubbard Brook Experimental Forest, N.H. in one year (year x, 1981-1989) and recruitment of yearling males into the population in subsequent seasons (year x+1,1982-1990). Adapted from Sherry and Holmes (1992).

These findings are not the only line of evidence that breeding habitat is of major importance in maintaining population levels. Competition for habitat occurs in summer, just as in winter, suggesting that suitable breeding habitat is also limited in its supply relative to demand. Evidence for summer habitat competition comes from the widespread occurrence of territoriality resulting in overdispersion of individuals, habitat saturation (e.g., Sherry and Holmes 1989), and despotic habitat selection, which is characteristic of many breeding populations of long-distance Neotropical migrants (see Sherry and Holmes MS).

Evidence for Limitation on Migratory Passage

Although less is known about habitat requirements and limitation of birds during migration, such times must also be critical. The facts that migrants need to refuel at frequent intervals, that they often become concentrated into particular flyways and stopover points, and that some at least are territorial in passage habitats indicate the potential importance of suitable stopover habitats (see Sherry and Holmes MS). Recently, it has been shown that migrants compete for food resources in passage habitats (Moore and Yong 1991). In addition, Moore and Simons (1992) suggest that high quality habitat during migration may be "limited in the absolute sense, or effectively so, because migrants cannot search for the 'best' stopover site." Thus, more research attention must be focused on the frequency and extent to which habitat for migrants during passage might be limiting, and the environmental features that determine habitat quality during these periods of the birds' annual cycle.

Summer-and-Winter Limitation

The evidence summarized above suggests that populations of Neotropical migrant birds are affected by events at all times of year. In one species, Kirtland's Warbler (Dendroica kirtlandii), evidence exists that the population is limited simultaneously by both amount of habitat in large stands of young jack pine (Pinus banksiana) and by rainfall effects on food abundance in the Bahamas where this species winters. But it is still not clear, even for Kirtland's Warbler, whether one season is more important than any other. A possible resolution to this question, suggested by both Morse (1980, 1989) and Svensson (1985), is that ecological conditions in both seasons might be limiting Neotropical migrant populations.

This idea was explicitly developed by Cox (1985) in his model for the evolution of avian migration systems. Cox proposed that migratory populations should be limited simultaneously in summer and winter by a dynamic equilibrium between fecundity and mortality in a changing array of habitats. Specifically, Cox argued that a population in which overwinter survival was temporarily increased would expand into a greater array of breeding habitats (because the greater winter survival would compensate for decreased fecundity in the newly added, but inherently less preferred breeding habitats). Conversely, improved breeding season fecundity would also, in a compensatory manner, increase the range of habitats in which individuals were found in winter. If this hypothesis is correct, we should expect to find density-dependent habitat selection in both summer and winter. This seems to be supported by current data, as reviewed above (see also Sherry and Holmes MS). Unfortunately no comprehensive studies have yet been conducted that consider populations of particular Neotropical migrant species in multiple habitats in both summer and winter. Such information on the ecology of individual species in both summer and winter habitats is needed to determine whether density-dependent habitat selection occurs, when mortality is greatest, and how the impact of varying levels of reproductive success affects recruitment and other population processes. Only in such a way can the relative importance of different habitats and environmental factors be rigorously evaluated.

The important point from the perspective of how to manage these migrant populations is that this summer-and-winter limitation hypothesis leads to the prediction that large-scale loss of habitat or decline in its quality can disproportionately influence a population in either season, and thus sufficient habitat in both seasons is unequivocally necessary for a sustainable population. It is tempting to focus attention on environmental changes in one season, for example when we have better data concerning that season or when our political institutions mandate concern for the landscapes at one end of the annual cycle. Dramatic loss of tropical rainforest habitats, for example, has focused much attention on the plight of migrants that winter within rainforest interior, but it is rarely possible even for such species to be certain that habitat change in one season affects a population more than that in another season. The demise of Bachman's Warbler (Vermivora bachmani) is often attributed to conversion of lowland forests to sugar cane plantations in Cuba, where the species wintered (Terborgh 1980, 1989; Rappole et al. 1983; Morse 1989), but Remsen (1986) argues just as plausibly for the importance of canebrake habitat loss in the southeastern United States where this species nested in summer. Evidence is accumulating that rainforest loss is contributing significantly to declining wood Thrush (Hylocichla mustelina) populations (Morton 1992), but changes in summer habitats are almost certainly important as well. The alarmingly sustained decline of Cerulean Warbler (Dendroica cerulea) populations may be the result of rapid habitat loss in both breeding and wintering areas (Robbins et al. 1992), but it is difficult to determine in which season habitat loss is most important.

Evidence from Migrants' Life Histories

As a final part of the review section of this paper, we note that life history characteristics of long-distance migrant birds are not only relevant to the question of population limitation and habitat use, but also suggest important management goals. The very act of migration, taking advantage of seasonally changing environments, can be viewed as a kind of ecological opportunism, distributed over the range of habitats exploited in summer, winter, and while in passage in between. Thus, migrants necessarily evolved behaviorally opportunistic strategies to cope with constantly changing habitat abundances and variable ecological conditions annually (Morse 1989). This necessity for some degree of ecological flexibility to exploit several habitats during the annual cycle has led some to view migrants as weed-like opportunists that seasonally invade disturbed, fringe habitats of tropical and temperate communities because of an inability to compete with resident birds (Karr 1976; Morse 1980; Lack 1986; Leisler 1990, 1992; O'Connor 1990). A very different view has developed more recently, mostly because of rapidly increasing knowledge about how migrants use wintering habitats in the Neotropics. This alternative view is that migrants are tightly integrated into tropical communities because of competitive abilities evolved to facilitate efficient exploitation of specialized tropical habitats and resources (Morton and Greenberg 1989, Rappole 1991, Rappole et al. 1992, Morton 1992). The resolution of these different perspectives has important management implications, because ecologically resilient populations of behaviorally flexible opportunists would need far less management than habitat and resource specialists at a time when human populations are converting forests to pasture, croplands, second growth, and scrub habitats, particularly in tropical countries (Morton and Greenberg 1989, Rappole 1991, Powell et al. 1992, Rappole et al. 1992, Morton 1992). As Morton (1992, p. 582) put it, "There is little conservation value in the concept that migrants as a group are birds of successional habitats that chase after ephemeral, superabundant food, such that deforestation will not harm them." Although this extreme position may be based in part on political conviction, review of the literature provides some support for both points of view (Sherry and Holmes MS).

Neotropical-Nearctic migrants are sometimes characterized as "integral components" of tropical (or temperate) bird communities in recognition of the fact that these birds are not simply temporary visitors to tropical communities, relegated to disturbed ("fringe") habitats by superior competitive abilities of resident species, as was once widely believed. Instead, they are now widely considered to be not only well adapted to virtually every tropical habitat and community, but in fact evolved in the tropics. Levey and Stiles (1992) summarize the growing evidence for this conclusion, and argue that the precursors of long-distance migratory behavior are amply represented by diverse intratropical (e.g., elevational) movements exhibited by resident tropical species. Neotropical-Nearctic migrants are thus merely the endpoint of a series of tropical adaptations, involving behavioral plasticity and generalized diets, to exploit seasonal, and sometimes temporally and spatially unpredictable, tropical resources (e.g., fruit, nectar, and many kinds of small insects). Such resources are often found within relatively seasonal habitats such as forest canopy, dry forests, and second growth vegetation, but some migrants such as wood thrushes and some Empidonax flycatchers readily winter within rainforest interior habitat. After spending over half the year in tropical habitats (Keast 1980), long-distance migrants then take advantage of seasonally abundant resources and safe nesting sites at higher latitudes (MacArthur 1972, Herrera 1978, O'Connor 1990). Migrants have relatively high annual survival (Greenberg 1980, Morse 1989, Ricklefs 1992), making them similar demographically to tropical resident species, which is probably facilitated by wintering in mild tropical habitats. Migrants maintain moderately high annual fecundity, higher than that of most tropical resident species, which offsets mortality costs of migration, but lower than that of most temperate residents (Greenberg 1980, Ricklefs 1992). Temperate residents may outcompete migrants for the best opportunities to produce large clutches and multiple broods by defending the best early season nesting and feeding sites (O'Connor 1981, Cox 1985). Thus migrants and residents in both seasons appear to compete for seasonal resources, reinforcing the view that migrants are well adapted, integral components of both breeding and wintering communities.

Finally, despite opportunistic adaptations to seasonal resources on the part of many species, migrants appear to be no less specialized in their habitat and resource use than are many resident species. Most New World wood warblers (Parulinae), for example, are specialized for breeding in particular floristic associations (coniferous forest, or northern or southern hardwoods), in one or a few successional stages, in swamp or scrublands, in fire-maintained jackpine woodlands, and so on (Keast 1980, Morse 1989). The same is true of migrants breeding in Britain (O'Connor 1985, 1990), where specialized habitats are probably necessary for high enough fecundity to offset annual mortality losses. In winter, Neotropical-Nearctic migrants are ecologically segregated relative to each other and to resident species, and they exhibit as great a degree of specialization as seen in many tropical residents (Stiles 1980, Terborgh 1980, Morton and Greenberg 1989, Lynch 1989, 1992, Leisler 1990, 1992, Rappole 1991; but see Hutto 1992). Thus, habitat specialization is characteristic of many migrants in both summer and winter, and probably evolved to maintain both high breeding season fecundity (compared with tropical residents) and high winter survival (compared with temperate residents).

We therefore view migrants as a unique evolutionary response to seasonally changing environments. These migrants are both integral components of tropical and temperate communities, often competing effectively with residents for seasonal foods, and ecological opportunists at a diverse range of spatial scales. Life-history adaptations of migrants to ecological conditions in both winter and summer habitats thus emphasize our proposition above that population limitation is likely to occur in both summer (breeding) and winter(survival)habitats.

MANAGEMENT IMPLICATIONS

The information available about populations of long-distance migratory bird species thus supports the hypothesis that habitats for Neotropical migrants may be limiting in both summer and winter, as well as during migration. These findings have important implications for conservation and management efforts, which we develop below in the form of seven recommendations.

1.The first recommendation, and we think the most important, is that management policy include habitat necessary to maintain populations of Neotropical-Nearctic migrants in summer breeding areas, in wintering quarters, and along migratory routes. Migrants compete for high quality habitat at essentially all times of year, and thus significant loss or deterioration of habitat at any major part of the annual cycle could lead to population declines. Existing examples of simultaneous summer and winter habitat changes that are correlated with population declines--in some cases in the same species populations--reinforces this management recommendation.

2.The second recommendation is that management should emphasize habitats as landscapes where migrants can maintain their own populations. Each species cannot be treated as an independent entity distinguishable from the habitat in which it evolved. Viewing a species outside the context of its habitat is particularly dangerous when it leads to arbitrary management targets (such as numbers of nest boxes or snags). Such targets too often address the symptoms of a population decline (e.g., loss of nest sites) rather than underlying ecological causes such as increased nest parasitism, increased nest predators due to habitat fragmentation, or insufficient time for regeneration of new habitat. Instead, management should focus on sustainable habitat quality and quantity necessary to support particular species. If a population has already reached threatened or endangered status, any action to increase the population should of course be considered, but actions such as putting out nest boxes or cowbird control programs should be viewed as temporary measures until sufficient amount of new habitat can be made available.

As mentioned above, an understanding of migrants' life-histories leads to a view of their habitats as entire landscapes characterized by inherent variability and continuous change--attributable to normal ecosystem processes. Habitats for migrant birds should not be viewed simply as assemblages of snags or plants with distinctive floristic and physiognomic characteristics, but as ecosystems capable of sustaining complex processes of disturbance, regeneration, and seral development in various ways. Many migrant species populations have evolved the ability to respond to variability in their habitats, including dramatic seasonal and year-to-year changes in food abundance (e.g., emergences of cicadas or aquatic insects, and irruptions of defoliating insects), nest predator populations, fires, and weather anomalies such as droughts, floods, and hurricanes. Birds in general, but migrants in particular, have extraordinary dispersal capabilities to find newly created habitats, or to move from deteriorating ones, depending on how great the distance is to the next suitable unit of habitat. Species such as Neotropical-Nearctic migrants can move over global scales to exploit completely different breeding versus winter survival niches (Alerstam and Hogstedt 1982). The ability to take advantage of seasonally and annually changing resources (i.e. opportunism), coupled with widescale movements literally define what migrants are, and help assure that they can effectively exploit changing environments. This opportunistic use of seasonal environments requires the availability of continually changing habitats within landscapes in order to provide safe and productive habitats for these species.

3.The third recommendation is to manage for a normal range of migrant population sizes, rather than target any one level of abundance. Temporarily low populations might be acceptable as long as new habitats become available quickly enough to rebuild populations, and as long as genetic factors such as inbreeding depression do not inhibit successful reproduction. Thus management strategies must be sufficiently flexible to accommodate the continuous changes inherent in the habitats exploited by migrants, and the resulting, but normal, population fluctuations. Important in this regard is the need for management flexibility, especially in view of global climate change projected during coming decades. Global change scenarios suggest that habitats we recognize at present will not only move in location (potentially crossing present political boundaries and regional mandates), but will in some cases become completely unrecognizable due to independently shifting ranges of plant species comprising those habitats (e.g., Botkin 1990). Successful management will require the ability to anticipate such changes, to re-organize management guidelines and priorities, to transfer responsibilities for management among political entities, and possibly even to help mobilize the political support necessary to reorganize some landscapes (e.g., adding to current park boundaries to increase the range of elevations and habitats, or to establish wildlife corridors). For example, if global warming eliminates present jack pine stands in Michigan, and they cannot simply be shifted to the north due to lack of suitable sandy soils (Botkin 1990), then where else can sufficiently large burns be established to regenerate the necessary expanses of jack pine needed for Kirtland's Warblers to breed? More than anything else, managers must come to accept uncertainty and change as natural and acceptable aspects of the ecosystems in which most animals thrive (Botkin 1990). Variability in habitat characteristics, such as the frequency and extent of environmental disturbances, may be the best argument yet for managing habitat-species complexes rather than managing any particular species per se.

Finally, given the large number of Neotropical migrant species, it will probably be far more difficult to manage for each species individually than to manage habitats containing several species (e.g., bottomlands hardwoods in the southeastern U.S., containing Swainson's Warbler, Parula Warbler, Prothonotary Warbler, and Cerulean Warbler). One can then use the success of single species as indicators of successful management of the habitat. Managing habitats has the additional benefit of conserving many other kinds of organisms.

4.The fourth recommendation, which is related to the previous one, is that migrant populations need to be managed for enough individuals to buffer against temporary, local habitat loss or disturbance. This point is derived from a knowledge of the demographic and life-history characteristics of migrants. Surprisingly for opportunistic species, many migrant populations may be less resilient than populations of temperate resident species to temporary declines, i.e. slower to recover from declines (O'Connor 1992). This is because migrants have relatively low fecundity compared with temperate residents, and possibly smaller population sizes, both of which decrease potential recolonization ability. Recent research on how migrants use habitats, particularly those in winter, has shown that migrants can no longer be viewed as behaviorally plastic ecological generalists, i.e. temporary invaders of disturbed tropical habitats (Rappole 1991, see Sherry and Holmes MS). Migrants are, in many cases, habitat specialists, and they often use very specific microhabitats (such as dead leaf clusters containing concealed arthropods) or specialized food resources (Morton and Greenberg 1990). Environmental disasters such as habitat loss, drought, or hurricanes may thus devastate migrant populations as much as, if not more than, resident bird populations. Managers must therefore manage habitats and landscapes such that migrant populations remain at a great enough total size and can spread across multiple landscape units, so that "normal" and natural, yet potentially catastrophic, local habitat disturbances do not eliminate an entire species.

5.The fifth recommendation is that management at times must be tailored to the needs of individual species. Although seemingly contrary to the points above, there are times where some species are so rare that we must take every effort to boost their populations, even if this means targeting those particular habitats or even breeding birds in captivity. Migrants include a diverse set of species, each with its own particular habitat requirements, demography, and life-history. Thus, some species may behave very differently from others in response to habitat changes, and may require fundamentally different management considerations. Some migrant species are extraordinarily flexible in terms of habitats and diet (e.g., Yellow-rumped Warblers and American Redstarts) and these probably require little concern from managers at present. Other species are presently endangered in part because of stereotypical dependence on particular safe nesting sites, nesting materials, foods, or other resources (Morse 1989). A good example may be Bachman's Warbler, as we mentioned above, even though we cannot presently resolve whether summer or winter habitats were more important.

6.The sixth recommendation is the need to manage for, and distinguish between, the quantity and quality of habitat available for Neotropical-Nearctic migrants. Assessment of habitat availability or quantity is of primary importance. On a first approximation, the total abundance of a migrant species is roughly proportional to the total area of suitable habitat available. Thus, for example, managers responsible for Kirtland's Warblers must provide an adequate area of early successional, recently burned jack pine stands in Michigan to maintain enough individuals to avoid genetic or demographic bottlenecks, and the same may be said of the "cedar brakes" in Central Texas, to which the Golden-cheeked Warbler is restricted (Morse 1989). Habitat quantity will probably be monitored most efficiently in the future using a variety of increasingly sophisticated methods developed recently, such as that involving remote sensing and Geographic Information Systems (GIS), coupled with accurate census data from the ground (e.g. Powell et al. 1992).

Identifying habitat quantity, however, is not sufficient--quality is also important. In the breeding season, some habitats are more suitable than others, as indicated by bird densities, mating success and, particularly, breeding productivities (Sherry and Holmes MS). Likewise, variation in quality of winter habitat for migrants occurs frequently, as evidenced by differences in density, sex- and age-distribution patterns, and competition for "good" sites (Sherry and Holmes MS). Information about habitat quality is crucial for management purposes because it helps in prioritizing habitats, and in developing models of how changing habitats in a landscape will alter total population size. Differences in population abundances among habitats tell us how populations change, but demographic information will tell why populations are changing and is crucial for evaluating why densities are changing, i.e., the effect of food abundance, predator or brood parasites on nest success, to mention a few. Thus, management policies must also be based on demographic parameters, the most important of which are listed in Table 1.

Habitat quality raises the issue of "source" and "sink" populations (see Pulliam 1988, Pulliam and Danielson 1991). A source population reproduces sufficient individuals to maintain local abundance and produce colonists of newly available habitat, whereas a sink population is maintained by continual immigration of individuals from other, more productive habitats. Many populations of Neotropical migrants occupying fragmented woodland habitats, at least in parts of the midwestern U.S., are presently sink populations (Gibbs and Faaborg 1990, Robinson 1992). Migrant species breeding in the White Mountains of New Hampshire, on the other hand, benefit from extensive, non-fragmented stands of northern hardwoods forest, and these probably represent source populations (Holmes et al. 1992, Sherry and Holmes 1992). Using Black-throated Blue

Table 1. — Some important demographic parameters of bird populations useful in assessing habitat quality.

Fecundity

- Clutch size
- Number of annual broods (many migrants single brooded, but some double-brooded)
- Nesting(fledging) success
- Mass at fledging, or other index to post-fledging survival
- Age of first breeding (by sex)
- Mating success

Survival

- Annual survival (summer-to-summer, or winter-to-winter, see Holmes and Sherry 1992)
- Over-summer survival
- Over-winter survival

Other parameters

- Age-structure (proportion of yearlings:adults)
- Sex ratio
- Dispersal distances (by age, or sex)

Warblers as an example, and assuming annual survival is between 50% and 70% and that fledglings survive to the start of the next breeding season about half as well as adults, then it is easy to show that 1.7-4 fledglings are needed to replace adults lost (Sherry and Holmes manuscript). Holmes et al. (1992) found that Black-throated Blue Warblers fledged an average of 4.3 young per female per season (range = 3.5-4.9) over a period of four years, indicating that this population was producing more than enough fledglings to maintain the population. Similarly, American Redstarts at Hubbard Brook produced enough fledglings to offset typical mortality rates most years, although the population declined when nest predator populations decreased nesting success in the mid-1980's (Sherry and Holmes 1991, 1992). We should certainly become concerned when populations exist in sinks, where production of offspring is insufficient to balance losses occurring because of mortality or emigration. Source populations need be of less management concern. Management policy should attempt to increase population source areas in a landscape, but secondary habitats can also help stabilize population dynamics (Bernstein et al. 1991).

The effects of diverse ecological factors on the quality of a habitat are thus best assessed by monitoring a population's demography, but this procedure requires a substantial commitment of time, effort, and trained personnel. Ralph et al. (1992) provide an up-to-date manual on standardized methods and information necessary to study bird populations in the field, such as methods to quantify seasonal productivity of offspring using nest-monitoring studies. It may be possible for managers to involve scientists and amateur bird enthusiasts in the process of monitoring migrants demographically, and not just numerically.

It should also be noted that the quality and quantity of habitat may be independent. For example, a cowbird-elimination program begun in Kirtland's Warbler habitat in 1971 resulted in dramatic increases in nestling productivity (see Morse 1989: Fig. 11-2), but did not dramatically increase the population. Several factors probably contributed to this result, including the difficulty of many birds finding mates (Probst 1986), but the biggest factor was almost certainly the limited quantity of habitat, as evidenced by the effect of newly burned jack pine stands (Mayfield 1992).

Finally, it is becoming increasingly clear that many migrants compete for quality (source) habitats (e.g. Sherry and Holmes 1989, Marra et al. MS), suggesting that they are limited in supply relative to demand year-round. In such habitats, individuals behaviorally limit the density of birds sustainable per unit of habitat (Newton 1992). In such cases, management plans that focus on expanding the availability of habitat will be far more effective than trying to push densities above these habitat-specific carrying capacities.

7.Our final recommendation is that safeguarding of the annual range of habitats necessary to maintain viable migrant populations will require extraordinary communication and coordination among managers, scientists, and the public across international borders. Migrants illustrate particularly well the adage that a chain is only as strong as its weakest link. We thus cannot overemphasize the importance of habitat preservation and management year-round, i.e. throughout the entire breeding and wintering (and migratory passage) ranges of particular species, since any migrant population is sensitive to loss of habitat at any part of its annual cycle. No matter how much money goes into preserving habitat in the breeding range, a population could still go extinct due to deterioration of its wintering habitat, and vice versa. What we know presently about the biology of these birds clearly emphasizes the importance of simultaneous breeding and wintering season population limitation for these species.

We thus urge that those vested with managing these populations increase communication and collaboration with scientists and land managers in all countries where these species spend part of the year. Partnerships organized to span the geographical range of particularly threatened or endangered migrant species, involving North American and Latin American/Caribbean governments, resource-management agencies, private conservation organizations, or scientists in tropical countries must be encouraged. Such formal partnerships, including "sister forests," would be particularly productive if they paired up groups working on the same threatened or endangered species at different times of the year, such as the Kirtland Warbler Recovery Team with agencies in the Bahamas.

We have stressed repeatedly the importance of conserving large tracts of quality habitat throughout the year to safeguard healthy populations of Neotropical-Nearctic migrants. This is, of course, a far more complicated task than it sounds for a variety of reasons besides just the global extent of the habitats under consideration. This task will require maintaining not only large quantities of habitat, but also quality habitat in terms of the potential fecundity and survival probabilities of the birds. Thus, monitoring of abundances and demographic characteristics of populations must be extensive and accurate. Considerable political will may be required to act on the information so gathered, because much habitat is already occupied or under pressure to be used by humans in ways that are not necessarily compatible with the birds' requirements. Conservation of habitats in the wintering ranges of migrant birds will be particularly important, because loss of habitat in the tropics continues unabated. Thus it is difficult to escape the conclusion that tropical wintering habitat will become limiting to at least some species in the near future, if such is not already occurring (Terborgh 1980, 1989; Morton 1992; Rappole et al. 1992; Robbins et al. 1992). Declines in habitat quality in North America have also severely affected Neotropical migrant populations. Preliminary efforts are underway to assess the potential vulnerability of species and habitats most threatened in winter (Morton 1992) and year-round (Terborgh 1989, Reed 1992), and such efforts need to be refined and expanded.

ACKNOWLEDGEMENTS

Our research on Neotropical migrants has been supported by the National Science Foundation, Tulane University, and Dartmouth College, and with the cooperation of the Hubbard Brook Experimental Forest of the Northeast Forest Experiment Station, U.S. Forest Service, and various individuals and government agencies in Jamaica, W.I. We acknowledge all of their help and support. We also thank D. Capen, R. Hutto, and P.Marra for comments on this manuscript.

LITERATURE CITED

Alerstam, T., and G. Hogstedt. 1982. Bird migration and reproduction in relation to habitats for survival and breeding. Ornis. Scand. 13: 25-37.

Ambuel, B., and S.A. Temple. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. Ecology 64: 1057-1068.

Arcese, P., J.N.M. Smith, W. M. Hochachka, C.M. Rogers, and D. Ludwig. 1992. Stability, regulation, and the determination of abundance in an insular song sparrow population. Ecology 73: 805-822.

Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7: 1-57.

Baillie, S.R., and W.J.Peach. 1992. Population limitation in Palearctic-African migrant passerines. Ibis 134 Suppl. 1:120-132.

Bernstein, C., J.R. Krebs, and A. Kacelnik. 1991. Distribution of birds amongst habitats: theory and relevance to conservation. Pp. 317-345 in C.M. Perrins, J.-D. Lebreton, and G.J.M. Hirons, eds. Bird Population Studies: Relevance to Conservation and Management. Oxford University Press, New York.

Botkin, D.B. 1990. Discordant harmonies: a new ecology for the twenty-first century. Oxford Univ. Press, N.Y.

Cox, G.W. 1985. The evolution of avian migration systems between temperate and tropical regions of the New World. Am. Nat. 126: 451-474.

Ekman, J. 1984. Density-dependent seasonal mortality and population fluctuations of the temperate-zone willow tit (Parus montanus). J. Anim. Ecol. 53:119-134.

Elgood, J.H., R.E. Sharland, and P.E. Ward. 1966. Palearctic migrants in Nigeria. Ibis 108: 84-116.

Enemar, A., L. Nilsson, and B. Sjostrand. 1984. The composition and dynamics of the passerine bird community in a subalpine birch forest, Swedish Lapland. A 20-year study. Ann. Zool. Fenn. 21: 321-338.

Finch, D. 1991. Population ecology, habitat requirements, and conservation of Neotropical migratory birds. Gen. Tech. Rep. RM-205. Fort Collins, CO: U.S. Dept. of Agriculture, Forest Service. Rocky Mountain Forest and Range Experiment Station. 26 p.

Fretwell, S.D. 1972. Populations in a seasonal environment. Princeton University Press, Princeton, N.J.

Fretwell, S. 1986. Distribution and abundance of the Dickcissel. Curr. Ornith. 4: 211-242.

Fretwell, S., and H.L. Lucas, Jr. 1970. On territorial behavior and other factors influencing habitat distribution in birds. I. Theoretical development. Acta Biotheor. 19: 16-36.

Gibbs, J.P., and J. Faaborg. 1990. Estimating the viability of Ovenbird and Kentucky Warbler populations in forest fragments. Conserv. Biol. 4: 193-196.

Greenberg, R. 1980. Demographic aspects of long distance migration in birds. Pp. 493-504 in A. Keast and E.S. Morton, eds. Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Institution Press, Wash.

Greenberg, R. 1986. Competition in migrants birds in the nonbreeding season. Curr. Ornithol. 3:281-307.

Greenberg, R. 1992. Forest migrants in non-forest habitats on the Yucatan peninsula. Pp. 273-286 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash.

Hagan, J.M., and D.W. Johnston (eds). 1992. Ecology and conservation of Neotropical migrant land birds. Smithsonian Press, Wash D.C.

Herrera, C. 1978. On the breeding distribution patterns of European migrant birds: MacArthur's theme reexamined. Auk 95: 496-509.

Holmes, R.T., and T.W. Sherry. 1992. Site fidelity of migratory warblers in temperate breeding and Neotropical wintering areas: implications for population dynamics, habitat selection, and conservation. Pp. 563-578 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash

Holmes, R.T., T.W. Sherry, P.P. Marra, and K.E. Petit. 1992. Multiple-brooding and productivity of a Neotropical migrant, the Black-throated Blue Warbler (Dendroica caerulescens) in an unfragmented temperate forest. Auk 109: 321-333.

Holmes, R.T., T.W. Sherry, and L. Reitsma. 1989. Population structure, territoriality, and overwinter survival of two migrant warbler species in Jamaica. Condor 91: 545-561.

Holmes, R.T., T.W. Sherry, and F.W. Sturges. 1986. Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Brook. Ecol. Monogr. 56: 201-220.

Holmes, R.T., T.W. Sherry, and F.W. Sturges. 1991. Numerical and demographic responses of temperate forest birds to annual fluctuations in their food resources. Acta XX Congr. Internat. Ornithol.: 1542-1556.

Hutto, R.L. 1988. Is tropical deforestation responsible for the reported declines in Neotropical migrant populations? Am. Birds 42: 375-379.

Hutto, R.L. 1992. Habitat distributions of migratory landbird species in western Mexico. Pp. 221-239 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash

Karr, J. R. 1976. Seasonality, resource availability, and community diversity in tropical bird communities. Amer. Natur. 110: 973-994.

Keast, A. 1980. Migratory parulidae: what can species co-occurrence in the north reveal about ecological plasticity and wintering patterns. Pp. 457-476 in A. Keast and E.S. Morton, eds. Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Institution Press, Wash.

Kelsey, M.G. 1989. A comparison of the song and territorial behavior of a long-distance migrant, the Marsh Warbler, Acrocephalus palustris, in summer and winter. Ibis 131: 403-414.

Lack, P. 1986. Ecological correlates of migrants and residents in a tropical African savanna. Ardea 74: 111-119.

Leisler, B. 1990. Selection and use of habitat of wintering migrants. Pp. 156-174 in E. Gwinner (ed.) Bird migration. Springer-Verlag, Berlin.

Leisler, B. 1992. Habitat selection and coexistence of migrants and Afrotropical residents. Ibis 134 suppl. 1: 77-82.

Levey, D.J., and F.G. Stiles. 1992. Evolutionary precursors of long-distance migration: resource availability and movement patterns in Neotropical landbirds. Amer. Natur. 140: 447-476.

Lopez Ornat, A. L., and R. Greenberg. 1990. Sexual segregation by habitat in migratory warblers in Quintana Roo, Mexico. Auk 107: 539-543.

Lynch, J.F. 1989. Distribution of overwintering nearctic migrants in the Yucatan Peninsula. 1. general patterns of occurrence. Condor 91: 515-544.

Lynch, J.F. 1992. Distribution of overwintering Nearctic migrants in the Yucatan Peninsula, II: use of native and human-modified vegetation. Pp. 178-196 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash

Lynch, J.F. and D.F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. Biol. Conserv. 28: 287-324.

MacArthur, R.H. 1972. Geographical ecology: patterns in the distribution of species. Harper and Row, N.Y.

Martin, T.E. 1987. Food as a limit on breeding birds: a life history perspective. Ann. Rev. Ecol. Syst. 19: 453-487.

Martin, T.E. 1992. Breeding productivity considerations: what are the appropriate habitat features for management? Pp. 455-473 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash

Marra, P.P., T.W. Sherry, and R.T. Holmes. 1993. Territorial exclusion by a Neotropical migrant warbler in Jamaica: a removal experiment with American redstarts (Setophaga ruticilla). Auk, in press.

Mayfield, H.F. 1992. Kirtland's Warbler population. Paper delivered at AOU meeting, Ames Iowa, June 1992.

Moore, F.R., and T.R. Simons. 1992. Habitat suitability and stopover ecology of Neotropical landbird migrants. Pp. 345-355 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash

Moore, F.T., and W. Yong. 1991. Intercontinental-bird migrants compete for food resources during stopover. Behav. Ecol. Sociobiol. 28: 85-90.

Morse, D.H. 1980. Population limitation: breeding or wintering grounds? Pp. 505-516 in A. Keast and E.S. Morton, eds. Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Institution Press, Wash.

Morse, D.H. 1989. American warblers. Harvard University Press, Cambridge, Massachusetts.

Morton, E.S. 1992. What do we know about the future of migrant landbirds? Pp. 579-589 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Wash.

Morton, E.S., and R. Greenberg. 1989. The outlook for migratory birds: "future shock" for birders. American Birds 43: 178-183.

Morton, E.S., J.F. Lynch, K. Young, and P. Mehlhop. 1987. Do male Hooded Warblers exclude females from nonbreeding territories in tropical forest? Auk 104: 133-135.

Newton, I. 1992. Experiments on the limitation of bird numbers by territorial behavior. Biol. Reviews 67: 129-174.

Nolan, V. Jr. 1978.The ecology and behavior of the Prairie Warbler Dendroica discolor. Ornithol. Monogr. 26: 1-595.

O'Connor, R.J. 1981. Comparisons between migrant and non-migrant birds in Britain. Pp. 167-195 in Aidley, D.J., ed. Animal migration. Cambridge University Press, Cambridge, England.

O'Connor, R.J. 1985. Behavioral regulation of bird populations: a review of habitat use in relation to migration and residency. Pp. 105-142 in R.M.Sibly and R.H. Smith, eds. Behavioral ecology: ecological consequences of adaptive behavior. Blackwell Scientific Press, Oxford, England.

O'Connor, R.J. 1990. Some ecological aspects of migrants and residents. Pp. 175-182 in E. Gwinner, ed. Bird migration. Springer Verlag, Berlin & Heidelberg.

O'Connor, R.J. 1992. Population variation in relation to migrancy status in some North American birds. Pp. 64-74 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash.

Perrins, C.M. 1980. Survival of young great tits, Parus major. Proc. Inter. Ornith. Congr. 17: 159-174.

Powell, G.V.N., J.H. Rappole, and S.A. Sader. 1992. Neotropical migrant landbird use of lowland Atlantic habitats in Costa Rica: a test of remote sensing for identification of habitat. Pp. 287-298 in J.M. Hagan III and D.W. Johnston, eds. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Press, Wash.

Price, T. 1981. The ecology of the Greenish Warbler Phylloscopus trochiloides in its winter quarters. Ibis 123: 131-144.

Probst, J.R. 1986. A review of factors limiting the Kirtland's Warbler on its breeding grounds. Amer. Midl. Nat. 116: 87-100.

Pulliam, H.R. 1988. Sources, sinks, and population regulation. Amer. Natur. 132: 652-661.

Pulliam, H.R., and B.J. Danielson. 1991. Sources, sinks, and habitat selection: a landscape perspective on population dynamics. Amer. Natur. 137 (Supplement): S50-S66.

Pulliam, H.R., and J.B. Dunning 1987. The influence of food supply on local density and diversity of sparrows. Ecology 68: 1009-1014.

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F.DeSante. 1992. Field methods for monitoring landbirds. USDA Forest Service, Arcata, CA

Rappole, J.H. 1991. Migrant birds in Neotropical forest: a review from a conservation perspective. Pp. 259-277 in T. Salathé, ed. Conserving migratory birds. ICBP Technical Publication No. 12. Cambridge, England.

Rappole, J.H., E.S. Morton, and M.A. Ramos. 1992. Density, philopatry, and population estimates for songbird migrants wintering in Veracruz. Pp. 337-344 in J. M. Hagan and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Wash.

Rappole, J.H., E.S. Morton, T.E. Lovejoy, and J.L. Ruos. 1983. Nearctic avian migrants in the Neotropics. Washington, U.S. Department of the Interior, Fish and Wildlife Service.

Rappole, J.H., and D.W. Warner. 1980. Ecological aspects of migrant bird behavior in Veracruz, Mexico. Pp. 353-393 in A. Keast and E.S. Morton, eds., Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Institution Press, Wash.

Reed, J.M. 1992. A system for ranking conservation priorities for Neotropical migrant birds based on relative susceptibility to extinction. Pp. 524-536 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash.

Remsen, J.V. Jr. 1986. Was Bachman's Warbler a bamboo specialist? Auk 103: 216-219.

Ricklefs, R.E. 1992. The megapopulation: a model of demographic coupling between migrant and resident landbird populations. Pp. 537-548 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash.

Robbins, C.S., J.W. Fitzpatrick, and P.B. Hamel. 1992. A warbler in trouble: Dendroica cerulea. Pp. 549-562 in J.M. Hagan III and D.W. Johnston, eds. Ecology and Conservation of Neotropical migrant Landbirds. Smithsonian Press, Wash.

Robbins, C.S., J.R. Sauer, R. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proc. Nat. Acad. Sci 86: 7658-7662.

Robinson, S.K. 1992. Population dynamics of breeding birds in a fragmented Illinois landscape. Pp. 408-418 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Wash.

Rodenhouse, N.L., and R.T. Holmes. 1992. Results of experimental and natural food reductions for breeding Black-throated Blue Warblers. Ecology 73: 357-372.

Schwartz, P. 1980. Some considerations on migratory birds. Pp. 31-36 in A. Keast and E.S. Morton, eds., Migrant birds in the Neotropics: ecology behavior, distribution, and conservation. Smithsonian Press, Wash. D.C.

Sherry, T.W., and R.T. Holmes. 1989. Age-specific social dominance affects habitat use by breeding American Redstarts (Setophaga ruticilla): a removal experiment. Behav. Ecol. Sociob. 25: 327-333.

Sherry, T.W., and R.T. Holmes. 1991. Population age structure of long-distance migratory passerine birds: variation in time and space. Acta XX Congr. Internat. Ornithol. 20: 1542-1556.

Sherry, T.W., and R.T. Holmes. 1992. Population fluctuations in a long-distance Neotropical migrant: demographic evidence for the importance of breeding season events in the American Redstart. Pp. 431-442 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash. Smithsonian Press, Wash.

Sherry, T.W., and R.T. Holmes. MS. Where and how are populations of Neotropical migrant landbirds limited: breeding, passage, or wintering habitats?

Sliwa, A., and T.W. Sherry. 1992. Surveying wintering warbler populations in Jamaica: point counts with and without broadcast vocalizations. Condor 94:924-936.

Stacier, C.A. 1992. Social behavior of the Northern Parula, Capte May Warbler, and Prairie Warbler wintering in second-growth forest in southwestern Puerto Rico. Pp. 308-320 in J.M. Hagan III and D.W. Johnston, eds. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Press, Wash.

Stiles, F.G. 1980. Evolutionary implications of habitat relations between permanent and winter resident landbirds in Costa Rica. Pp. 421-436 in A. Keast and E.S. Morton, eds, Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Press, Wash.

Svensson, S.E. 1985. Effects of changes in tropical environments on the North European avifauna. Ornis Fenn. 62: 56-63.

Terborgh, J.W. 1980. The conservation status of Neotropical migrants: present and future. Pp. 21-30 in A. Keast and E.S. Morton, eds, Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Press, Wash.

Terborgh, J.W. 1989. Where have all the birds gone? Princeton University Press, Princeton.

Terborgh, J.W. 1992. Perspectives on the conservation of Neotropical migrant landbirds. Pp. 7-12 in J.M. Hagan III and D.W. Johnston, eds. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Press, Wash. Smithsonian Press, Wash.

Tomialijac, L., and T. Wesolowski. 1990. Bird communities of the primeval temperate forest of Bialowieza, Poland. Pp. 141-166 in A. Keast, ed., Biogeography and ecology of forest bird communities. SPB Academic Publishing, The Hague.

Virolainen, M. 1984. Breeding biology of the Pied Flycatcher Ficedula hypoleuca in relation to population density. Ann. Zool. Fennica 21: 187-197.

Whitcomb, R.F., C.S. Robbins, J.F. Lynch, F.L. Whitcomb, M.K. Klimkiewicz, and D. Bystrack. 1981. Effects of forest fragmentation on the avifauna of the eastern deciduous forest. Pp 125-205 in R.L. Burgess and D.M. Sharpe, eds. Forest island dynamics in man-dominated landscapes. Springer Verlag, NY

Wiens, J.A. 1977. On competition and variable environments. Amer. Scien. 65: 590-597.

Wiens, J.A. 1989. The ecology of bird communities. Cambridge University Press, Cambridge.

Winker, K., J.H. Rappole, and M.A. Ramos. 1990. Population dynamics of the Wood Thrush in southern Veracruz, Mexico. Condor 92: 444-460.

Winstanley, D., R. Spencer, and K. Williamson. 1974. Where have all the Whitethroats gone? Bird Study 2: 1-14.

Wundele, J.M. Jr. 1992. Sexual habitat segregation in wintering Black-throated Blue Warblers in Puerto Rico. Pp. 299-307 in J.M. Hagan III and D.W. Johnston, eds., Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Wash.

Stopover Habitat: Management Implications and Guidelines

Frank R. Moore[1], Sidney A. Gauthreaux, Jr[2], Paul Kerlinger[3], and Ted R. Simons[4]

Abstract — If persistence of migrant populations depends on the ability to find favorable conditions for survival throughout the annual cycle, factors associated with the en-route ecology of migrants must figure in any analysis of population change and in development of a comprehensive conservation "strategy." We view en-route habitat selection as a hierarchical process. Once migration routes are recognized and geographical variability in the route and timing are documented, important stopover habitat for Neotropical migrants can be delimited. The continent-wide pattern of migration concentrates migrants in relation to ecological barriers (e.g., the Atlantic Ocean, Gulf of Mexico). Protection and management of habitats used by migrants in relation to ecological barriers should be a prominent conservation priority. How effectively migrants satisfy energy demands and meet en-route contingencies depends not only on the habitat's intrinsic suitability, but also on time and energy available for selecting among alternative habitats, relative availability of more suitable habitats, the migrant's searching efficiency and probability of survival during migration.

STATEMENT OF PROBLEM

Conservation of Neotropical landbird migrants is complicated by the very life history characteristic that permits these birds to exploit seasonal environments, namely migration. Choice of habitat must be made in Neotropical wintering quarters, temperate breeding areas, and repeatedly during migration. Each habitat encountered during the annual cycle faces different threats of degradation and destruction (Gradwohl and Greenberg 1989).

Although debate over the causes of the decline in populations of landbird migrants will continue, attention has focused on events associated with the breeding and wintering phases of the migrant's annual cycle (Terborgh 1989; Askins et al. 1990). What has been largely overlooked in our developing conservation strategy is importance of habitat during migration. Habitat use during migration has profound consequences for a bird's (1) ability to satisfy energy requirements, (2) vulnerability to predators, and (3) exposure to environmental stress. How migrants respond to contingencies that arise during migration affects their survival and reproductive success. Unfortunately, we know little about what types of habitats are most important at this time, where they occur, and how their distribution and abundance are changing as a result of development and land conversion. Nor do we know much about migrant-habitat relations.

If persistence of migrant populations depends on the bird's ability to find favorable conditions for survival throughout the annual cycle, factors associated with en-route ecology of migrants must figure in any analysis of population change and in development of a comprehensive conservation "strategy" for Neotropical wintering landbird migrants (e.g., Moore and Simons 1992). Unless habitat requirements during migration are met, conservation measures that focus on temperate breeding grounds or Neotropical wintering areas will be compromised (Dunne et al. 1989).

[1]*Department of Biological Sciences, University of Southern Mississippi, Hattiesburg, MS 39406.*

[2]*Department of Biological Sciences, Clemson University, Clemson, SC 29634.*

[3]*Cape May Bird Observatory, Cape May Point, NJ 08212.*

[4]*National Park Service, Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903.*

Our objectives are threefold: (1) Emphasize stopover habitat as a critical link in conservation of Neotropical landbird migrants, (2) appreciate importance of geographic scale in understanding en-route ecology of landbird migrants, and (3) identify management guidelines specific to the migratory phase of the annual cycle.

CONSEQUENCES OF EN-ROUTE HABITAT USE

The benefits of migration, regardless of whether they accrue through increased survivorship by overwintering in the tropics, increased productivity by breeding in temperate areas, or both, must be balanced against costs of migration. Besides energetic demands of transport, migrants must (a) adjust to unfamiliar habitats which vary in suitability, (b) resolve conflicting demands of predator avoidance and food acquisition, (c) compete with other migrants and resident birds for limited resources, (d) respond to unfavorable weather, and (e) correct for orientation errors. Moreover, migratory birds must balance conflicting demands between the need to stopover and satisfy energy requirements and selective pressures for timely arrival on breeding (Francis and Cooke 1986) and wintering areas. Whereas feeding meets energy demands and reduces risk of starvation, foraging migrants incur other costs, including a slower pace of migration and increased risk of predation. These problems are magnified when a migrant must cope with an ecological barrier (e.g., Rappole and Warner 1976, Moore and Kerlinger 1987, 1991), especially for a hatching-year bird on its first migration.

As stopover habitat is transformed, degraded or disappears, likelihood of solving those problems decreases, cost of migration increases, and a successful migration is jeopardized. Mortality during migration, though difficult to estimate, may be substantial, and probably falls disproportionately on the hatching-year age class (e.g., Ketterson and Nolan 1982, 1983). Whether an individual is recruited into the population will depend on events during the period between independence-from-parents to the bird's first breeding attempt. Hence, study of different age-classes during migration is essential to understanding causes of population change and the formulation of sound conservation policy.

Although it is difficult to measure the effect of en route habitats on survival or reproductive success, it is possible to evaluate the immediate consequences in relation to how effectively migrants satisfy energy demands during migration. Individuals in migratory disposition become hyperphagic and deposit substantial lipid stores which are mobilized to meet energetic requirements of migration. As lipid stores are depleted during migration, some free-ranging birds are capable of rapidly rebuilding reserves in a few days at rates approaching 10% of body mass/day (e.g., Moore and Kerlinger 1987).

Birds mobilize stored lipid for energy during migratory flight, so many individuals arrive in stopover habitat in a fat-depleted condition (e.g., Rappole and Warner 1976, Moore and Kerlinger 1987, Kuenzi et al. 1991). Several consequences follow if stores cannot be replenished soon after arrival: (1) lean migrants have a smaller "margin of safety" to buffer the effect of adverse weather on availability of food supplies during stopover (e.g., Moore and Kerlinger 1990), (2) efforts to satisfy energy demand may expose fat-depleted migrants to increased predation pressure (Lindström 1989), (3) if lean birds remain longer at stopover sites than birds in better energetic condition (e.g., Moore and Kerlinger 1987) and do not make up lost time, they will necessarily arrive later on the breeding grounds. Migrants that arrive late on the breeding grounds may jeopardize opportunities to secure a territory or a mate.

EXTRINSIC FACTORS AND THE EFFECT OF SCALE ON EN-ROUTE HABITAT USE

Habitat selection by nonbreeding land bird migrants is a hierarchical decision-making process (sensu Hutto 1985a; see Moore and Simons 1992). At the broad geographical level (i.e., highest level in hierarchy) most individuals are "programmed" to follow a migratory pathway between their breeding and nonbreeding areas, and the same intrinsic factors (e.g., amount of resource, protection from predation) that determine suitability of a nonbreeding habitat probably have influenced evolution of currently used migratory routes and wintering areas. Habitats not frequented may have high extrinsic costs associated with travelling to them rather than a high intrinsic cost associated with their use. By the same token use of some en route habitats may result from extrinsic benefits (short distance or favorable wind patterns) rather than the habitat's intrinsic qualities (see Gauthreaux 1980b).

We begin with emphasis on large scale (inter-continental and continental) movements of birds between their breeding and wintering grounds and then move down the hierarchy of spatial scale to discuss particular geographical regions important to en route ecology of Neotropical migrants (e.g., northern coast of the Gulf of Mexico during spring and fall migration, Atlantic Coast in the fall, importance of riparian woodlands as stopover habitat in grassland and desert biomes).

Geographical Pattern of Seasonal Timing of Migration

Much of what we know about the seasonal timing of bird migration in North America comes from work of field observers and bird banders, and their findings have been regularly summarized in spring and fall migration issues of "American Birds" (formerly "Audubon Field Notes"). Virtually every state has a checklist or bird book containing information on seasonal occurrences of migrant birds. Saunders (1959) examined variation in timing of spring arrivals among 50 different species in comparison with mean 40-year arrival dates and found that in late, cold springs migrants arrived later than in early, warm springs. Gauthreaux and LeGrand (1975) associated advancement or retardation of seasonal timing of migration with year-to-year changes in continental wind patterns. Robbins et al. (1983) summarized considerable data on seasonal timing of bird migration for most North American species. This information is presented on species maps as isochronal lines that show average first-arrival date where birds migrating to the north may be seen about the first of March, April, May, and June. Preston (1966) analyzed mathematically timing of spring and fall migration and found that in general those species that go early in fall return late in spring (e.g., waterfowl, sparrows). Preston discusses evidence that shows breeding birds occupy their summer habitat as soon as it is habitable and depart as soon as they have finished breeding. Variability in timing of a species' migration is less in spring than fall, hence birds are better synchronized in spring. During fall migration some species show an almost bimodal timing with young and adults traveling at somewhat different times (see Murray 1966). In the spring, males of most species arrive before females, and adults precede young (Francis and Cooke 1986, Moore et al. 1990).

A number of factors must be considered in discussing seasonal timing of migration. The more important of these are vegetational development in spring, food availability, and climatic factors in spring and fall. Weydemeyer (1973), in a 48-year study of spring arrivals of migrants in Montana, found ranges in dates of arrival were greatest for species arriving late March and April and least for species arriving late May and June. Slagsvold (1976) working in Norway found for the country as a whole a 6-day delay in bird arrival for each 10-day delay in vegetation development. Thus, arrival of migrants at higher latitudes and altitudes was faster than development of vegetation. Slagsvold also found earlier arriving species varied considerably in arrival date at a particular locality from year to year, but late arriving species had much less variation in arrival time. Pinkowski and Bajorek (1976) examined spring arrival dates of 29 migrants and summer resident species in southern Michigan over a 7-year period. They concluded that granivorous, omnivorous, and aquatic species tend to arrive earlier than strictly insectivorous species, and earlier arriving species have a greater variance in arrival time than species arriving late in spring. Hagan et al. (1991) studied the long-term mean timing of spring migration, within-year, and among-year variance in timing of 27 free-living Nearctic migrant species. They found that tropical wintering species showed significantly less within-year and among-year variation in timing of migration, suggesting the mechanism regulating their migration is primarily endogenous while the mechanism that regulates migration of more temperate-wintering species is sensitive to environmental change.

Geographical Aspects of the Neotropical Migration System

A wealth of information on geographical patterns of bird migration in North America can be found in state bird books and check-lists; state, regional, and national bird periodicals (e.g., "American Birds"); and even range maps in some popular identification field guides (e.g., Robbins et al. 1983, National Geographic Society 1983).

A very coarse-grained picture of migration flux in North America can be found in analyses of gamma diversity (total number of land bird species breeding or wintering in quadrats of 500 km per side) in different parts of North and Central America (fig. 1a, b). For a particular geographical region it is possible to obtain a general impression of the amount of migration if one compares change in number of species between summer and winter for the same quadrat. Gamma diversity shows the greatest drop from summer to winter in Canada while little change can be found in the southern United States. In the latter region in fall departing migrants are replaced by arriving migrants from farther north. For quadrats south of the border gamma diversity is higher during winter than during summer as Neotropical migrants vacate their breeding grounds in late summer and fall and move into Central America and northern South America to overwinter. However, not all changes in gamma diversity over North America can be attributed to Neotropical migrants, because some migrants do not cross the southern border of the U.S. Also, some species are not recorded in summer or winter quadrats because they are strictly transient in that area.

When information on breeding distribution is added to the picture, the geographical pattern of Neotropical migration is further clarified. Figure 2 shows a map of proportions of breeding songbird individuals in undisturbed vegetation communities that winter in the Neotropics (after MacArthur 1959). MacArthur found the eastern deciduous forest contained more Neotropical landbird migrants than northern coniferous forests and grasslands, and he correlated differences with the contrast between winter and summer food supplies in the given habitat. Willson (1976) in a partial reanalysis of MacArthur's (1959) findings showed: (1) North American Neotropical migrants are less prevalent in grasslands than forests, but there is no significant difference in proportion of Neotropical migrants in deciduous and coniferous forests, (2) most Neotropical migrant birds breed primarily in deciduous forests, and most of those that breed in coniferous forests are wood-warblers. In general considerably more Neotropical landbird migration occurs in the eastern two-thirds of the United States than in the West (Lowery 1951, Lowery and Newman 1955, 1966). One explanation for the greater amount of migration in the East comes from the fact the breeding ranges of several "eastern" species of Neotropical migrant extend considerably farther west and north of eastern forests of the U.S., but the birds migrate through the East. The breeding and migration range of the Philadelphia Vireo (*Vireo philadelphicus*) (fig. 3) illustrates this

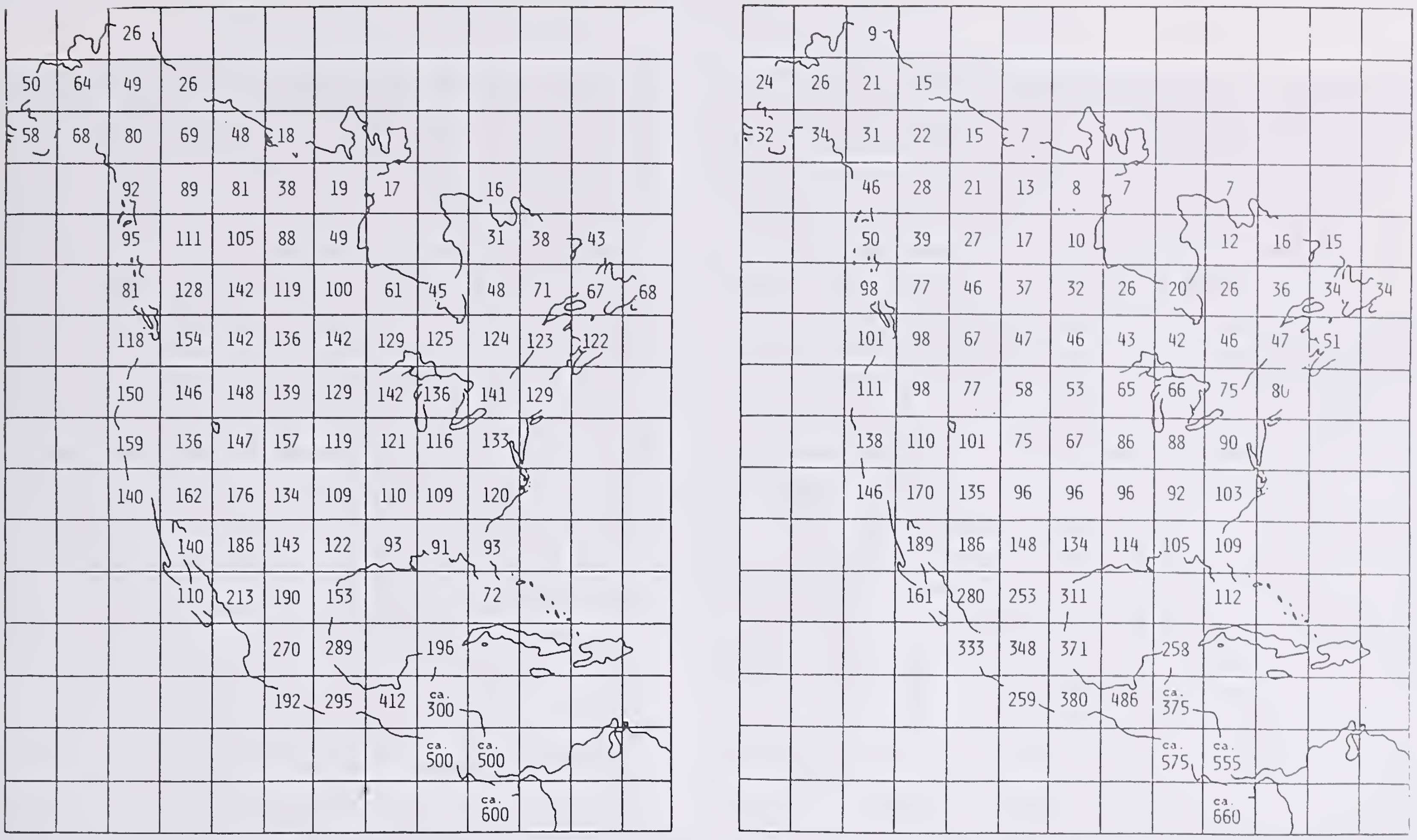


Figure 1a,b. — Gamma diversity (the total number of land bird species breeding (left) or wintering (right) in quadrats of 500 km per side) in different parts of North and Central America.

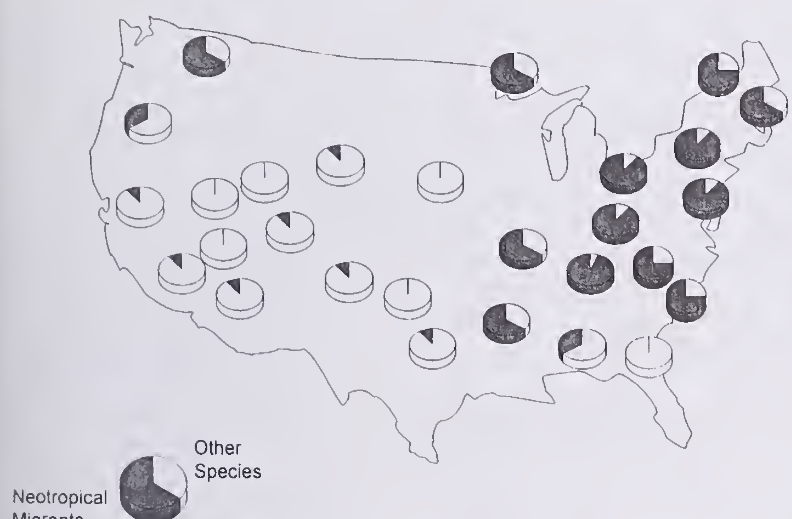


Figure 2. — Proportions of breeding bird individuals in undisturbed vegetation communities that winter in the Neotropics (see MacArthur 1959, Willson 1976).

point. Approximately 33 species of Neotropical migrants conform to this pattern. Another basis for the pattern of more migration in the East is that more Neotropical migrants (species and individuals) breed in the East (fig. 2). For example, among North American wood-warblers that migrate to the neotropics, 40 species occur east of the Rocky Mountains and 15 species of warblers are found west of the mountains. Western species winter almost entirely within a narrow strip of west Mexico from Sonora south to Guatemala while eastern warblers

Figure 3. — The breeding (stippled) and migration (hatched) range of the Philadelphia Vireo (*Vireo philadelphicus*).

generally winter in geographically separate areas of the Bahamas, West Indies, eastern Mexico, Central America, and northern South America (Hutto 1985a).

When drawing inferences about continent-wide patterns, keep in mind that information on the spatial and temporal pattern of migration, not to mention migration volume ("traffic rate"), is not readily available for southwestern United States or the West in general. Radar and direct visual (ceilometer and moon watching) studies must be conducted to fill that gap. It is clear that riparian or riverine habitats in the southwestern U.S. are vital to landbird migrants, notably woodland species (Sprunt 1975), and concentrate a diversity of migrants in large numbers. Similarly, shelterbelts on the Great Plains represent islands of suitable habitat for woodland migrants (Martin 1980).

For the most part longitudinal separation of species and populations of migratory land birds that exists during breeding persists during migration and during winter (vireos [Barlow 1980], tyrant flycatchers [Fitzpatrick 1980], paruline warblers [Keast 1980; Hutto 1985a], and Neotropical migrants in general [Rappole et al. 1983]). At a continent-wide scale explanations for these patterns are varied and may relate to location of breeding and wintering areas, major topographical features, availability of suitable resources on the migration route, peculiarities of life history, and prevailing direction of winds during the migration seasons (Rappole et al. 1979, Gauthreaux 1980a, Hutto 1985a). Clearly the mild climate of the Pacific Coast, the north-south mountain ranges of western North America, and grasslands east of the mountains play an important role in maintaining the integrity of western land bird migration patterns. Likewise western mountains, extensive grasslands, and prevailing westerly winds help maintain the eastern bias to seasonal movements of "eastern" Neotropical migrants during migration.

Continent-wide, seasonal differences in migration pathways can be related to prevailing wind patterns at different latitudes such that in spring Neotropical migrants are biased westward by prevailing easterlies at low latitudes and eastward at higher latitudes by prevailing westerlies (Bellrose and Graber 1963, Gauthreaux 1980a). These prevailing wind patterns (fig. 4 top) produce a clockwise pattern of migratory pathways (fig. 4 bottom) that account for many Neotropical migrants being more abundant in fall on the East coast and the western Atlantic Ocean (Williams et al. 1977) as they move toward their tropical wintering grounds. In spring the clockwise flow (fig. 5 top) biases many migrants departing from the tropics toward the northern and northwestern coast of the Gulf of Mexico and the lower Mississippi Valley (fig. 5 bottom) with reduced numbers in most of Florida and extreme southeastern U.S. (e.g., Blackburnian Warbler [*Dendroica fusca*], see Crawford 1981; Crawford and Stevenson 1984).

Prevailing wind patterns, in concert with geographical differences in overwintering areas, also influence the relative magnitude of trans-Gulf and circum-Gulf spring migration such that several species that winter primarily in the Greater Antilles (e.g., Cape May Warbler (*Dendroica tigrina*) and Black-throated Blue Warbler (*D. caerulescens*) are abundant in Florida in spring and become quite rare westward along the northern Gulf Coast (Robertson and Woolfenden in press). Depending on the winds aloft during spring trans-Gulf flights, migrants may be "transported" anywhere from the coast of Mexico to the coast of Florida. Weather surveillance radar (WSR-57) has been used to delimit the geographical pattern of landing areas of trans-Gulf migrants as they arrive on the Louisiana coast in spring (Gauthreaux 1975). Virtually every day between the beginning of April and the middle of May, large scale trans-Gulf flights consisting of a variety of species of Neotropical migrants arrive on the northern Gulf coast when winds across the Gulf are favorable. With fair weather (about 80 per cent of the time) the majority of these birds overfly the 25 to 30 mile (40 to 48 kilometer) width of the coastal marshes and alight in inland forested areas.

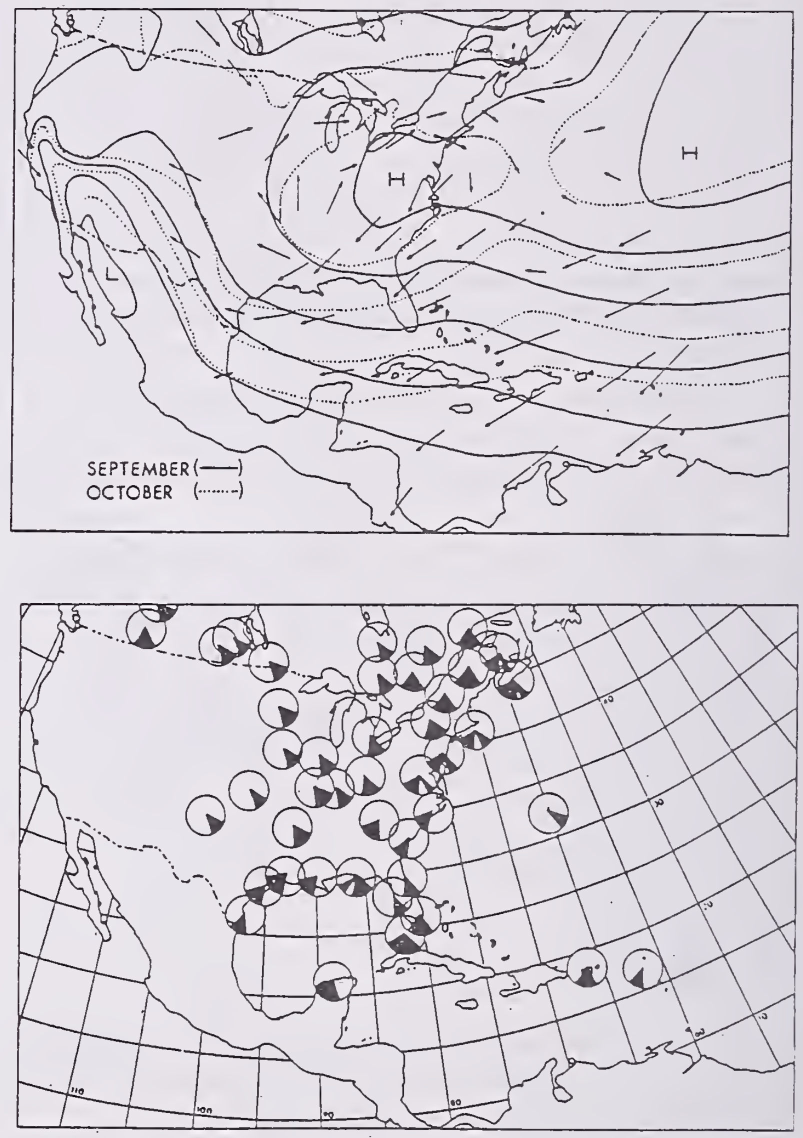
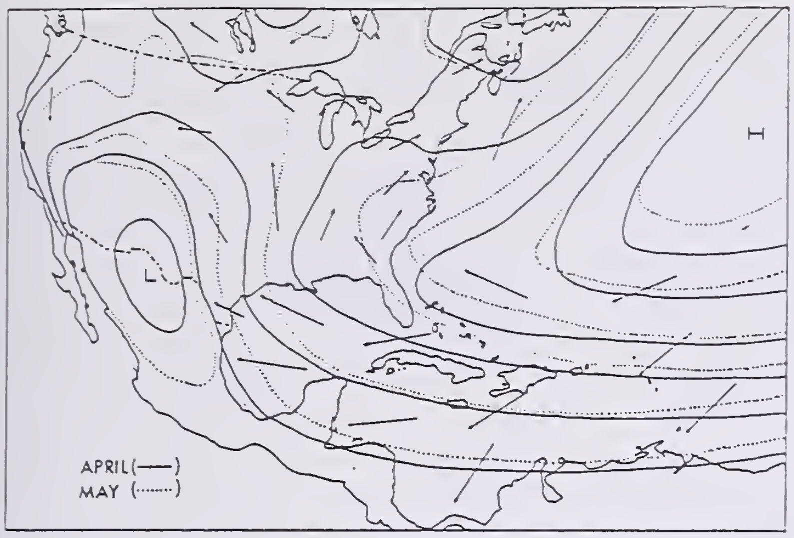


Figure 4. — (TOP) The distribution of sea-level barometric pressure patterns in fall. Continuous and dotted lines connect points of equal pressure for the months of September and October, respectively. The arrows indicate the resultant direction of surface winds. Prevailing wind patterns produce a clockwise pattern of migratory pathways. (BOTTOM) The directional tendencies of nocturnal passerine migration in fall. The circular plots show the predominant direction for a given area. The thickness of the wedge approximates the usual variability in direction. When two major directional tendencies exist for an area, they are both indicated.



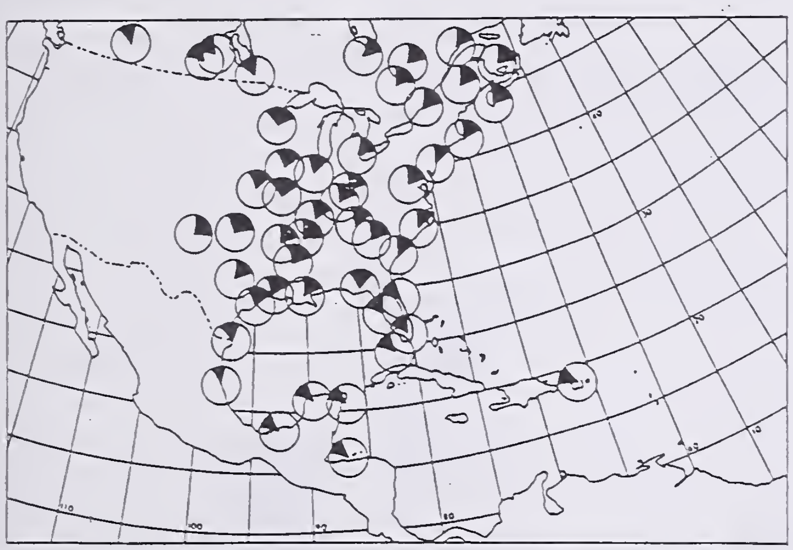


Figure 5. — (TOP) The distribution of sea-level barometric pressure patterns in spring. Continuous and dotted lines connect points of equal pressure for the months of April and May, respectively. The arrows indicate the resultant direction of surface winds. Prevailing wind patterns produce a clockwise pattern of migratory pathways. (BOTTOM) The directional tendencies of nocturnal passerine migration in spring. The circular plots show the predominant direction for a given area. The thickness of the wedge approximates the usual variability in direction. When two major directional tendencies exist for an area, they are both indicated.

INTRINSIC SUITABILITY AND SELECTION AMONG EN-ROUTE HABITATS

Now we turn to selection among habitat types within the landscape scale (e.g., pine versus deciduous woodland) and consider the en-route habitat requirements of Neotropical landbird migrants. Over the course of a season's migration a songbird like a Philadelphia Vireo encounters a variety of habitats, most with new food, competitors, and predators. After a night's migration a songbird often finds itself in a habitat very different from the one it occupied the previous day, let alone the previous year. Despite the diversity of habitat types encountered, largely correlative evidence indicates that migrants prefer certain habitat types and select among alternatives during stopover (e.g., Hutto 1985b, Moore et al. 1990, Winker et al. 1992).

Changes in distribution of migrants among habitat types from one migratory season to the next are consistent with en-route habitat selection. For example, foliage-gleaning, insectivorous migrants showed shifts in habitats used from one migratory season to the next during passage through southeastern Arizona (Hutto 1985b). Moreover, changes were tied to changes in availability of insect prey. Similarly, Winker and his colleagues (1992) reported seasonal shifts in distribution of Northern Waterthrush (*Seiurus noveboracensis*) among swamp, floodplain and willow habitats in the St. Crois River Valley, Minnesota, while Swainson's Thrush (*Catharus ustulatus*) shifted from drier habitats in spring toward wetter sites in autumn in the same study area.

When use of five habitat types was examined on Horn Island, a barrier island off the northern coast of the Gulf of Mexico (Moore et al. 1990), distribution of spring trans-Gulf migrants deviated from that expected based on availability of habitats (fig. 6). Whereas Scrub-Shrub comprised 14% of available habitat, it was characterized by the greatest number of species, highest species diversity, and the largest number of individuals.

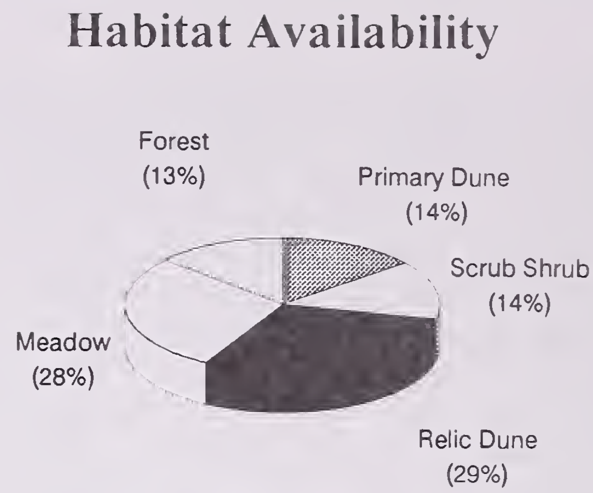
Habitat selection was apparent when fall migrants were mist-netted in five habitats in Cape May, New Jersey (Kerlinger pers. observations). For example, Connecticut Warbler (*Oporornis agilis*) were invariably found in hedge rows between old, grass fields. Moreover, most Connecticut Warblers were caught in mist-nets placed across rather than parallel to the hedge row. This species was never found in forest interior, nor were they seen frequently during transects done along hedge rows or other habitat types.

Determinants of Habitat Suitability

En-route habitat selection occurs because the probability a migrant will meet its energetic requirements and achieve safe passage is correlated with the intrinsic suitability of stopover habitat. Three factors constrain migrants to certain types of habitats: foraging opportunities, competition with other migrants and with resident birds, and shelter against predators and adverse weather (see Hutto 1985a, Moore and Simons 1992). Possibly the single most important constraint during migration is to acquire enough food to meet energetic requirements, especially for long-distance migrants which must overcome geographic barriers (e.g., Wood 1982, Bairlein 1987, Biebach 1990, Moore 1991). It is no wonder that differential use of en-route habitat is tied to food availability (e.g., Bibby et al. 1976, Bibby and Green 1983, Martin 1980, 1985, Graber and Graber 1983, Hutto 1985b, Moore and Yong 1991).

The physical structure of habitat, including plant species composition and foliage structure, influences habitat suitability by affecting how birds move through habitat and how they see and capture prey (Holmes and Robinson 1981, Robinson and Holmes 1982, 1984). Such constraints could affect rate at which migrants replenish energy reserves.

Habitat Use by Migrants



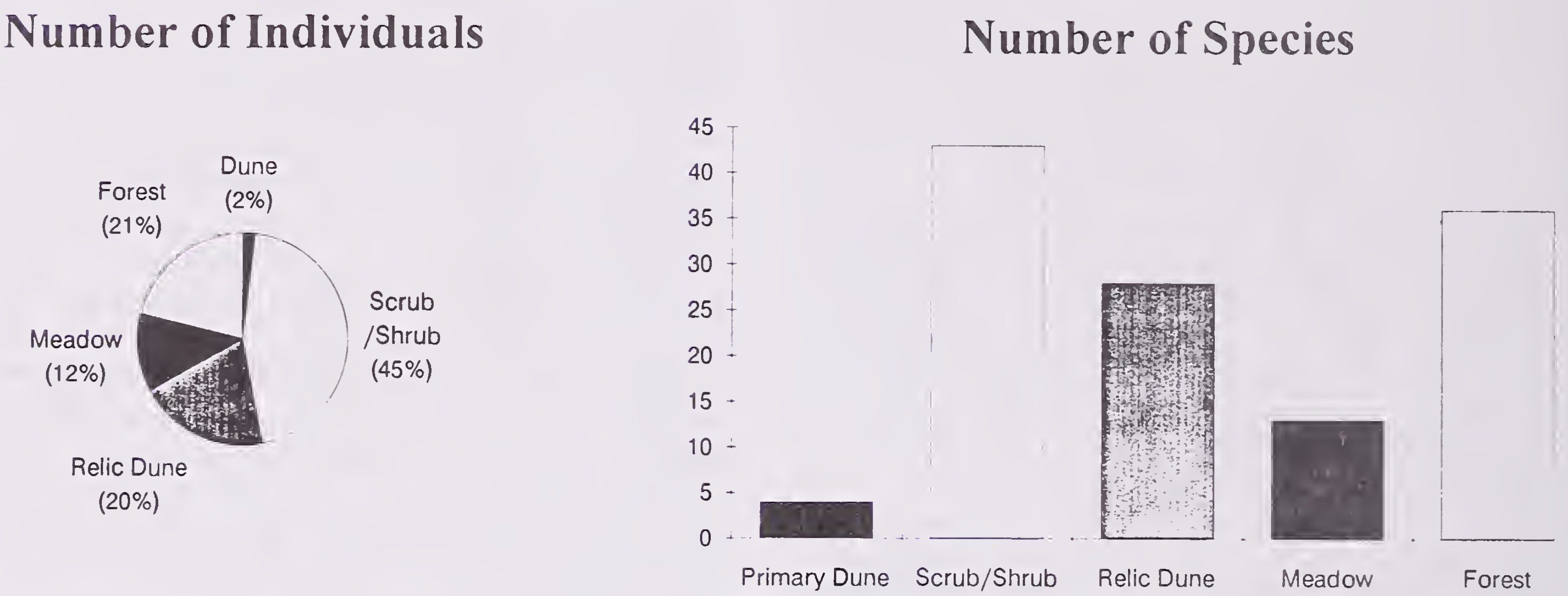


Figure 6. — Differential use of five habitat types by Neotropical landbird migrants on Horn Island, a barrier island off the northern coast of the Gulf of Mexico (after Moore et al. 1990).

Habitat extent or "patchiness" also contributes to habitat suitability. Bird species require different threshold levels of habitat area below which they find habitat unsuitable (Robbins et al. 1989). Sensitivity to area might affect habitat use during migration and the rate at which migrants replenish energy reserves. Suitable habitat associated with ecological barriers are often fragmented and many woodlands average only a few hectares in area. Whereas dehydration does not appear to be a serious en-route problem for small landbird migrants (Haas and Beck 1979, Biebach 1990), water economy might constrain migratory range and could explain why some individuals stop despite sufficient reserves for continued migration.

A safe place to rest may be as an important determinant of suitability as food availability. In Cape May, New Jersey, where as many as 80,000 migrating hawks and falcons have been counted in a single autumn migration season, predation on songbirds is intense (Wiedner et al. 1992). Kerlinger (1989) speculated that some hawks migrate along coasts because of the seasonal concentration of potential prey, notably energetically stressed birds which might be easy prey. If habitat offers refuge from predators and provides appropriate foods in sufficient quantities, there is little question about its suitability for stopover. When the best areas for depositing fat are also the most dangerous, the migrant must trade off energy gain against mortality risks. In general, we expect fat-depleted migrants to be more willing to "trade off" risk of predation to meet energetic requirements than are birds that arrive with unmobilized fat stores.

Migrants might suffer muscular fatigue during sustained flight over ecological barriers and might stopover to metabolize lactate and "repay" oxygen debt, regardless of their fat status. Stopover would also be required for tissue repair if migrants are forced to catabolized muscle tissue to offset unexpected energy demands or if muscle fibers are damaged during sustained, long-distance flight.

Mechanism(s) of Habitat Selection

Many researchers believe selection of a location to make a migratory stopover occurs during daylight hours. Although most birds end their migratory flight before dawn, many make short flights after sunrise (Wiedner et al. 1992) -- a phenomenon often called "morning flight". Morning flight differ from normal nocturnal migration in that it usually occurs within two hours after dawn, at low altitudes (sometimes from treetop to treetop), flights are of short duration, and migrants are often in flocks. In addition, the direction of morning flight is rarely the same as the previous night's migration. On the Cape May peninsula, New Jersey, thousands of migrants can be observed in morning flight north, away from the end of the peninsula, toward forested areas up the Delaware Bayshore (Wiedner et al. 1992). At other sites in the New Jersey coastal plain, morning flight is west or northwest, again toward forested areas (Gauthreaux, pers. comm.). Once birds reach forested areas they diffuse, presumably their preferred habitats. Similarly, we would not be surprised if riparian areas "attracted" landbirds following a night's migration (see Terrill and Ohmart 1984).

Although it may not be obvious why certain habitats are more attractive to migrants, observations of migrants arriving along the northern coast of the Gulf of Mexico following a trans-Gulf crossing suggest that migrants "rank" alternative habitats during an initial exploratory phase shortly after arrival. An initial "exploratory phase" to habitat selection might be adaptive if availability of highly suitable habitat is unpredictable, as it probably is for a passage migrant.

What cues migrants use to select among alternative habitats is poorly understood. Habitat assessment involves acquiring information about alternatives. One source of information comes from sampling a habitat, which might include number of food items harvested, time spent in a habitat, and time since the last food item was consumed. Migrants may also pay attention to the number of other migrants present. Presumably a more suitable habitat would attract more individuals, although more migrants would intensify competition for resources.

A second source of information involves knowledge of distribution of resources in the environment (i.e., prior information). Prior information might increase foraging efficiency. During migration, however, birds experience a variety of unfamiliar habitats and often do not spend much time in one location -- circumstances likely to preclude use of prior information.

Constraints on Habitat Selection

How effectively migrants satisfy energy demands and meet en-route contingencies depends not only on the habitat's intrinsic suitability, but also on (1) time and energy available for selecting among alternative habitats, (2) relative availability of more suitable habitats, (3) migrant's searching efficiency and (4) probability of survival during migration. For example, when adverse weather conditions are encountered while aloft, a migrant might be forced to land in habitat it would otherwise bypass. If energy reserves are depleted, stopover "options" are more narrowly circumscribed (i.e., suitable en-route habitat may be effectively limited if migrants do not have the luxury of searching for the "best" stopover site). For a fat-depleted migrant unfamiliar with availability of favorable stopover habitat, benefits of rejecting suboptimal habitat may be outweighed by cost of finding a better site (see Moore and Simons 1992).

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Ecological diversity of migratory species, coupled with the often variable weather patterns that steer migratory movements, make assessment of habitat requirements and development of management strategies for migrants particularly difficult. The complexity of this issue, and the fact that the abundance of migrants found at individual stopover sites can vary dramatically from year to year, makes it tempting to devalue the migratory period when developing conservation programs. Because Neotropical migrants spend more of their lives in breeding and wintering habitats, these would seem a natural target for conservation efforts. Certainly, the characteristics and distribution of breeding and wintering habitats are somewhat easier to define.

It is generally assumed that higher energetic costs and mortality rates experienced by birds during migration are offset by higher productivity and/or survival on the breeding and wintering grounds (e.g., Lack 1946, Greenberg 1980). If mortality is concentrated in the migratory period, then we must assume factors that increase cost of migration could have a disproportionate influence on overall population levels. Thus, while individual fragmented woodlots may represent local population sinks on breeding grounds, birds in these habitats can often select alternative or more productive habitats. In contrast, the rigors of migration often place birds close to their physiological limits in unfamiliar landscapes, where they simply do not have the luxury of selecting alternative habitats. Therefore, a lack of suitable stopover habitat will result in death or reproductive failure for Neotropical migrants and contribute substantially to future population declines. Some management guidelines and recommendations are organized according to geographic scale (see below) and listed in Table 1.

Within-Habitat Scale

In light of these threats, there is a pressing need for information on stopover ecology and habitat requirements of Neotropical migrants. Unfortunately, we still know very little about the fine scale habitat characteristics that influence prey availability or other aspects of habitat quality. For example, satisfying the energy demand of migration is not simply a matter of hyperphagia. Availability of nutrients that specifically enhance migratory fattening has as strong an effect on the course of migration as the gross abundance of food at a particular stopover site (Bairlein 1991). It must also be recognized that migrating birds use en-route habitat in different ways -- for different

Table 1. — Suggested guidelines and recommendations specific to the migratory period and organized according to geographic scale.

A. WITHIN-HABITAT SCALE
1. Migrants use en-route habitat for different reasons: Rest, fat deposition, molt, hydration, safety from predators.
2. A variety of foods, including insects and fruit, is important both spring and fall migration. Fruit facilitates fat deposition and provides a rapid (short-term) solution to nutrient deficiencies which result from prolonged activity (i.e., migratory flight).
3. Management practices that reduce food (insect, fruit) abundance should be scrutinized (e.g., pesticide application).
B. LANDSCAPE SCALE
1. Given diversity of migratory species, a diverse array (mosaic) of habitats is preferred.
2. Floristic and structural diversity is desired (e.g., mixed forest and scrub/shrub habitats "attract" more individuals and are characterized by greater species richness).
3. Maintain mixed communities in urban and agricultural landscapes as well as managed forests. For example, city parks can host dozens of species and many individuals during migration.
C. GEOGRAPHIC SCALE
1. Because migratory pathways are only loosely defined and influenced by seasonal weather patterns, suitable stopover habitat should be managed across a breadth of possible migratory pathways. A matrix of widely distributed habitats may be more effective than a small number of large habitat areas.
2. The continental-wide pattern of migration concentrates migrants in relation to ecological barriers. Crossing barriers can place extreme energetic demands on migrants.
3. Protection and management of habitats used by migrants in relation to ecological barriers should be a priority, especially along the northern coast of the Gulf of Mexico (spring and fall), the Atlantic Coast (fall), and riparian habitats in the Southwestern U.S. (spring and fall). Conservation is exacerbated by population growth and land conversion taking place in both coastal and riparian areas.
4. Migrants and their habitats should be included as significant coastal resources in state Coastal Zone Management plans.

reasons; some birds try to deposit lipid stores, others use the site as a molting ground (e.g., Winker et al. 1992), and still others simply rest until nightfall (Biebach 1991). As we refine our understanding of determinants of habitat suitability, we must combine this knowledge with an analysis of habitat status and trends to develop future conservation priorities.

Among-Habitat Landscape Scale

Recent studies along the northern coast of the Gulf of Mexico (e.g., Moore et al. 1990; Kuenzi et al. 1991), in the Upper Mississippi Valley (Winker et al. 1992), and the Delmarva Peninsula (Mabey et al. 1992) have begun to identify some of the local and landscape scale features important to migrants. For example, spring migrants clearly preferred habitats with greater structural diversity when they arrived on the northern Gulf coast following a trans-Gulf flight (Moore et al. 1990). Structurally complex habitats, comprised of forest with a mixed shrub layer contained the greatest diversity and abundance of migrants. Similarly, species richness is greatest in mixed forest, deciduous forest, and scrub/shrub habitats associated with the Delmarva Peninsula (Mabey et al. 1992).

Maintenance of mixed communities in urban and agricultural landscapes as well as managed forests should improve habitat quality for migrants. For example, city parks can host dozens of species and many individuals during migration. Without these habitat "islands" many birds would not have any place in which to stopover. Although these "migrant traps" are important habitat, they should not be construed as alternatives to larger, undeveloped areas. In general, given the ecological diversity of this group of birds, avoid monoculture forests while maintaining floristic and structural diversity at stopover sites should be a habitat management goal. Efforts at habitat restoration should emphasize scrub/shrub and mixed forests communities.

Geographic Scale

First, it is clear that migratory pathways are only loosely defined and are shaped by seasonal weather patterns. Second, radar and field studies confirm that importance of an individual patch of habitat varies from year to year; a function of the number of migrants stopping-over and their energetic condition. The conservation implications of these observations argue for protection of suitable stopover sites across the breadth of known migratory routes. When managing for migratory species, a matrix of smaller and more widely-distributed habitats may be more effective than a small number of large habitat patches.

Once migration routes are recognized and geographical variances in the route and timing documented, one can delimit important stopover habitat for Neotropical migrants. A number of important stopover locations have been identified where concentrations of Neotropical migrants occur (e.g., Block Island, Rhode Island; Delmarva Peninsula; Cape May, New Jersey; High Island, Texas; Dry Tortugas, Florida; Long Point Bird Observatory, Ontario), but in nearly all cases habitat is limited, or areas are small and isolated, or both. Neotropical migrants require more extensive stopover habitat, particularly along the

Atlantic Coast in fall and along the Gulf Coast in spring and fall. Stopover habitat in the interior is also critically important in North America wherever extensive deforestation and fragmentation have occurred (intensive and extensive agricultural areas) and, of course, in expansive areas of grassland and desert where stopover habitat for migrants that prefer woodlands is almost nonexistent except for narrow riparian woodlands. Such areas must be maintained and even increased (e.g., Platte River in Nebraska).

The continent-wide pattern of migration concentrates migrants in relation to ecological barriers. Crossing ecological barriers such as water bodies, mountain ranges, deserts, and more recently, agricultural and urban landscapes, can place extreme energetic demands on migrants. Furthermore, problems associated with ecological barriers are magnified for hatching-year birds on their first migration. When food is plentiful even an inefficient forager may have few problems finding enough food to deposit sufficient lipid stores. However, inefficiency and lack of experience in young migrants could become important if food becomes scarce or when migrants experience increased energy demand (e.g., trans-barrier flights).

Therefore, protection and management of habitats used by migrants before and after they cross ecological barriers should be a prominent conservation priority. Examples include; cheniers and coastal woodlands along the northern coast of the Gulf of Mexico, riparian habitats in the Southwestern U.S. and maritime forests and shrub communities along the eastern seaboard. Consider the consequences of en-route habitat loss on landbird migrant populations: Densities will increase in remaining areas, which will intensify competition. Increased competition may reduce food availability and increase interference, thereby slowing migration, delaying arrival on breeding and wintering areas, and increasing predation pressure. Increased competition may also re-distribute birds among habitats, with younger, less experienced migrants forced into poorer sites where mortality rates are expected to be higher. The challenge of identifying and protecting coastal habitats will be heightened by explosive population growth taking place in these areas. Concentration of the U.S. population along coasts is projected to continue well into the next century (Figure 7; Cullitan 1990). About half of our total population now live in coastal areas. By 2010, coastal populations will have grown from 80 million to more than 127 million people, an 60% increase. The Northern Gulf Coast, collectively the most important migratory stopover area in North America, is expected to see significant population increases (Figure 7; Cullitan 1990). The southern migration of industry coupled with changing demographics will increase development pressure of stopover habitats in the decades ahead. Some coastal habitats spared from development are threatened by accelerating rates of coastal erosion (Dolan et al. 1989). The combined effects of coastal subsidence, disruption of sediment supplies, and sea level rise will add further to loss of important stopover habitats. Creation of new habitats to replace those lost to coastal erosion will be a major conservation challenge in the next century.

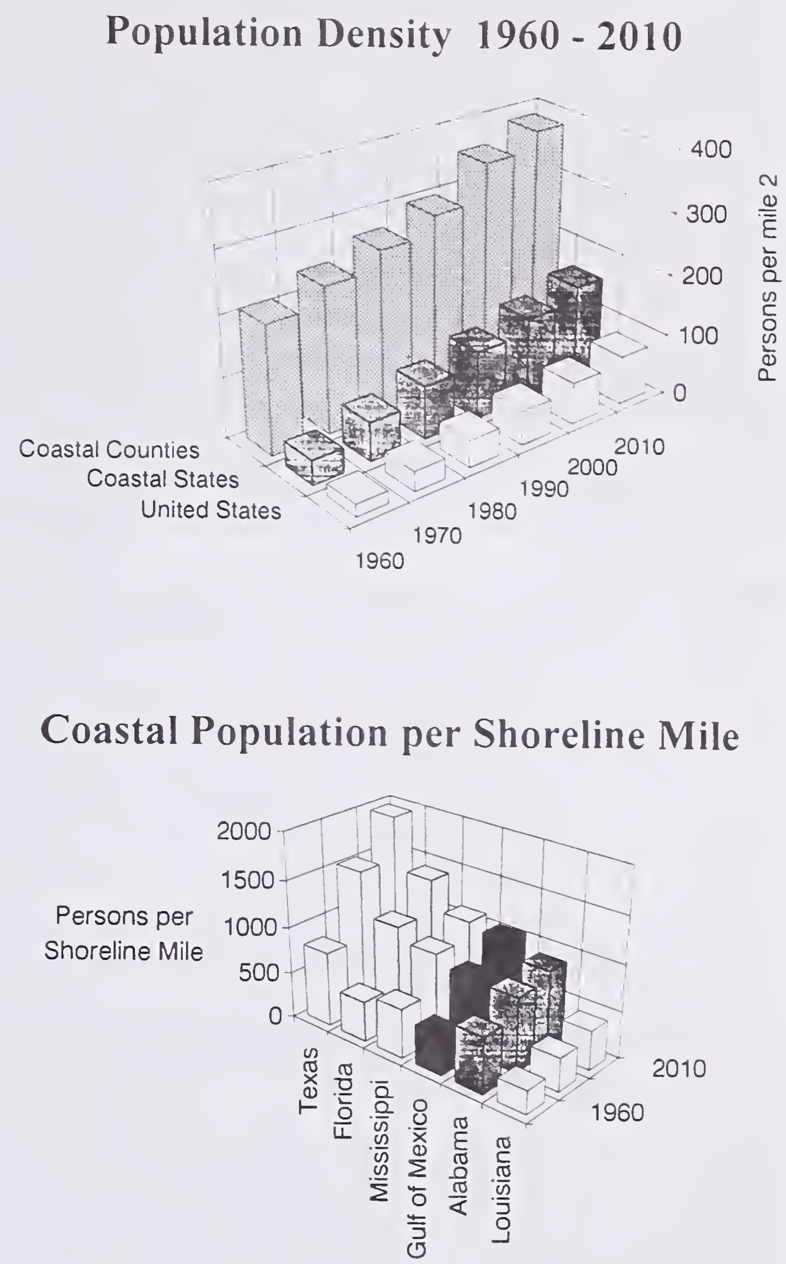


Figure 7. — (TOP) Projected changes in population density for coastal counties, coastal states, and the United States from 1960 to 2010. (BOTTOM) Coastal population per shoreline mile for the northern coast of the Gulf of Mexico.

ACKNOWLEDGEMENTS

We thank W. Barrow, D. Finch, W. Hunter, and P. Stangel for their comments on the manuscript, and P. Simons and C. Belser for help with figures and manuscript preparation. Our research with Neotropical landbird migrants has been supported by the National Park Service, National Wetlands Research Center (USFWS), USDA Forest Service, National Science Foundation, and the National Geographic Society.

LITERATURE CITED

Askins, R. A., J. F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7: 1-57.

Bairlein, F. 1987. The migratory strategy of the Garden Warbler: A survey of laboratory and field data. Ringing & Migr. 8: 59-72.

Bairlein, F. 1991. Nutritional adaptations to fat deposition in the long-distance migratory Garden Warbler *Sylvia borin*. Acta XX Congressus Internationalis Ornithologic: 2149-2158.

Barlow, J. C. 1980. Patterns of ecological interactions among migrant and resident vireos on the wintering grounds. pp. 79-107 *in* Migrant Birds in the Neotropics: Ecology, Behavior, Distribution, and Conservation. (A. Keast and E. S. Morton, Eds.). Random House (Smithsonian Inst. Press), NY.

Bellrose, F. C. and R. R. Graber. 1963. A radar study the flight directions of nocturnal migrants. Proc. XIII Intern, Ornith. Congr., 362-389.

Bibby, C. F., and R. E. Green. 1983. Food and fattening of migrating warblers in some French marshlands. Ringing & Migration 4: 175-184.

Bibby, C. F., R. E. Green, G. R. M. Pepler, and P. A. Pepler. 1976. Sedge warbler migration and reed aphids. British Birds 69: 384-399. Biebach, H. 1990. Strategies of trans-Sahara migrants. Pp. 352-367 *in* Bird Migration (E. Gwinner, Ed.). Springer-Verlag, Berlin.

Crawford, R. L. 1981. Bird casualties at a Leon County, Florida TV tower: a 25-year migration study. Bull. Tall Timbers Res. Sta. 22: 1-30.

Crawford, R. L. and H. M. Stevenson. 1984. Patterns of spring and fall migration in northwest Florida. J. Field Ornithol. 55: 196-203.

Culliton, T.J., M.A. Warren, T.R. Goodspeed, D.G. Remer, C.M. Blackwell, and J.J. McDonough, III. 1990. Fifty years of population change along the nation's coasts 1960-2010. Coastal Trends Series, Report No. 2. Rockville, MD: NOAA, Strategic Assessment Branch.

Dolan, R., S.J. Trossbach, and M.K. Buckley. 1989. Patterns of erosion along the Atlantic Coast. Pp. 17-21 *in* Barrier Islands: Process and Management (D.K. Stauble, Ed). ASCE, New York.

Dunne, P., R. Kane, and P. Kerlinger. 1989. New Jersey at the Crossroads. New Jersey Audubon. Franklin Lanes, New Jersey.

Fitzpatrick, J. W. 1980. Wintering of North American tyrant flycatchers in the Neotropics. Pp. 67-78 *in* Migrant Birds in the Neotropics: Ecology, Behavior, Distribution, and Conservation (A. Keast and E. S. Morton, Eds.). Random House (Smithsonian Inst. Press), New York.

Francis, C. M. and F. Cooke. 1986. Differential timing of spring migration in wood warblers (Parulinae). Auk 103:548-556.

Gauthreaux, S. A., Jr. 1975. Coastal hiatus of spring trans-Gulf bird migration. Pp. 85-91 *in* A Rationale for determining Louisiana's coastal zone. Report No. 1, Coastal Zone Management Series (W. G. McIntire, M. J. Hershman, R. D. Adams, K. D. Midboe, and B. B. Barrett, Eds). Center for Wetland Resources, Louisiana State University, Baton Rouge, Louisiana.

Gauthreaux, S. A., Jr. 1980a. The influence of global climatological factors on the evolution of bird migratory pathways. Proceedings XVIIth International Ornithological Congress. West Berlin. Pp. 517-525. Verlag der Deutschen Ornithologen-Gesellschaft, Berlin.

Gauthreaux, S. A., Jr. 1980b. The influences of long-tern and short-term climatic changes on the dispersal and migration of organisms. Pp. 103-174 *in* Animal Migration, Orientation, and Navigation (W. Keeton and H. Wallraff, Eds). Academic Press, Inc. New York.

Gauthreaux, S. A. Jr. and H. E. LeGrand, Jr. 1975. The changing seasons: Spring migration 1975. Amer. Birds 29:820-826.

Graber, J. W., and R. R. Graber. 1983. Feeding rates of warblers in spring. Condor 85: 139-150.

Gradwohl, J. and R. Greenberg. 1989. Conserving nongame migratory birds: A strategy for monitoring and research. Pp. 297-328 *in* Audubon Wildlife Report 1989/1990 (W. Chandler et al., Ed.). Academic Press, New York.

Greenberg, R. 1980. Demographic aspects of long-distance migration. Pp. 493-516 *in* Migrants in the Neotropics (A. Keast and E. Morton, Eds.). Smithsonian Institution Press, Washington, D.C.

Haas, W., and P. Beck. 1979. Zum Fruhjahrszug palaarktischer Vogel uber die westliche Sahara. J. Ornithol. 120: 237-246.

Hagan, J. M., T. L. Lloyd-Evans, and J. L. Atwood. 1991. The relationship between latitude and the timing of spring migration of North American landbirds. Ornis Scandinavica 22:129-136.

Holmes, R. T. and S. K. Robinson. 1981. Tree species preferences of foraging insectivorous birds in a northern hardwoods forest. Oecologia 48: 31-35.

Hutto, R. L. 1985a. Habitat selection by nonbreeding, migratory land birds. Pp. 455-476 *in*. Habitat Selection in Birds (M. Cody, Ed). Academic Press, New York.

Hutto, R. L. 1985b. Seasonal changes in the habitat distribution of transient insectivorous birds in southeastern Arizona: competition mediated? Auk 102: 120-132.

Keast, A. 1980. Spatial relationships between migratory parulid warblers and their ecological counterparts in the Neotropics. Pp. 109-130 *in* Migrant Birds in the Neotropics: Ecology, Behavior, Distribution, and Conservation. (A. Keast and E. S. Morton, Eds.). Random House (Smithsonian Inst. Press), NY.

Kerlinger, P. 1989. Flight Strategies of Migrating Hawks. University of Chicago Press, Chicago, IL.

Ketterson, E. and V. Nolan, Jr. 1982. The role of migration and winter mortality in the life history of a temperate-zone migrant, the Dark-eyed Junco as determined from demographic analyses of winter populations. Auk 99: 243-259.

Ketterson, E. and V. Nolan, Jr. 1983. The evolution of differential bird migration. Current Ornithology 3: 357-402.

Kuenzi, A. J., F. R. Moore, and T. R. Simons. 1991. Stopover of Neotropical landbird migrants on East Ship Island following trans-Gulf migration. Condor 93: 869-883.

Lack, D. 1946. Do juvenile birds survive less well than adults? Brit. Birds 39: 258-264.

Lindström, Å. 1989. Finch flock size and risk of hawk predation at a migratory stopover site. Auk 106: 225-232.

Lowery, G. H. 1951. A quantitative study of the nocturnal migration of birds. Univ. Kansas Publ. Mus. Nat. Hist. 3:361-472.

Lowery, G. H. and R. J. Newman. 1955. Direct studies of nocturnal bird migration. Pp. 238-263 *in* Recent Studies in Avian Biology (A. Wolfson, Ed.). Urbana: Univ. Illinois Press.

Lowery, G. H. and R. J. Newman. 1966. A continentwide view of bird migration on four nights in October. Auk 83:547-86.

Mabey, S.E., J. McCann, L.J. Niles, C. Bartlett, and P. Kerlinger. 1992. Neotropical migratory songbird regional coastal corridor study. Final Report. National Oceanic and Atmospheric Administration, Contract # NA90AA-H-CZ839.

MacArthur, R. H. 1959. On the breeding distribution pattern of North American birds. Auk 76:318-325.

Martin, T. E. 1980. Diversity and abundance of spring migratory birds using habitat islands on the Great Plains. Condor 82: 430-439.

Moore, F. R. 1991. Ecophysiological and behavioral response to energy demand during migration. Acta XX Congressus Internationalis Ornithologic: 753-760.

Moore, F. R., and P. Kerlinger. 1987. Stopover and fat deposition by North American wood-warblers (Parulinae) following spring migration over the Gulf of Mexico. Oecologia 74: 47-54.

Moore, F. R., and P. Kerlinger. 1991. Nocturnality, long-distance migration, and ecological barriers. Acta XX Congressus Internationalis Ornithologic: 1122-1129.

Moore, F. R. and T. R. Simons. 1992. Habitat suitability and stopover ecology of Neotropical landbird migrants. Pp. 345-355 *in* Ecology and Conservation of Neotropical Migrant Landbirds. (J. M. Hagan and D. W. Johnson, Eds.). Smithsonian Institution Press, Washington, DC and London.

Moore, F. R., and W. Yong. 1991. Evidence of food-based competition among passerine migrants during stopover. Behav. Ecol. Sociobiol. 28: 85-90.

Moore, F. R., P. Kerlinger, and T. R. Simons. 1990. Stopover on a Gulf coast barrier island by spring trans-Gulf migrants. Wilson Bull. 102: 487-500.

Murray, B. G., Jr. 1966. Migration of age and sex classes of passerines on the Atlantic coast in autumn. Auk 83:352-360.

National Geographic Society. 1983. Field Guide to the Birds of North America. National Geographic Society, Washington, D. C.

Pinkowski, B. C. and R. A. Bajorek. 1976. Vernal migration patterns of certain avian species in southern Michigan. Jack-Pine Warbler 54:62-68.

Preston, F. W. 1966. The mathematical representation of migration. Ecology 47:375-392.

Rappole, J. H., and D. W. Warner. 1976. Relationships between behavior, physiology and weather in avian transients at a migration stopover site. Oecologia 26: 193-212.

Rappole, J. H., E. S. Morton, T. E. Lovejoy, III, and J. L. Ruos. 1983. Nearctic avian migrants in the Neotropics. U.S. Department of the Interior, Fish and Wildlife Service. U.S. Government Printing Office.

Rappole, J. H., M. A. Ramos, R. J. Oehlenschlager, D. W. Warner, and C. P. Barkan. 1979. Timing of migration and route selection in North American Songbirds. Pp. 199-214 *in* Proc. First Welder Wildlife Foundation Symposium (D. L. Drawe, Ed.). Welder Wildlife Foundation, Sinton, Texas.

Robertson, W. B., Jr. and G. E. Woolfenden. In press. Florida Bird Species: An Annotated List. Special Publication No. 6. Florida Ornithological Society, Gainesville, FL.

Robbins, C. S., B. Bruun, H. Zim, and A. Singer. 1983. A Guide to Field Identification: Birds of North America. Golden Press. New York.

Robinson, S. K. and R. T. Holmes. 1982. Foraging behavior of forest birds: the relationships among search tactics, diet, and habitat structure. Ecology 63: 1918-1931.

Robinson, S. K. and R. T. Holmes. 1984. Effects of plant species and foliage structure on the foraging behavior of forest birds. Auk 101: 672-684.

Saunders, A. A. 1959. Forty years of spring migration in southern Connecticut. Wilson Bull. 71:208-19.

Slagsvold, T. 1976. Arrival of birds from spring migration in relation to vegetational development. Norw. J. Zool. 24:161-173.

Sprunt, A. 1975. Habitat management implications of migration. In: Proc. Symp. on Management of Forest and Range Habitats for Non-game Birds. USDA Forest Service, GTR WO-1. Pp. 81-86.

Terborgh, J. 1989. Where have all the birds gone? Princeton University Press, Princeton, NJ.

Terrill, S. B. and R. D. Ohmart. 1984. Facultative extension of fall migration by Yellow-rumped Warblers (*Dendroica coronata*). Auk 101: 427-438.

Weydemeyer, W. 1973. The spring migration pattern at Fortine, Montana. Condor 75:400-413.

Wiedner, D. S., P. Kerlinger, D. A. Sibley, P. Holt, J. Hough, and R. Crossley. 1992. Visible morning flights of neotropical landbird migrants at Cape May, New Jersey. Auk 109: in press.

Williams, T. C. , J. M. Williams, L. C. Ireland, and J. M. Teal. 1977. Autumnal bird migration over the western North Atlantic Ocean. Amer. Birds 31:251-267.

Willson, M. F. 1976. The breeding distribution of North American migrant birds: A critique of MacArthur (1959). Wilson Bull. 88(4):582-587.

Winker, K., D. W. Warner, and A. R. Weisbrod. 1992. The Northern Waterthrush and Swainson's Thrush as transients at a temperate inland stopover site. Pp. 384-402 *in* Ecology and Conservation of Neotropical Migrant Landbirds. (J. M. Hagan and D. W. Johnson, Eds.). Smithsonian Institution Press, Washington, DC.

Wood, B. 1982. The trans-Saharan spring migration of yellow wagtails (*Motacilla flava*). J. Zool., Lond. 197: 267-283.

Management and Conservation of Migratory Landbirds Overwintering in the Neotropics

Daniel R. Petit[1], James F. Lynch[2], Richard L. Hutto[3], John G. Blake[4], and Robert B. Waide[5]

Abstract — Loss of tropical broadleaved forests and concurrent population declines of long-distance migratory birds in temperate breeding areas have been closely linked in both scientific and popular literature; however, little evidence of a causal association currently exists. We review the current land use situation in the neotropics, the projected outcome of deforestation early in the 21st century, and the extent of knowledge of migratory bird habitat use on the wintering grounds. From that information, we assess the likely current and future impact of deforestation on migratory birds, and examine land use practices that may be compatible with the concept of conservation of those species.

At least 40% of the original tropical forests have been converted to other land uses. Most remaining tropical forests lie in the vast Amazon Basin, where few neotropical migrants spend winter. Permanent pasture and agriculture each presently comprise 10-30% of land area in many countries. Reasons for the rapid pace of deforestation are deeply rooted in socioeconomic problems of developing nations; solutions to those issues must be realized and implemented before forest conversion will slow. Early in the 21st century, once-forested landscapes will most likely be a mosaic of agricultural lands, cattle pastures, and secondary forests in various stages of regeneration. Large tracts of mature forest will probably be restricted mainly to national parks and reserves. Thus, tropical landscapes will be changing increasingly toward "agroscapes". Migratory birds as a group are most abundant in tropical habitats that are: (1) disturbed; (2) of medium stature (5-20 m); found at (3) low (m) elevations, and (4) high latitudes (15° N); and located (5) on the mainland. Slight to moderate levels of disturbance enhance numbers of migrants occupying broadleaved forest sites. However, species vary considerably in their preferences for winter habitats, such that broad generalizations may have limited use for actual on-site management and conservation plans. We examined habitat use by 123 species of migratory landbirds through an extensive literature review. Based upon the apparent reliance of species on undisturbed, broadleaved habitats, we identified 23 species that may be highly vulnerable to alteration of tropical forests.

Use or conversion of natural vegetation associations in the tropics as it relates to impacts on native flora and fauna can be placed under three broad categories: "conservative", "sustainable", and "destructive". "Conservative" land uses, such as protected parks and reserves, will play a major role in maintaining biodiversity. However, future economic growth and retention of natural resources in Latin America rest upon the concept of "sustainable" development. Several examples of sustainable forestry, such as strip clearcutting, appear highly compatible with goals of management of neotropical migratory

[1]Daniel R. Petit, Department of Biological Sciences, Arkansas Cooperative Fish and Wildlife Research Unit, University of Arkansas, Fayetteville, Arkansas 72701. Present address: Smithsonian Environmental Research Center, P.O. Box 28, Edgewater, Maryland 21037.

[2]James F. Lynch, Smithsonian Environmental Research Center, P.O. Box 28, Edgewater, Maryland 21037.

[3]Richard L. Hutto, Division of Biological Sciences, University of Montana, Missoula, Montana 59812.

[4]John G. Blake, Department of Biology, University of Missouri--St. Louis, 8001 Natural Bridge Road, St. Louis, Missouri 63121.

[5]Robert B. Waide, Center for Energy and Environment Research, University of Puerto Rico, G.P.O. Box 3682, San Juan, Puerto Rico 00936.

birds. Finally, "destructive" practices, such as heavily grazed or managed pastures and extensive monocultures, are the greatest threat to migratory birds in Latin America and the Caribbean.

Several measures need to be enacted within all national boundaries to ensure viability of migratory bird populations is not threatened by events on wintering grounds. These include: (1) assessment and monitoring of bird populations; (2) identification of both present and future threats; (3) identification of critical areas and habitats; (4) incorporation of sustainable development into land use planning; and (5) development of a system of protected reserves. Because neotropical migrants as a group are more tolerant of forest disruption and artificial environments than are resident species, conservation of migrants could be accomplished within plans devised for resident species.

INTRODUCTION

Loss of tropical broadleaved forests (Myers 1980, Lanly 1982) and concurrent population declines of migratory landbirds that breed in temperate North America and overwinter in the tropics (Robbins et al. 1986, Sauer and Droege 1992) have been closely linked in both the scientific and popular literature. Conversion and fragmentation of moist, tropical forests has been convincingly implicated in population declines or extirpation of permanent resident tropical bird species (e.g., Willis 1974, Lovejoy et al. 1984, Scott and Brooke 1985, Thiollay 1992), but impacts of tropical deforestation on migratory species that breed in North America are more dubious. The overwintering period could be a time of intense selective pressure on neotropical migrants because of mortality associated with stress from migratory flights, occupation of unfamiliar habitats by juvenile birds, and increased competition for food due to inflated densities of potential competitors (Morse 1980). Because these pressures should be exacerbated in the face of widespread alteration of native vegetative associations, a conceptual basis exists for a causal relationship between habitat changes on tropical wintering grounds and breeding populations of migrants. However, firm evidence for such a causal relationship remains obscure because of limited knowledge of ecologies of migrants during the boreal winter. Indeed, basic information on habitat distributions of migrants during winter (including habitat-specific survival rates) would greatly reduce the present-day gap between speculation and sound inference.

Threat of loss of biological diversity has been an impetus for the global conservation effort during the past several decades. In this light, recognition of potential future ecological catastrophes, such as extinction of plants and animals, is central to developing a coherent strategy for conserving natural communities for future generations. If tropical forest destruction and conversion are potentially responsible for estimated declines of certain migratory birds, then efforts must be initiated to identify, preserve, and manage appropriate tropical habitats for those species.

Development of pragmatic conservation plans for overwintering migratory landbirds requires assessment of several pertinent questions related to tropical forest alteration and its potential impact on migratory birds: What are the sociological and economical correlates of tropical forest destruction? What is the current extent of forests and other vegetation associations in the neotropics? What is the likely scenario for change in these natural resources as we enter the 21st century? What geographic regions and habitat types do migratory landbirds use and does overall habitat use reflect relative suitability? In this chapter, we briefly review these topics to lay the foundation for our assessment of present and future problems faced by migrants in the neotropics and the potential management and conservation solutions to those issues. Such an analysis is timely in light of the desire of both North American and Latin American governments to prevent further loss of biological diversity, including migratory birds, in the neotropics (Canadian Minister of the Environment 1983; U.S. Fish and Wildlife Service 1990; U.S. Congress, Office of Technology Assessment 1992).

FOREST DESTRUCTION AND THE STATUS OF TROPICAL FOREST ASSOCIATIONS

Migratory birds are found in nearly all natural vegetation associations in the neotropics, but several vegetation types are particularly important: wet/moist broadleaved forests, dry broadleaved forests, pine or mixed-pine forests, and mangrove forests. These categories are used here to develop a basis for understanding the extent and reasons for tropical deforestation and are discussed in further detail below; vegetation groupings are broad, but information on rates of conversion of specific vegetation associations in the tropics is not readily available. Accurate rates of deforestation are difficult to determine because of limited and conflicting data and variable use of such vocabulary as "deforestation" (Hamilton 1991). The terms "deforestation", "removal", and "conversion" (Melillo et al. 1985) of tropical forests are used synonymously throughout this paper to represent transformation of forested land to shifting cultivation, permanent crops, pasture, or extensive clear-cuts. Selective logging and other relatively minor disturbances to forests (e.g., collection of firewood) are generally not included under these headings.

Direct and Indirect Causes of Tropical Deforestation

Forests in the New World Tropics are typically cut to create agricultural or grazing lands, or to provide timber products (Myers 1981) that are often marketed overseas (e.g., Parsons 1976). Direct and indirect causes of deforestation are varied and complex, but most can be attributed to socioeconomic inequalities, both within developing countries and between developing and industrialized countries. That is, demand from industrialized nations for inexpensive agricultural products, as well as unequal distribution of land and resources among citizens of Latin American nations, have created a social and economic system where the bulk of the populace is poor and dependent upon subsistence agriculture (Leonard 1987, Ascher and Hubbard 1989). Examined slightly differently, wholesale depletion of natural forest resources in the neotropics can be viewed as a result of the inability of locally available technology to keep pace with population growth (Myers 1987). However, conservation biologists and sociologists believe that widespread implementation of available forest management practices would greatly relieve mounting pressures on tropical forests (e.g., World Resources Institute 1985, Anderson 1990, Thelen 1990). Outlined below are four major forest types and their current status within the neotropics.

Moist Broadleaved Forest

Moist and wet tropical forests (popularly termed "rain forests") occur in areas that receive 150-500 cm precipitation/year. Although the rapid removal of moist broadleaved forests from the neotropics during the past thirty years is an indisputable fact (Myers 1980, Lanly 1982, Sader and Joyce 1988), the exact rate of cutting and ultimate fate of deforested lands is difficult to assess (Melillo et al. 1985). At least 40% of the area originally covered by tropical moist forest has been converted to other land uses, with the bulk of remaining forests situated in the vast Amazon Basin (Myers 1980, 1991; World Resources Institute 1985; Mahar 1989). Mexico and most Central American nations contain (% of their original moist forest (Leonard 1987, Myers 1991, and projected trends from above sources). Because of the historical pattern of settlement and land use in tropical landscapes, a greater fraction of mid-to-high elevation moist forests are intact compared to coastal and other low elevation forests (Holdridge 1970, Janzen 1988). The relentless pace of forest cutting is especially alarming to conservation biologists, who fear that mass extinctions may occur before the full extent of biological diversity in the neotropics can even be evaluated (Leonard 1987).

Dry Broadleaved Forest

Most attention to tropical deforestation has focussed on moist/wet forests. However, dry forest associations, which comprised 42% of the total area of all tropical and subtropical forests (Brown and Lugo 1982), have been subjected to the greatest pressures from human populations. Tropical dry forests occur most extensively in western Mexico and Central America, northern and western South America, and on the Yucatan Peninsula and several Carribean islands. A combination of low precipitation (usually <150 cm/yr), pronounced dry season(s), and stressful edaphic conditions often produce climax forest types represented by short (<20 m), sclerophyllous trees or thorn forests (Murphy and Lugo 1986). Dry, semi-deciduous forests are also more open and less complex structurally than wet, evergreen forests (Holdridge et al. 1971). These climatic conditions allow dry forests to be easily cleared and maintained by fire and often produce more productive soil for agriculture and grazing than do moist forests (Murphy and Lugo 1986, Janzen 1988). Moreover, the relatively dry climate is more conducive to human settlement (Murphy and Lugo 1986). For all these reasons, areas supporting dry forest are usually the first to be cleared and settled in the tropics (Holdridge 1970, Hartshorn 1992). Janzen (1988) suggested the critical period for conservation of tropical dry forests was 100 years ago and that most of the dry forest biome has now been reduced to scattered fragments.

Mangroves

Mangroves, a group of unrelated tree species occupying sites within the bounds of high and low tides (Simberloff 1983), fringe many salt and brackish water ecosystems in tropical and subtropical regions. Information on the status of mangrove forests is even more sparse than that for upland forests, but all indications suggest these forests are declining due to pollution, unrestricted collection of firewood and timber, and coastal development (Christensen 1983, Leonard 1987). For example, country environmental profiles summarized in Leonard (1987) indicate that <10% of the original mangrove forests remain in Guatemala, and that mangroves have been significantly reduced in Costa Rica (half of original mangroves harvested), Panama, and El Salvador. Overall, mangroves do not provide primary winter habitat for many migratory land birds, but they are important in certain regions and for certain species (see below).

Pine Forest

Pine and mixed pine-hardwood forests occur naturally in scattered regions throughout northern Central America, Mexico, and the Caribbean and have been introduced for plantation harvesting as far south as Ecuador (e.g., Garrison and Pita 1992). Many migrants associated with conifers during the breeding season also overwinter in pine-dominated habitats (see below). Pine forests have not been depleted to the same extent as broadleaved forests because pines are fast-growing and more easily managed than tropical broadleaved trees. Indeed, fire control and management schemes have allowed commercial production to expand dramatically in recent years, while still maintaining relatively constant acreage (e.g., see references in Leonard 1987; also see Salazar 1990). A proportion of these stands representing mature and old growth forest, however, appears to be declining due to accelerated harvesting schedules (Leonard 1987).

Future Scenario For Tropical Forests

Projections of tropical broadleaved forest resources surviving into the first several decades of the 21st century are dismal, but clearly dependent upon the level of conservation and management initiated by individuals, corporations, and governments during the next decade (e.g., Myers 1979, Janzen 1986, Gradwohl and Greenberg 1988, Wilson 1988). Currently, approximately half the area is capable of sustaining broadleaved forests in the neotropics actually supports closed-canopy forest, but most of this is in the Amazon Basin (Myers 1980, 1991; Mahar 1989). Most deforested land has been converted to permanent pasture and agricultural land, each comprising approximately 10-30% of the area in most Central American countries (Leonard 1987:Table A.33). Many surviving closed forests are not old-growth, but represent advanced secondary forests that probably have not yet reached their former levels of biological diversity and ecological function (Opler et al. 1977, Mabberley 1992). Moist forests in Latin America and the Caribbean as a whole are being destroyed at a rate of approximately 0.5-1.0% per annum (Lanly 1982, Grainger 1983). However, deforestation is nearly three times higher within the area encompassing the winter ranges of most migratory species (Mexico to Colombia). Caribbean islands already have been so extensively altered that little natural forest remains to be cut (Myers 1980, Lugo 1990, McElroy et al. 1990, Arendt 1992).

The following scenario of the probable fate of forested neotropical biomes is based upon a compendium of published data and projections of conservation biologists. It assumes that current rates of deforestation will not be substantially reduced in the near future (Simberloff 1986). By the early 21st century, once-forested neotropical landscapes will mostly be a mosaic of agricultural lands, cattle pastures, and secondary forests in various stages of regeneration (Terborgh 1980, Melillo et al. 1985, Janzen 1986). In all regions except Amazonia, extensive tracts of primary or advanced secondary forest will probably be restricted mainly to national parks and reserves, as in present-day Costa Rica (Stiles 1985, Sader and Joyce 1988). In much of Mesoamerica and the Caribbean, forests will be reduced to disturbed, isolated fragments that occur predominantly at higher elevations (Rappole et al. 1983, Rubinoff 1983, Janzen 1986). The Brazilian Amazon will contain the bulk of the remaining undisturbed moist forest in the New World Tropics (Myers 1980, Lanly 1982). Mangrove and other wetland ecosystems will also be degraded, but to what extent is difficult to predict. Although the extent of upland pine forests may remain essentially unchanged, intensified timber management is likely to cause major changes in age structure and floristic composition. Management-oriented forestry, including agroforestry, is projected to be integrated into many forest ecosystems in the ensuing decades (National Research Council 1982, Anderson 1990, Kiernan et al. 1992). Estimations of extinctions of tropical flora and fauna due to this rapid conversion of forested landscapes to "agroscapes" (sensu Janzen 1986) range from catastrophic to relatively mild (Simberloff 1986, Raven 1988, Wilson 1988). How might these dramatic changes in landscape composition affect migratory landbirds? To begin to address that question, we need to critically examine habitat use, survival, and behavioral ecology of migrants during the overwinter period and then place this information into the context of widespread removal of primary tropical forests.

HABITAT AND GEOGRAPHIC DISTRIBUTION OF MIGRANTS IN THE NEOTROPICS

Conventional wisdom holds that migratory landbirds in the neotropics are most abundant (1) at higher tropical latitudes and (2) in disturbed habitats, such as secondary growth and edges (Karr 1976, Terborgh 1980, Willis 1980). A third generality, that overwintering migrants occur disproportionately at middle elevations (1000-2500 m), has also received some support during the past 30 years (Karr 1976; for review, see Terborgh 1980). Research conducted in the past 15 years allows a more quantitative assessments of these and other generalizations. Furthermore, application of information on general patterns of habitat use by target species groups can help conservationists identify areas and habitats that warrant special protection (Margules and Usher 1981, Diamond 1985).

We compiled data from nearly 50 studies (>300 study sites) to identify those habitats and regions in the tropics supporting the greatest numbers of migratory birds during winter. Only reports that met the following criteria were included in analyses: (1) study was conducted largely or entirely during the winter period (as opposed to autumn or spring migration); (2) sites were located between the Tropics of Capricorn and Cancer, with the exception of one study located in southern Florida and the Bahamas; (3) data on habitat use were gathered through a scientifically acceptable procedure, such as visual/auditory surveys or mist-netting (simple species lists based upon informal surveys were not included); and (4) data were collected within defined individual vegetation types (survey results pooled over several habitats were not acceptable). Several types of information were extracted from each study: (1) percent of individuals surveyed that were North American migrants; (2) percent of species surveyed that were migrants; and (3) total number of migratory species detected. Because all three of those variables were significantly correlated (percent individuals vs. percent species, Spearman's $r = 0.83$; percent individuals vs. number of species, $r = 0.55$; percent species vs. number of species, $r = 0.64$; $P < 0.0001$) and exhibited similar trends in our analyses below, only results based upon numbers of migratory species detected will be presented. Habitat, topographic and geographic information were taken from descriptions provided by each author or from other relevant sources. Environmental data were grouped in broad categories for statistical analyses (Table 1). Analysis of variance (or Kruskal-Wallis test) was used to detect statistically significant

Table 1. — Habitat and geographical information used in analyses of migrant distribution in the neotropics.

Variable	Category	Description
HABITAT TYPE	Moist forest	Semi-evergreen to evergreen forests >10 m tall in regions generally receiving >150 cm rain/yr. Examples include wet, moist, montane, and cloud forests.
	Dry forest	Semi-evergreen to deciduous forests > 5-10 m tall in regions generally receiving <150 cm rain/yr with a pronounced dry season. Examples include dry, oak, and sclerophyll, as well as arid limestone, forests.
	Pine forest	Habitats dominated by coniferous trees. Examples include pine and pine-oak-fir forests and pine-savanna.
	Scrub	Early successional or naturally-occurring broadleaved habitats <5-8 m tall. Examples include early successional dry and moist forests, thornscrub, and savanna-scrub.
	Open	Natural or human-altered habitats low in stature with few woody plants. Examples include open field, pasture, coastal dunes, marsh, and savanna.
	Artificial	Vegetation types heavily altered for agricultural or residential uses, but with vegetation >4 m tall. Examples include urban areas/parks and citrus or coffee plantations.
HABITAT HEIGHT	<5 m 6 - 10 m 11 - 20 m >20 m	
DISTURBANCE	Disturbed	Moderate to heavy disturbance. Examples of disturbances include logging, fragmentation, agriculture, residential, and clearing of forest understory.
	Undisturbed	Very slight to nonexistent disturbance.
ELEVATION	≤200 m 201 - 500 m 501 - 1000 m 1001 - 2000 m >2000 m	
INSULARIZATION	Mainland Island	
LATITUDE	≤5° N 6 - 15° N 16 - 25° N >25° N	

(P) differences in distribution of migrants across gradients or categories of the environmental variables. Below, we present a synopsis of those results; more details can be found in Petit et al. (unpubl. ms.).

Habitat Type

On average, migratory species richness reached its peak in residential and agricultural habitats (fig. 1A). Those artificial habitats supported approximately 50% more species than vegetation types dominated by natural woody vegetation associations and more than twice the number of species found in open areas, such as pastures and grasslands. These analyses support the belief that more migratory species overwinter in disturbed than in undisturbed, vegetation types (Karr 1976, Terborgh 1980). However, no habitat association exhibited a highly depauperate migratory bird assemblage, which indicates that migrants as a group use a broad array of vegetation types during winter (see Lynch 1992).

Habitat Height

More species per study were observed in habitats of intermediate height (5-20 m) than in habitats of shorter or taller stature (fig. 1B). Because many habitat types attain heights of 5-20 m, this analysis cannot directly equate habitat heights with particular vegetation types. However, these data suggest that most migrants avoid tall, moist forests, the only habitat that

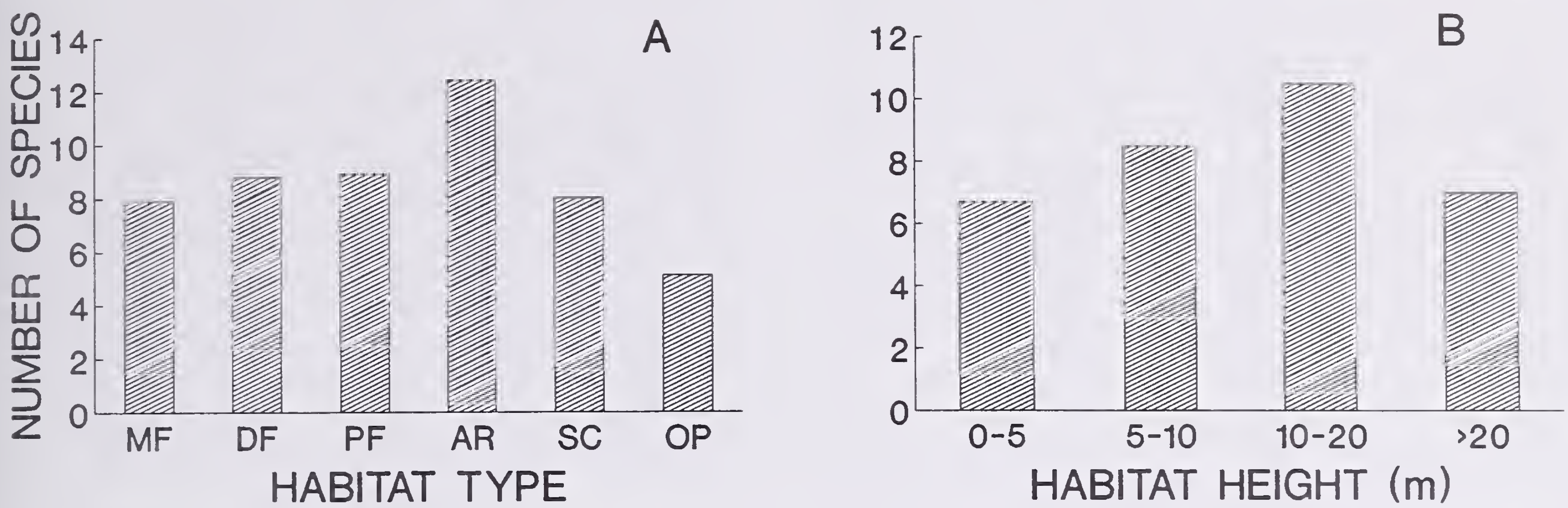


Figure 1. — Average number of migratory species detected per study plot (A) for different habitat types and (B) across habitats of various canopy heights. MF = moist (wet) forest; DF = dry forest; PF = pine forest; AR = artificial habitats, such as urban parks, residential areas, and citrus groves; SC = scrub or early second-growth; and OP = open habitats, such as grassland and pasture. See text and Table 1 for details.

typically exceeds 20 m in height. This interpretation is supported by the fact that migrants were twice as abundant in shorter (≤20), regenerating moist forest plots (average of 13 species detected) than in mature forests (6 species).

Disturbance Level

The number of migratory species was greatest in disturbed habitats (fig. 2A). Because this result could reflect use of artificial habitats (all of which are classified as disturbed) as opposed to disturbed natural forest, we examined the effect of disturbance within each forested vegetation type. Disturbed moist and dry forests supported 100% and 37% more species (respectively) than their undisturbed counterparts, although this difference was not statistically significant for dry forests. Disturbance level did not greatly influence use of pine forests by migratory birds as a group.

In general, then, more migratory species at a given site occur in disturbed habitats than in natural vegetation types, confirming patterns recognized by Karr (1976), Terborgh (1980) and many ornithologists before them. However, our analyses show that natural forests also support a diverse assemblage of migrants. Moreover, not all types of disturbance provide suitable habitat for migratory birds. Most migratory birds require that some woody vegetation persists, often in the form of canopy or subcanopy trees (Saab and Petit 1992). One exception appears to be citrus groves, where migratory bird abundance and richness can sometimes exceed that of most other nearby habitats (Mills and Rogers 1992, Robbins et al. 1992).

Elevation

Migrants were under-represented at elevations above ca. 500 m (fig. 2B), contradicting the previously cited generalization that migrants prefer middle elevations (Leck 1972a, Karr 1976). Even within a given forest type, lowland sites supported at least as many, and usually more, species as did higher elevations.

Insularization

Migratory bird assemblages were nearly twice as species-rich on continental sites compared with island habitats (fig. 3A), contrary to patterns described by Leck (1972b) and Karr (1976). Migratory birds comprised similar proportions (individuals and species) of the total avifauna on islands and the mainland (Petit et al., unpubl. ms.), but this result was due to a latitudinal effect (see below) associated with the fact that most Caribbean islands are located at more northerly latitudes within the tropics. The relative paucity of migrants within habitats on islands may be due to increased energetic costs and mortality risks associated with flying long distances over unsuitable (water) habitat in search of relatively small land masses (Moreau 1972, Terborgh and Faaborg 1980).

Latitude

The number of migratory species detected per study reached its peak between 16° N and 25° N (northern Central America and southern Mexico), which was twice the number of species present in southern Central America and South America (fig. 3B; also see

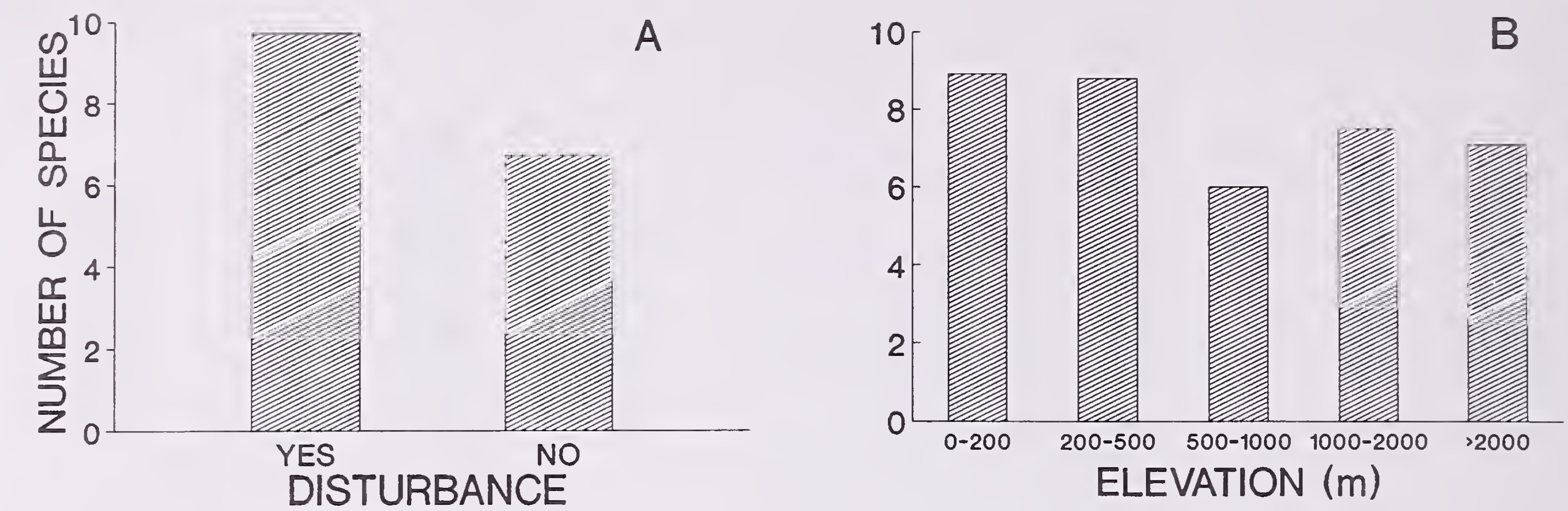


Figure 2. — Average number of migratory species detected per study plot that varied in (A) level of disturbance and (B) elevation. See text and Table 1 for details.

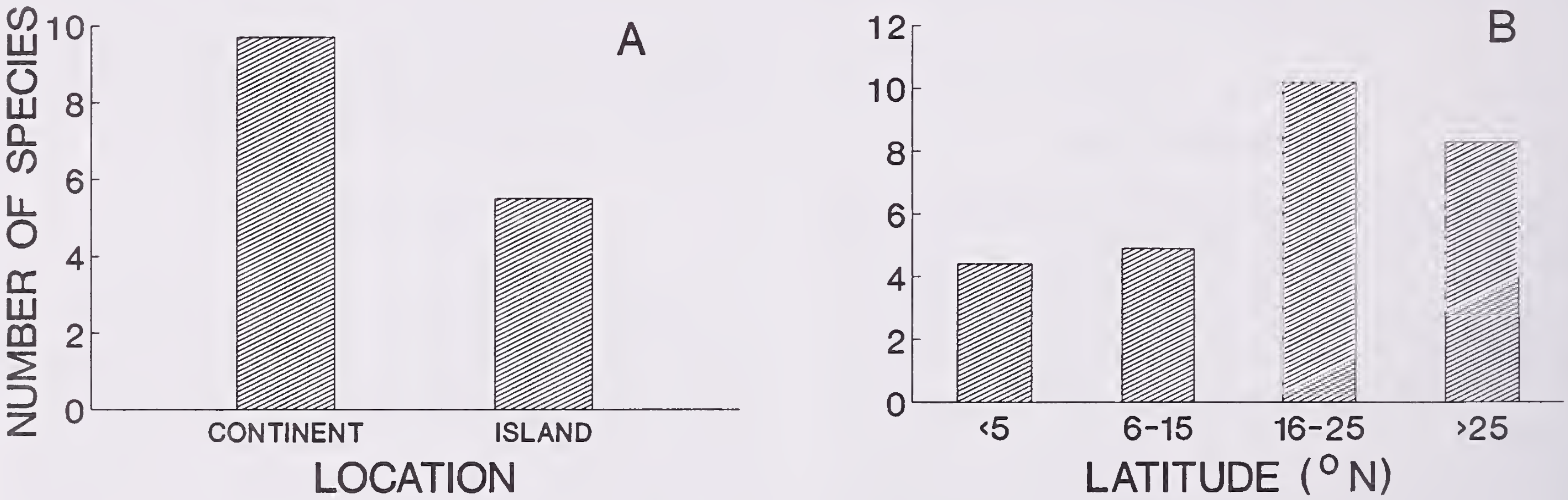


Figure 3. — Average number of migratory species detected per study plot on (A) islands vs. mainland sites and (B) at different latitudes. See text and Table 1 for details.

Rappole et al. 1983). Again, this distribution may reflect costs and risks of migration (Greenberg 1980, Terborgh and Faaborg 1980).

MOIST AND DRY FORESTS: TWO THREATENED TROPICAL ASSOCIATIONS

Taken together, the above analyses suggest that the greatest number of migratory species are found in disturbed, low elevation habitats at high tropical latitudes in Mexico and northern Central America. These geographic and ecological patterns may provide general preliminary guidelines for identification of important habitat for migratory birds as a group. However, we recognize that bird-habitat relationships are both complex and species-specific. Identification of the most appropriate potential reserves, for example, may be best served by considering each area on a site-by-site basis and by taking into account individual species of particular interest. Moreover, not all habitats that support migrants are of primary interest to conservation biologists because some represent habitats (e.g., early successional growth, plantations) that are being created, not threatened, by forest conversion. However, several forest associations are of special importance to conservation efforts in the neotropics. Here, we examine ecological correlates of migratory bird use of moist and dry forest associations using the data set outlined above.

The most widely-recognized formations of moist (including wet) tropical forest are based upon Holdridge's (1947) Life Zone concept as they relate to elevation (also see Whitmore 1991). Here, we consider four broad categories of moist forest: coastal (<200 m), lowland evergreen (200-500 m), lower montane (500-2000; includes premontane), and upper montane (2000 m) forests. Coastal forests were distinguished from lowland evergreen forests because of often higher human populations along coastlines compared to more upland areas (e.g., Myers 1980:150, Janzen 1986). Because the level of forest disturbance was related to habitat occupancy by neotropical migrants (see above), disturbed and undisturbed sites were examined separately.

In disturbed moist forests, numbers of migratory species showed a weak (nonsignificant) tendency to decline with elevation. Migratory birds in undisturbed moist forests, on the other hand, showed a significant decline in number of species across the elevational gradient. Undisturbed coastal and lowland evergreen forests contained 35% and 125% (respectively) more migratory species than undisturbed, montane (>500 m) forests. Upper montane (cloud) forests supported fewest migratory species in both disturbed and undisturbed forests. In nearly all moist forest associations, disturbed sites supported more migratory species than more pristine sites. Thus, migrants as a group appear to prefer lowland (<500 m) evergreen forests to montane forests, but this relationship is weaker where forests are disturbed. Migrants may increase use of habitats along an elevational gradient in response to slight or moderate levels of forest perturbation if disturbances enhance suitability of wet forests for those species (Petit 1991).

Although the general pattern of moist forest use suggests disturbed and lowland forests support the greatest number of migratory bird species, all moist forest associations were used by migrants. Information on body condition (e.g., fat scores) and overwinter survival rates are necessary to gain better insight into suitability of each forest association, but moist tropical forest clearly represents an important habitat for overwintering migrants. On average, eight migratory species were detected within each plot of evergreen forest (fig. 1A), representing about one-fifth the total winter bird community on those sites (Petit et al., unpubl. ms.). Moreover, disturbed and undisturbed mature, evergreen forests are principal winter habitats for >40 migratory species (Petit et al., unpubl. ms.; see below). In summary, despite the fact that migrant diversity tends to be highest in disturbed forests, conservation of many migratory species, in addition to hundreds of species of resident tropical species, is dependent upon preservation of undisturbed moist evergreen forests.

Dry forests contained similar numbers of migratory species as found in moist forests, although migrants comprised a larger proportion of the local avifauna in dry forests (Petit et al., unpubl. ms.). Disturbance may have an important effect on numbers of migrants occupying dry forests, as disturbed sites contained nearly 60% more species than undisturbed sites. However, this trend was not statistically significant. More migratory species were detected on plots situated within coastal and lowland dry forests (average of 9.5 species) than in upland forests (8 species), but the difference was not significant. Migrants were significantly more abundant in taller (>10 m) dry forests and on mainland sites.

Dry forests represent an important habitat for migrants during winter, especially at more northerly latitudes. Little is known about use of dry forest habitats in South America by migrants (Bosque and Lentino 1987. Because the Pacific slope of Mexico and Central America is comprised largely of dry forest associations and because a large proportion of species that breed in western North America overwinter there (Hutto 1980, Terborgh 1980), retention of dry forest is especially important for migratory bird conservation. Additionally, dry forest associations are significant for species overwintering on the Yucatan Peninsula (Lynch 1989) and Caribbean islands (Arendt 1992).

MIGRANTS MOST LIKELY TO BE IMPACTED BY TROPICAL DEFORESTATION

Analysis of overall patterns of habitat use by migrants on a regional or continental level is important in determining those habitats and geographic locations that support the greatest number of individuals and species, an especially critical need during the initial stages of identification and development of prospective biological reserves (Diamond 1986, Jenkins 1988). This type of conservation plan, similar to both gap analysis (Burley 1988) and the "coarse filter" approach to species management (Noss 1987a), is aimed at maximizing the number of species that gain protection, while minimizing acreage to be acquired. However, equally important is assessment of habitat needs of individual species to identify those migrants that may not be adequately protected under a general management plan. Furthermore, interpreting observed population declines of migrants requires a firm understanding of year-round ecologies of those species. Habitat-dependent factors (e.g., probability of nest predation or survival) during both breeding and nonbreeding seasons are thought to be the root causes of those declines (Aldrich and Robbins 1970, Terborgh 1980, Greenberg 1986). Not surprisingly, obtaining quantitative information on habitat association of neotropical migrants is frequently cited as a primary research priority by conservation biologists (Rappole et al. 1983, Hutto 1989, Lynch 1989, Blake and Loiselle 1992).

Abundant qualitative information exists on winter habitat use by neotropical migrants, but summarizing those data is difficult because of the divergent goals of each study as well as different ways in which data were collected, presented, and interpreted. We summarized this information in a quantitative, objective manner by extracting data from the literature and

Table 2. — Projected vulnerability of neotropical migratory landbirds to anthropogenic alteration of tropical, broadleaved forests. See Appendix A for details.

HIGHLY VULNERABLE

Chuck-will's-widow (*Caprimulgus carolinensis*)	Worm-eating Warbler (*Helmitheros vermivorus*)
Olive-sided Flycatcher (*Contopus borealis*)	Swainson's Warbler (*Limnothlypis swainsonii*)
Western Wood-Pewee (*Contopus sordidulus*)	Northern Waterthrush (*Seiurus noveboracensis*)
Veery (*Catharus fuscescens*)	Louisiana Waterthrush (*Seiurus motacilla*)
Blackburnian Warbler (*Dendroica fusca*)	Kentucky Warbler (*Oporomis formosus*)
Blackpoll Warbler (*Dendroica striata*)	Scarlet Tanager (*Piranga olivacea*)

VULNERABLE BUT TOLERANCE TO SLIGHT DISTURBANCE

Whip-poor-will (*Caprimulgus vociferus*)	Golden-winged Warbler (*Vermivora chrysoptera*)
Yellow-bellied Flycatcher (*Empidonax flaviventris*)	Chestnut-sided Warbler (*Dendroica pensylvanica*)
Great Crested Flycatcher (*Myiarchus crinitus*)	Bay-breasted Warbler (*Dendroica castanea*)
Wood Thrush (*Hylocichla mustelina*)	Cerulean Warbler (*Dendroica cerulea*)
White-eyed Vireo (*Vireo griseus*)	Prothonotary Warbler (*Protonotaria citrea*)
Yellow-throated Vireo (*Vireo flavifrons*)	

VULNERABLE BUT OCCUPY SITES OF MODERATE DISTURBANCE

Black-billed Cuckoo (*Coccyzus erythropthalamus*)	Northern Parula (*Parula americana*)
Yellow-billed Cuckoo (*Coccyzus americanus*)	Magnolia Warbler (*Dendroica magnolia*)
Broad-tailed Hummingbird (*Selasphorus platycercus*)	Black-throated Blue Warbler (*Dendroica caerulescens*)
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	Black-throated Gray Warbler (*Dendroica nigrescens*)
Eastern Wood-Pewee (*Contopus virens*)	Townsend's Warbler (*Dendroica townsendi*)
Acadian Flycatcher (*Empidonax virescens*)	Hermit Warbler (*Dendroica occidentalis*)
Willow Flycatcher (*Empidonax traillii*)	Black-throated Green Warbler (*Dendroica virens*)
Least Flycatcher (*Empidonax minimus*)	Black-and-white Warbler (*Mniotilta varia*)
Hammond's Flycatcher (*Empidonax hammondii*)	American Redstart (*Setophaga ruticilla*)
Gray Flycatcher (*Empidonax wrightii*)	Ovenbird (*Seiurus aurocapillus*)
Western Kingbird (*Tyrannus verticalis*)	Connecticut Warbler (*Oporornis agilis*)
Blue-gray Gnatcatcher (*Polioptila caerulea*)	MacGillivray's Warbler (*Oporornis tolmiei*)
Gray-cheeked Thrush (*Catharus minimus*)	Hooded Warbler (*Wilsonia citrina*)
Swainson's Thrush (*Catharus ustulatus*)	Wilson's Warbler (*Wilsonia pusilla*)
Solitary Vireo (*Vireo solitarius*)	Canada Warbler (*Wilsonia canadensis*)
Warbling Vireo (*Vireo gilvus*)	Yellow-breasted Chat (*Icteria virens*)
Blue-winged Warbler (*Vermivora pinus*)	Black-headed Grosbeak (*Pheucticus melanocephalus*)
Virginia's Warbler (*Vermivora virginiae*)	Hooded Oriole (*Icterus spurius*)
Lucy's Warbler (*Vermivora luciae*)	

applying it to an index which estimates vulnerability of a species to population decline due to alteration of tropical forest. Derivation of this index is outlined in Appendix A. It is important to keep in mind this vulnerability index is based upon only one of several factors (Rabinowitz et al. 1986) that could influence a species' susceptibility to extinction.

Of 123 migratory species considered, 23 (19%) were mainly restricted to undisturbed broadleaved forests during winter (top two sections of Table 2). These species should be most sensitive to forest alteration. Thirty-seven additional species (30%) were often associated with forested habitats, although they also used certain types of disturbed vegetation (e.g., tree crops, forest openings, fragmented forest; Table 2). That migratory birds utilize broadleaved forests during winter is not surprising, but this analysis provides direction as to which species are likely to be highly impacted by forest conversion, and suggests that at least 19% of migratory landbirds fall into that category. In fact, the 23 species most closely-tied to broadleaved forests (Table 2) possibly have already been affected by current levels of deforestation. Those 23 species exhibited average population declines >8 times that estimated for the 37 species less dependent upon close-canopied forests (1978-1988 population data taken from Sauer and Droege 1992). Furthermore, this trend is independent of nesting habitat (log-likelihood ratio test; $\underline{G}$ =

1.21, $\underline{P} > 0.50$). This last point is important because migrants that overwinter in broadleaved forests also tend to breed in forests in temperate areas, thereby confounding attempts to separate events during these two seasons (also see Robbins et al. 1989b, Sauer and Droege 1992). Our list of species in greatest danger of undergoing dramatic population changes should be considered conservative because only 123 of the approximately 200 species of neotropical migrant landbirds were considered in the above analysis. Furthermore, we incorporated only one aspect of the ecology of species (habitat use) that makes them vulnerable to extinction. Certainly, our inventory will expand when information on relative global population sizes and geographic winter ranges are incorporated (Rabinowitz et al. 1986, Kattan 1992, Reed 1992).

Many alarming predictions have been made (mostly in the popular and semi-technical literature) about the ultimate effect of tropical deforestation on migratory bird populations. Those assessments may well prove to be correct, but at the same time they often are not based on rigorous application of available scientific literature (also see perspectives of Hutto 1988). Several excellent overviews of migrant vulnerability to tropical forest conversion have been published and species lists derived from those studies correspond reasonably well with what we have produced (for example, see Rappole et al. 1983, Diamond 1991). Because these sensitive species exhibit varied responses to available habitat types, ecologies of individual species need to be embodied within future conservation plans. Finally, our list of species, like others, is based upon multiple assumptions and incomplete data; it is therefore open to further research and revision.

SUMMARY OF HABITAT USE

Data presented here are general and preliminary because most analyses considered only one or two habitat and geographic variables. Relative importance of each factor must be considered in the context of all other variables. These analyses, however, do provide an indication of use of different tropical habitats by migratory birds.

Clearly, all tropical habitats contained some migratory birds. Disturbed habitats, whether natural (e.g., regenerating or selectively logged wet forest) or unnatural (citrus plantation), supported the greatest number of migratory species. However, caution must be used when relating relative abundance of organisms to suitability because local high densities could reflect highly rigid dominance relationships and distributions based upon relative suitability of habitats (e.g., Van Horne 1981). For example, are young birds or females forced into suboptimal, disturbed habitats, where they overwinter in high densities relative to undisturbed forest (see below)? If so, mere distributions of individuals across habitat types does not give an accurate picture of relative suitabilities of those habitats, or indeed of habitat "preference" patterns. Information on physical condition of individuals, along with survival, is necessary to accurately assess value of each habitat to migrants (Holmes et al. 1989).

On the other hand, distributions of individuals among habitats may indeed provide a reliable indication of relative suitabilities of those vegetation types (Orians and Wittenberger 1991). For example, physical condition (Greenberg 1992) and survival rates (estimated indirectly through recapture rates; Rappole and Warner 1980, Robbins et al. 1987, Blake and Loiselle 1992) are not necessarily improved in undisturbed forests relative to disturbed forests (but, see Rappole et al. 1989). If the classical interpretation that habitat use reflects habitat suitability is, in fact, approximately correct, then our results and those of others suggest that migratory birds as a group are not being adversely affected by at least some current land use practices in Latin America and the Carribean. The task for future researchers is to determine how much disturbance (and in what form) can a tropical forest withstand and still be suitable as winter habitat for neotropical migrants (also see Lynch 1992).

DEVELOPMENT OF EFFECTIVE MANAGEMENT AND CONSERVATION PLANS: LIMITATIONS OF GENERALIZATIONS ABOUT MIGRANT HABITAT USE

Limitations in funding and control over land use force resource managers and conservation biologists to strive for management plans that maximize number of species and individuals protected. While we recognize that habitat requirements and population biology of each species are unique, there is nevertheless a practical need to develop useful generalizations about the requirements necessary for survival of migrant birds in the neotropics. Above, we attempted to categorize preferred habitats of migrants as a group, as well as requirements for individual species dependent upon broadleaved forests. Even at the species level, however, broad management plans may be difficult to formulate due to variation in winter habitat use exhibited by different individuals and populations. Habitat models must be applied cautiously for wildlife species across their North America ranges (Bart et al. 1984, Stauffer and Best 1986), and this concern may hold for wintering grounds as well. Thus, unrecognized intraspecific variation in habitat use and life history traits can lead to dysfunctional management guidelines. Below, we briefly discuss three sources of variation in winter habitat use critical for conservation of migratory bird populations.

Geographic Variation in Habitat Use

Some disagreement among avian ecologists about habitat requirements of certain migrant species in the tropics probably reflects geographic variation in habitat use (Greenberg 1986,

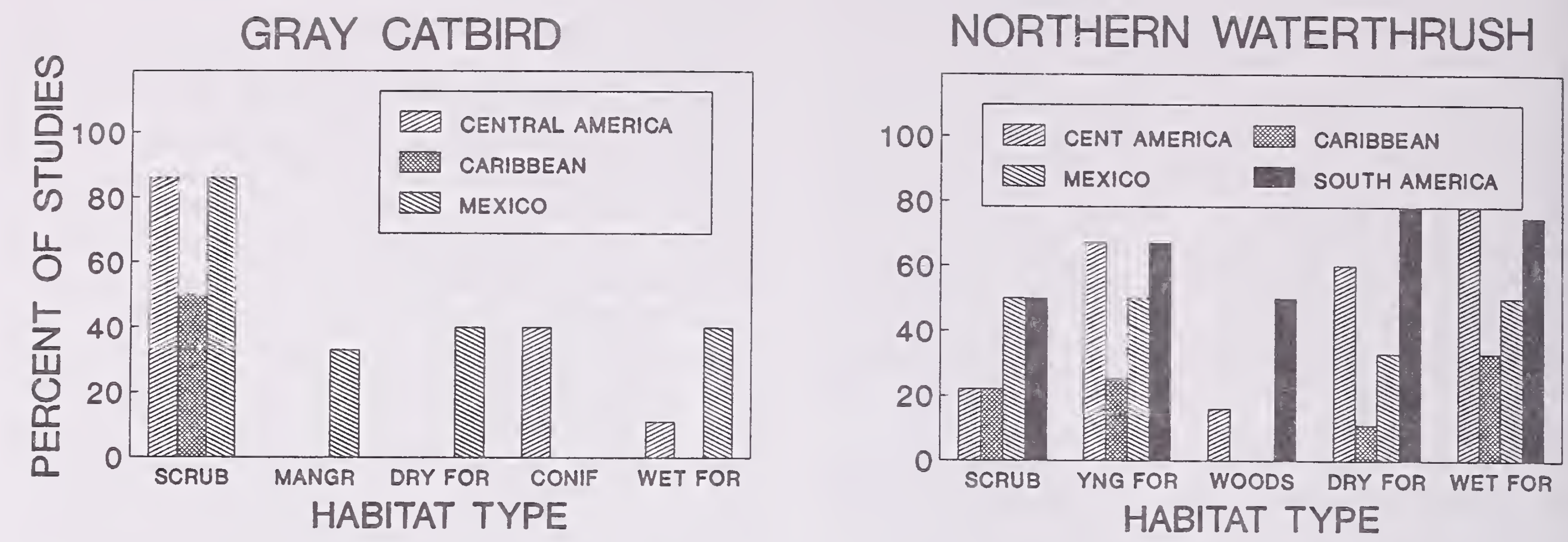


Figure 4. — Geographic variation in habitat use by Gray Catbirds and Northern Waterthrush. The ordinate represents the number of studies in which a species was found to occur in a given habitat type divided by the number of studies in which each species *could* have occurred in that habitat. See Appendix A for details.

Martin 1992, Morton 1992). For example, Gray Catbirds (*Dumetella carolinensis*) and Northern Waterthrushes (scientific names of some species are listed in Table 2) exhibit pronounced regional differences in habitat use (fig. 4). This may result from either disparate availability of habitats, regional differences in preference for certain habitat types, or a combination of both. Black-throated Green Warblers are commonly found in pine stands in northern Central America and on Caribbean islands, but occupy broadleaved forest associations in eastern Mexico and southern Central America, where pines are scarce (this study). This interpretation is complicated, however, by the fact that Black-throated Green Warblers at the edge of their winter range in western Mexico prefer montane broadleaved forest even though mixed-pine forests are present at similar elevations (Hutto 1992). Louisiana and Northern waterthrushes provide additional examples of how availability of a given habitat type in a region might influence habitat use. In continental areas, waterthrushes generally do not occupy residential areas during winter, but on densely-populated and developed Caribbean islands (compare Leonard 1987:Table A.2 with McElroy et al. 1990:Table 21.1) they use gardens as secondary habitats (this study; also see Arendt 1992).

Geographic variability in habitat preferences also may indicate either localization of different subspecies (see Ramos and Warner 1980) that respond to distinct habitat cues, or a manifestation of selective pressures that vary regionally. For example, geographic differences in habitat use could reflect differences in (1) assemblages of competing species (e.g., Bennett 1980, Keast 1980), (2) characteristics of the food base supported by vegetation associations (Janzen 1973), (3) predation pressure (Buskirk 1976) or other factors. Comparative studies of habitat use, and factors affecting that use, are needed to help determine the ecological basis of geographic variation in habitat occupancy. For the migratory bird community as a whole, certain habitats are of high regional importance, e.g., mangroves in the Caribbean and cloud forests in western Mexico and South America (fig. 5). Whether geographic differences in habitat use reflect variation in these factors, or others (e.g., population density, climate), is unknown. However, for present conservation efforts, the mechanism for geographic shifts may be less important than knowledge of their mere existence. Geographic variation in habitat use by individual species and

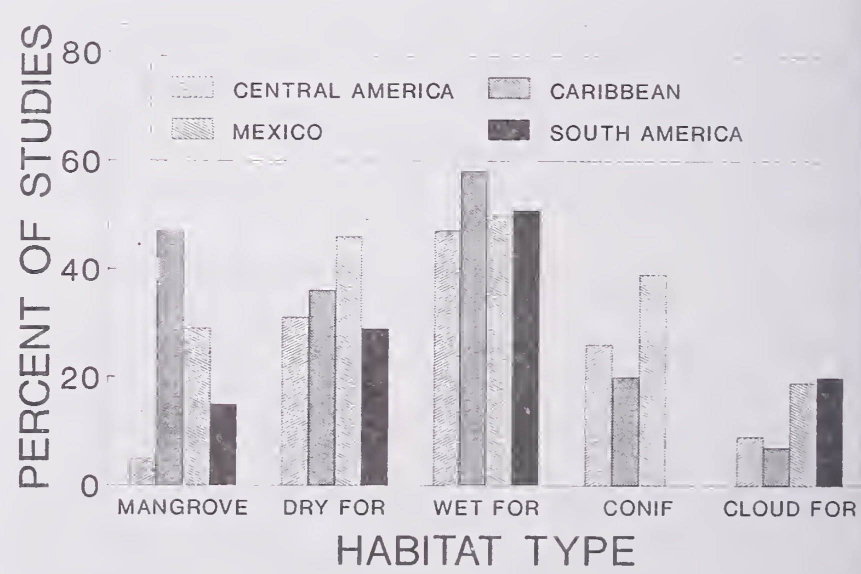


Figure 5. — Example of geographic variation in habitat use by migratory birds. The ordinate represents the number of studies in which a species was found to occur in a given habitat type divided by the number of studies in which each species *could* have occurred in that habitat, summed over all migratory species. See Appendix A for details.

regional assemblages may dictate a more localized (i.e., region-specific) approach to designing conservation plans for migratory birds in the tropics.

Sex- and Age-Specific Habitat Use

Habitat use by some migrants varies by sex, such that overall habitat distribution of a species reflects the combined, unique preferences of each sex. Lynch et al. (1985) showed that male and female Hooded Warblers in the Yucatan region differed in selection of winter habitat: males tended to occur in relatively tall, closed-canopy forest, while females were most often found in old-fields, native coastal scrub, treefall gaps, and other disturbed, low-stature vegetation. Sex-specific habitat selection has subsequently been documented for about 10 other migratory parulines (Lopez Ornat and Greenberg 1990, Wunderle 1992) and, in most cases, males occur at higher than expected frequencies in more mature habitats. Age-related exclusion of some individuals from certain habitats also may occur on wintering grounds, although evidence is sparse. In Belize, young (≥2 yr) male American Redstarts occupied habitats intermediate between those of females and older (>2 yr) males (Petit and Petit, unpubl. data). Pearson (1980) described a possible latitudinal gradient of age classes for overwintering Summer Tanagers *(Piranga rubra)*.

Sex- and age-specific habitat use has important ramifications for conservation of neotropical migrants. First, partitioning of winter habitats could lead to differential, habitat-based mortality rates either due to intrinsic factors or to more extensive loss of certain habitats than others. The resulting skewed sex-ratios would reduce the effective size of breeding populations and could dramatically enhance probability of local extirpation or extinction (Shaffer 1981). Second, placement of reserves must incorporate potential sex-based dichotomies in habitat use by assuring that appropriate habitat for both sexes is adequately represented. Finally, if innate or dominance-based habitat use is manifested in distinct geographic winter ranges for sex or age classes (e.g., Ketterson and Nolan 1983), then development of protected reserves or application of appropriate land use practices must be implemented throughout entire winter ranges of species.

Habitat Use During Migration

Migration to and from tropical areas is energetically stressful (Blem 1980) and mortality during this period may substantially limit size of breeding populations (Moore et al. 1990). Species use of available habitats during migration is largely unknown (but see Parnell 1969), especially in the tropics. Generally, though, migrants appear to be highly plastic (sensu Morse 1971) in their use of habitats during migration. Because migration habitats overlap extensively with winter habitats for many species, conservation of winter habitats may be an appropriate means of preserving vegetation types occupied during migration. However, there are certain situations where special consideration may need to be directed towards habitat requirements of migrants during migration. First, forest patches and other vegetation associations along coastal areas may represent significant habitats for birds initially arriving to a land mass after having flown over a large body of water (the same argument holds for birds preparing to leave a land mass). Migratory birds often are stressed after such flights and require rapid replenishing of fat reserves (Moore and Kerlinger 1987, Moore et al. 1990). Access to fresh water may be equally important.

Second, forested corridors (MacClintock et al. 1977, Noss 1987b) may be especially useful landscape components for birds during migration. Although the value of corridors to migrating birds is unknown, strips of remnant vegetation connecting larger patches are thought to be directly related to persistence of populations that make widespread movements throughout their annual cycle, such as migratory birds (e.g., Saunders 1990). Furthermore, some migrants wander extensively even during mid-winter in the neotropics (often associated with frugivorous habits) and those individuals may suffer higher mortality than sedentary counterparts (Rappole et al. 1989). Thus, corridors could be an effective management tool for both migrating and overwintering migratory birds (as well as for resident species; Loiselle and Blake 1991). The migratory period needs special consideration in design and placement of tropical reserves, as well as identifying agricultural, forestry, and other land uses that provide adequate habitats for birds in migration.

FINE FILTERS AND CONSERVATION OF RESTRICTED SPECIES AND HABITATS

Most migratory species overwinter in various types and seral stages of broadleaved forest (see above) and, therefore, conservation efforts clearly need to be directed towards those widespread habitats. However, whereas a "coarse-filter" approach is designed to protect the majority of the target fauna in a region, "fine-filter" management practices are aimed at catching those species that passed through the coarse filter because of special habitat or ecological requirements (Noss 1987a). Restricted habitats or ecosystems especially sensitive to anthropogenic disturbances need to be considered in migratory bird conservation efforts because several of those habitats, specifically mangrove swamps and pine forests, are pivotal in the winter ecologies of certain migrants.

Mangroves are declining due to unrestricted collection of firewood, pollution, and development along coastal areas (e.g., Leonard 1987). In general, mangroves are not a primary habitat for migrants, but within certain regions, particularly the Caribbean, mangroves provide important winter habitats for migratory birds. For example, several parulines, such as American Redstart, Louisiana Waterthrush, Ovenbird and

Black-and-white, Hooded and Magnolia warblers, use mangroves extensively on Caribbean islands, but are found much less commonly in such swamps in Central and South America. Thus, mangroves may provide an important alternative forested habitat in areas where deforestation has claimed much of the native upland vegetation. Sustenance of regional overwintering populations could be important in maintaining the diversity of species' gene pools (e.g., Franklin 1980), as well as the regional breeding populations in North America (Ramos and Warner 1980, Atwood 1992). Furthermore, mangrove forest is a principal habitat for at least three long-distance migrants (Prothonotary and Swainson's warblers and Northern Waterthrush) throughout those species' wintering ranges. Maintenance of mangrove ecosystems requires determined intervention by national governments.

More than a dozen species of migratory birds rely heavily on pine-dominated forests as a principal habitat during winter (Petit et al., unpubl. ms.). Pine forests, including pine-savanna and pine-oak woodlands, constitute widely-dispersed habitats in Mexico, northern Central America, and the Caribbean. Given the patchy nature of pine forests and the value of the pine resources to national economies, special attention needs to be devoted to this vegetation type to ensure that forests remain not only sustainable, but also ecologically viable for wildlife, including migratory birds. For instance, prescribed burning is often used to control broadleaved understory and reduce fuel loads in pine stands (Salazar 1990). However, loss of broadleaved understory causes a severe reduction in quality of those sites for most migratory and resident birds (D.R. Petit, unpubl. data). Wildlife management principles need to be incorporated into the rotational and management schemes of tropical pine forests (sensu Harris 1984).

Another important component of the fine-filter approach is identification of species with restricted geographic ranges, as those species may be highly susceptible to extinction due to isolated, local events (Rabinowitz et al. 1986). Migratory species that have extremely limited winter ranges, for example Black-capped Vireo (*Vireo atricapillus*), and Kirtland's (*Dendroica kirtlandii*), Swainson's, and Mourning (*Oporornis philadelphia*) warblers, are likely to be overlooked in broad, multinational attempts to develop parks and reserves.

EFFECTS OF LAND USE PRACTICES ON MIGRATORY BIRD HABITAT

The fate of tropical ecosystems ultimately lies in ability of governments and local tropical communities, as well as economists, sociologists, biologists, and other professionals, to identify, devise and implement land use practices that provide an increasing standard of living for citizens, while at the same time preserving viable populations of diverse flora and fauna. These two goals should be central issues for all groups mentioned above. Use or conversion of natural vegetation associations in the tropics as it relates to impacts on native flora and fauna can be placed under one of three broad categories: "conservative", "sustainable", and "destructive". These classifications are not discrete, but rather represent overlapping regions along a continuum from preservation to decimation of natural ecosystems (a continuum can also be envisioned for short- or long-term economic development). Below we discuss examples of each type of land use and how they might affect migratory birds. We then place land-use into the context of the conservation goals outlined above. Because cutting of tropical forests for alternative land uses necessarily leads to fragmentation of forest biomes, we begin this section with a brief overview of impacts of forest fragmentation on neotropical migratory birds during winter.

Effects of Forest Fragmentation on Migrants

Extensive research in North America has shown that presence of migratory birds breeding in temperate forests is intricately related to tract size (Whitcomb et al. 1981, Lynch and Whigham 1984, Blake and Karr 1987, Robbins et al. 1989a). Similar information on effects of insularization in Latin America, however, is meager. Fragmentation and isolation of tropical broadleaved forests have pronounced biological ramifications not only for plants and animals that are directly displaced, but also for individuals that remain after isolation. For example, the microclimate of fragments can be substantially altered within several hundred meters of edges, such that a concomitant change in plant species often results, which, in turn, is partly responsible for redistribution or local extinction of the fauna inhabiting the forest island (e.g., Lovejoy et al. 1984, Williams-Linera 1990, Laurance 1991, Laurance and Yensen 1991, Saunders et al. 1991). Forest fragments do not contain as many resident tropical bird species as contiguous tracts during either the breeding or nonbreeding season (Terborgh 1974, Willis 1979, Robbins et al. 1987). Most long-distance migrants, however, do not appear to exhibit such pronounced sensitivity to reduced forest area during the boreal winter (Robbins et al. 1987). In fact, many migrants that are area-sensitive on the breeding grounds show no such relationship, or are found at higher densities in forest remnants than in larger tracts, during winter (Robbins et al. 1987, 1992; Askins et al. 1992). These few studies support our previous conclusions that migrants as a group are most abundant in disturbed and fragmented habitats (see above). Despite the apparent lack of fragmentation effects on most migratory birds, so few data have been collected that results must be viewed as strictly preliminary. Indeed, several migratory species have exhibited disproportionate use of large forest tracts in the neotropics (Robbins et al. 1987) and some migratory species identified as highly susceptible to forest disturbance (Table 2) may also prove sensitive to the area of forest tracts.

"Conservative" Land Use Practices

All things being equal, preservation of extensive tracts of native vegetation would be the most acceptable conservation practice for many conservation biologists. In reality, socioeconomic considerations are often of overriding priority, such that limitations are placed on the extent of pristine ecosystems that can be protected from anthropogenic disturbances. Examples of conservative land use practices are well-known throughout the world, under the form of Biosphere Reserves, Wilderness Areas, National Parks, and World Heritage Sites. A system of such reserves is thought to play a critical role in the long-term preservation of tropical diversity (e.g., Rubinoff 1983, Wilson and Peter 1988, Cornelius 1991).

The concept of nature reserves also is highly compatible with conservation of migratory birds. As outlined above, several dozen migratory species occupy tropical broadleaved forests during winter (also see Petit et al., unpubl. ms.) and those most reliant upon undisturbed forests will be particularly susceptible to severe population declines in the future. Because tropical landscapes will undergo increased deforestation in coming decades, protected natural areas is one important approach for maintaining numbers of forest-dwelling, migratory birds, as well as resident species.

"Sustainable" Land Use Practices

The future economies and natural resources of Latin America are believed to rest upon the concept of "sustainable development", defined as "economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). This definition, as applied to forests, explicitly or implicitly identifies three components of sustainable development: competitive productivity, renewability of resources, and maintenance of ecological diversity (Maini 1992). Contained within the bounds of sustainable development are a myriad of land use practices which vary in their regard for "maintenance of ecological diversity". For example "extractive reserves" (Fearnside 1989) allow indigenous communities to remove certain highly-renewable products (e.g., Brazil nuts, rubber latex, medicinal plants, and fruits) from the reserve, but prohibit alteration of the natural structure or function of the forest. Clearly, this type of plan, if implemented properly, would provide suitable habitat for many species. At the other end of the continuum are certain types of "agroforestry" (von Maydell et al. 1982), in which native overstory trees are replaced with exotic species and understories are stripped clean by grazing cattle (e.g., Combe 1982). Despite substantial variation in the quality of "sustainable" lands for migratory birds (and other wildlife), some forms of sustainable development are relatively benign from the viewpoint of migratory bird conservation. Here, we outline several examples of sustainable development projects that take into account preservation of wildlife and appear to be compatible with survival of many migratory bird species.

One of the most promising forestry practices in the neotropics appears to be strip clearcutting (Hartshorn 1990, Ocana-Vidal 1992). This method of managing natural forests, conceived by the Tropical Science Center of Costa Rica, is designed to harvest wood from long (100-500 m), narrow (30-50 m) strips through forest. The width of a strip is meant to mimic natural treefall gaps, thereby allowing natural regeneration to occur rapidly. Several strips are harvested each year and cuts made in successive years are at least 100 m apart. The projected rotation period is currently set at 30-50 years. By reducing the area of each strip, detrimental effects associated with logging, such as erosion and alteration of local microclimate, are minimized. Extraction of logs is made with the aid of oxen to reduce disturbance and soil compaction. This design is similar in concept to that proposed by Harris (1984), whereby a certain proportion of a given tract remains in mature forest and areas in similar stages of regeneration are overdispersed. Few neotropical migrants that utilize forested habitats during winter appear to avoid sites that have undergone such small-scale disturbances (see above and Petit et al., unpubl. ms.). In fact, many forest-dwelling migrants are more common along forest edges than interior (Petit et al. 1992). Because strip clearcutting results in no net loss of forest cover and is economically beneficial to rural communities, it may prove to be an important forest management technique in the future.

A number of demonstration projects are currently underway evaluating economic feasibility of selective logging in rural communities as well as new approaches to minimize impacts of cutting and extraction of trees (e.g., Kiernan et al. 1992). Selective logging of highly marketable timber has been practiced in the neotropics for >200 years. However, in many instances, large national or multinational corporations have extracted timber, and little profit remains to be distributed among local landowners. One recent approach has been to form cooperatives, whereby local landowners pool their resources and make informed decisions (often with the aid of government and foreign consultants) about which and how many trees to harvest in a given year. In this way, local people derive the bulk of the economic benefit. Even extraction of single trees from tropical forests often results in major collateral damage to surrounding forest. Recently, though, harvesting practices have been implemented to reduce this extraneous damage and enhance value of sustainable forests (Dykstra and Heinrich 1992, Kiernan et al. 1992). Formation of cooperatives and implementation of environmentally-sound harvesting techniques has several implications for conservation of migratory birds. First, because income derived from cooperatives improves the local standard of living, fewer demands should be placed on surrounding forests. Second, reduced environmental damage from logging operations keeps the structural and microclimatic environment of the forest interior relatively intact.

Clearly, the more closely agroecosystems mimic natural vegetation associations the more suitable those systems are for forest-dependent wildlife. Many types of agroforestry strategies provide habitat for migratory birds. For example, Mayan cultures have incorporated concepts of sustainable forestry into their "forest gardens" for centuries (Alcorn 1990). These small plots of land surrounding family dwellings are comprised of native trees and shrubs that produce fruit, wood, nuts, and other products for sustaining the local community (Gomez-Pompa and Kaus 1990). Scattered among these woody plants are small patches of annual crops (e.g., corn, beans). There also may be regular management of nearby moist forest. Here, some undesirable trees are selectively removed to allow certain species to mature or fruit at faster rates (Anderson 1990, Gomez-Pompa 1991). Another form of agroecosystem that is widespread throughout the New World Tropics consists of low-stature tree crops (e.g., cacao, coffee) cultured under a canopy of shade trees (an unfortunate trend in recent years is to grow these crops without shade trees). Shifting-cultivation, one major cause of conversion of tropical forests, can be considered a form of sustainable development provided the proportion of landscape farmed at any one time is relatively small (Uhl et al. 1990). Shifting-cultivation realizes its greatest potential as a type of sustainable use when local farmers are able to incorporate sound management practices, thereby increasing the productive life of a plot and decreasing the pressure on surrounding forest. However, when population pressure results in shorter fallow periods and a higher proportion of the landscape being cultivated, the neutral or beneficial effects of shifting cultivation tend to become negative. These small-scale systems mentioned often result in more open, disturbed forests, habitats that support many species of migratory birds (see above).

Agroforestry is often manifested as a combination of cattle and overstory trees (for shade or timber) or trees crops, such as Citrus (Combe 1982, Shane 1986). These forms of land use are detrimental to many migratory species (e.g., forest specialists), but do have potential to provide habitat for certain neotropical migrants, depending mainly on the extent and complexity of woody cover that is maintained (Lynch 1989, Saab and Petit 1992). Incorporation of agroforestry practices into pasture development could provide a viable alternative to barren pasture, due to economic benefits to landowners and to use of these habitats by wildlife.

"Destructive" Land Use Practices

Destructive types of land use by definition provide few bird species with suitable habitat. Heavily-grazed pasture with few trees or shrubs is perhaps the most conspicuous form of tropical land use that is not readily occupied by migratory birds (Karr 1976, Saab and Petit 1992). Likewise, active rice (Robbins et al. 1992), corn, and bean fields probably support few species of migrants. Extensive monocultures, such as banana plantations (Stiles and Skutch 1989, Robbins et al. 1992) appear also to be avoided by migrants. Most migratory birds using these agricultural lands are habitat generalists (e.g., Yellow-rumped Warbler [*Dendroica coronata*]) or are characteristic of highly-disturbed vegetation types (e.g., Common Yellowthroat [*Geothlypis trichas*], Indigo Bunting [*Passerina cyanea*]) in their wintering areas. Suitable winter habitat is not presently limited for such species. Citrus monocultures, however, have been reported to contain extremely dense concentrations of migrants, including some species considered to be typical of forested habitats (Mills and Rogers 1992, Robbins et al. 1992).

Conversion of native vegetation to pasture and some types of non-woody monocultures, such as cash crops, are clearly the most imminent threats to wildlife in the neotropics. We have noted throughout this paper the potential detrimental impacts of tropical agriculture and cattle industries on forest-dwelling migratory birds. However, with increasing land area being devoted to cash crops and pasture, patches of second growth, which harbor large numbers of migratory birds, are also likely to be increasingly converted to those land uses. Thus, although our immediate concern for forest-dwelling species (Table 2) is clearly justified, we cannot discount the future threat that may face the dozens of migratory species that occur mainly in disturbed second growth in wintering areas (L.J. Petit, pers. comm.).

GUIDELINES FOR CONSERVATION OF MIGRATORY BIRDS IN THE NEOTROPICS

Several measures need to be enacted within all Latin American and Caribbean countries to ensure that viability of migratory bird populations is not threatened by events in wintering areas. These include: (1) assessment and monitoring of bird populations in different habitats; (2) identification of both present and future threats to migrants; (3) incorporating sustainable development into land use planning; (4) identification of critical areas and habitats needed for protection of migratory birds; and (5) development of a system of protected reserves based upon firm biological and sociological foundations.

Assessment and Monitoring

We presented a broad overview of winter habitat use by migratory birds. However, because of scant data and the great geographic variability in habitat use exhibited by many species, this preliminary assessment must be viewed with caution. Indeed, the validity of applying general information presented here to specific local field situations is dubious. What is needed is a comprehensive, quantitative survey of migrant habitat use in each of the major physiographic regions (or life zones) of each country. Within each such region, many potential habitats (e.g., different seral stages) should be assessed for their suitability (occupation) for each species. These data are already available for certain regions of some countries (e.g., Yucatan Peninsula and high-elevation life zones of western Mexico). The product of these efforts would be an abundance-weighted habitat and geographic analysis of the winter distributions of migratory birds, a central component necessary to build a conservation strategy for migratory birds in the neotropics (Greenberg 1986).

To assess habitat use and changes in long-term abundances of migratory birds, we recommend surveys based upon point counts (Hutto et al. 1986). The exact method needs to be worked out, but would probably require distinguishing individuals that are both within and beyond some threshold distance from the observer (see Hutto et al. 1986). Mist-netting could be used to supplement visual/auditory surveys and may provide important information about habitat-based survival rates. However, because of biases associated with mist-netting, comprehensive visual/auditory surveys should also be conducted in all regions.

Long-term monitoring of populations also would provide information on the temporal stability of habitat associations during winter and the relative importance of certain habitats as refugia for migrants during "bottleneck" (sensu Wiens 1977) years. For example, during drought years migrants may be unable to find sufficient food in some habitats, such as dry forests, and be forced to relocate to moister habitats (Faaborg et al. 1984). In this case, the benefit of access to moist forest in sustaining long-term populations is clear, although in most years moist forests may contain relatively few individuals.

Identification of Present and Future Threats

An important component of species conservation is identification of potential future sources of anthropogenically-induced mortality. To this end, broad-scale threats other than outright habitat destruction have been recognized by Rappole and co-workers (1983), who concluded that pollution (including pesticides) is an imminent problem. For example, migrants may face serious problems because of lax regulations on pesticide application in many developing countries (see references in Rappole et al. [1983]). Because some migratory birds occur in high densities in agricultural areas (see above), ecologists need to assess detrimental effects of pesticide ingestion on birds. Some areas where migrants presently abound may prove to be "ecological traps", where induced mortality is higher than in "preferred" habitats. Direct exploitation (e.g., for food or for the pet trade) and other sources of human-induced mortality are minor problems for most neotropical migrant landbirds.

A system needs to be implemented in Latin American and Caribbean countries that allows monitoring of point sources of pollution, areas that are undergoing unrestricted deforestation, and certain "development" projects that may threaten important areas or ecosystems. For example, the social and economic pressures in many developing countries lead to cutting of government-controlled forests by squatters for subsistence farming, who then apply (often successfully) to the government for ownership rights to that "developed" land. An effective system for monitoring illegal encroachment on forest and enforcing existing laws might greatly reduce conversion of pristine forests, but socioeconomic conditions that drive this type of forest cutting (Hough 1988, Gow 1992) have to be rectified before monitoring and enforcement can be fully effective. More responsible land use practices, however, may be the most effective means of conserving limited natural resources and promoting conservation of overwintering migratory birds.

The Need for Sustainable Development

Economists, ecologists, and conservationists need to stress the potential importance and compatibility of certain sustainable land uses and wildlife populations. However, few detailed research projects have focussed on the relationship between sustainable forestry or agroforestry and bird populations. Such information is necessary before definitive conservation plans can be drafted for regional or local use within the neotropics. Nevertheless, in principal, sustainable land uses offer the most promising alternatives for long-term stability of tropical economies and wildlife populations. An important area of future tropical research for avian ecologists is to determine relative benefits and costs of different modes of sustainable forestry. Furthermore, as agricultural lands expand throughout Latin America, wildlife management practices (e.g., maintenance of hedgerows and woodlots; Gradwohl and Greenberg 1991) need to be incorporated into landscape planning. It is also important to note that, while the current conservation emphasis is on forest-associated species, development of permanent pasture and agricultural plots consumes both mature forest and early second-growth. Thus, the current conservation status of nonforest birds could easily be reversed as disturbed second-growth areas are converted to permanent agriculture.

Identification of Sensitive Areas and Ecosystems and Development of a System of Protected Reserves

Increasing the frequency and accuracy of forest and land inventories would improve our ability to monitor the current status of natural ecosystems. Those data could be used to identify habitats and geographic areas in greatest need of conservation. Little biological basis exists for the current placement of many national parks and reserves in the neotropics, and political and economic considerations often determine where parks are located. As a result, key habitats in certain areas may be overlooked, with potentially disastrous effects on threatened species. As outlined above, national land inventories along with information on distribution of migrants among regions and habitats could provide the necessary insight into identification of the most appropriate locations for reserves. Moist and dry forests are clearly the associations most threatened by forest conversion. Protected areas should be dispersed among life zones in each region, not necessarily concentrated in the extensive tracts remaining in highlands. A useful approach to planning of tropical forest reserves is that devised by The Nature Conservancy: attempt to have all ecosystems represented within a region. This approach is believed to secure habitat for 80-90% of the species in temperate regions (Noss 1987a). Fine-filter (see above) guidelines could then be established to identify any unique species and habitats not adequately protected by a comprehensive reserve system. Although a system of reserves may be most easily accomplished <u>within</u> countries because of complications of multinational cooperation, long-term stability would be enhanced by coordination and integration of all planning and placement of national reserves into an overall Latin American network. Realistically, we must recognize the political "clout" of migratory land birds is very limited within Latin America and the Caribbean, except insofar as migratory bird issues can be used to attract outside resources into the region. A comprehensive, regional approach to conservation and land-use planning will, however, tend to improve long-term prospects for overwintering migrants, even if the impetus for such planning derives from the preservation of "local" resident (i.e., nonmigratory) birds and other wildlife.

CONCLUSIONS

The most imminent threat to migratory landbirds in the neotropics is destruction of forest ecosystems. Most migratory species appear tolerant of light-to-moderate levels of landscape alteration, and many may actually prefer disturbed sites to pristine vegetation. However, at least a dozen species of migratory landbirds are strongly associated with relatively undisturbed tracts of forest; these species may require individual attention in any regional conservation strategy. The long-term economic and sociological stability of Latin America is dependent upon rapid development and implementation of sustainable land use practices; rates of deforestation apparently have not slowed appreciably in recent years, and it is probable that little undisturbed forest will remain outside the Amazon Basin after several more decades of cutting and burning. Because neotropical migrants as a group are substantially more tolerant of forest disruption and artificial environments than are resident species, conservation of migrants could be accomplished within comprehensive conservation plans devised for resident bird species. The latter strategy will be more attractive to local people than a strategy that unduly emphasizes the welfare of what are commonly regarded as "North American" species. Perhaps our conservation strategy for overwintering migratory birds should focus on increasing the welfare of rural human populations, while simultaneously preserving habitats for resident wildlife species. If these twin efforts are successful, preservation of neotropical migrants on the wintering grounds will follow as a matter of course.

ACKNOWLEDGMENTS

K.E. Petit, L.J. Petit, K.G. Smith, and J. Withgott offered useful comments on the manuscript, and C. Paine provided helpful views on the vulnerability index. Petit's participation was supported by a grant from the U.S. EPA's Environmental Monitoring and Assessment Program to T.E. Martin.

LITERATURE CITED

ALCORN, J. B. 1990. Indigenous agroforestry strategies meeting farmers' needs. Pp. 141-151 <u>in</u> Alternatives to deforestation: steps toward sustainable use of the Amazon rain forest (A.B. Anderson, Ed.). New York, Columbia Univ. Press.

ALDRICH, J. W., & C. S. ROBBINS. 1970. Changing abundance of migratory birds in North America. Pp. 17-26 <u>in</u> The avifauna of northern Latin America (H.K. Buechner and J.H. Buechner, Eds.). Washington, D.C., Smithsonian Inst. Press.

ANDERSON, A. B. (Ed.). 1990. Alternatives to deforestation: steps toward sustainable use of the Amazon rain forest. New York, Columbia Univ. Press.

ARENDT, W. J. 1992. Status of North American migrant landbirds in the Caribbean region: a summary. Pp. 143-174 <u>in</u> Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

ASCHER, W., & A. HUBBARD (Eds.). 1989. Central American recovery and development: Task Force report to the International Commission for Central American Recovery and Development. Durham, North Carolina, Duke Univ. Press.

ASKINS, R. A., D. N. EWERT, & R. L. NORTON. 1992. Abundance of wintering migrants in fragmented and continuous forests in the U.S. Virgin Islands. Pp. 197-206 <u>in</u> Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

ATWOOD, J. L. 1992. Inferred destinations of spring migrant Common Yellowthroats based on plumage and morphology. Pp. 377-383 <u>in</u> Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

BART, J., D. R. PETIT, & G. LINSCOMBE. 1984. Field evaluation of two models developed following the habitat evaluations procedures. Trans. 49th N. Am. Wildl. Nat. Resour. Conf. 49:489-499.

BENNETT, S. E. 1980. Interspecific competition and the niche of the American Redstart (*Setophaga ruticilla*) in wintering and breeding communities. Pp. 319-335 <u>in</u> Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

BLAKE, J. G., & J. R. KARR. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68:1724-1734.

_____, & B. A. LOISELLE. 1992. Habitat use by neotropical migrants at La Selva Biological Station and Braulio Carrillo National Park, Costa Rica. Pp. 257-272 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

BLEM, C. R. 1980. The energetics of migration. Pp. 175-224 in Animal migration, orientation, and navigation (S.A. Gauthreaux, Ed.). New York, Academic.

BOSQUE, C., & M. LENTINO. 1987. The passage of North American migratory land birds through xerophytic habitats of the western coast of Venezuela. Biotropica 19:267-273.

BROWN, S., & A. E. LUGO. 1982. The storage and production of organic matter in tropical forests and their role in the global carbon cycle. Biotropica 14:161-187.

BURLEY, W. F. 1988. Monitoring biological diversity for setting priorities in conservation. Pp. 227-230 in Biodiversity (E.O. Wilson and F.M. Peter, Eds.). Washington, D.C., National Academy Press.

BUSKIRK, W. H. 1976. Social systems in a tropical forest avifauna. Am. Nat. 110:293-310.

CANADIAN MINISTER OF THE ENVIRONMENT. 1983. Guidelines for wildlife policy in Canada. Ottawa, Minister of the Environment.

CHRISTENSEN, B. 1983. Mangroves -- what are they worth? Unasylva 34:2-15.

COMBE, J. 1982. Agroforestry techniques in tropical countries: potential and limitations. Agroforestry Systems 1:13-27.

CORNELIUS, S. E. 1991. Wildlife conservation in Central America: will it survive the 90's? Trans. 56th N. Am. Wildl. Nat. Resour. Conf. 56:40-49.

DIAMOND, A. W. 1985. The selection of critical areas and current conservation efforts in tropical forest birds. Pp. 33-48 in Conservation of tropical forest birds (A.W. Diamond and T.E. Lovejoy, Eds.). ICBP Tech. Publ. No. 4.

_____. 1991. Assessment of the risks from tropical deforestation to Canadian songbirds. Trans. 56th N. Am. Wildl. Nat. Resour. Conf. 56:177-194.

DIAMOND, J. 1986. The design of a nature reserve system for Indonesian New Guinea. Pp. 485-503 in Conservation biology: the science of scarcity and diversity (M. E. Soule, Ed.). Sunderland, Massachesetts, Sinauer Associates.

DYKSTRA, D. P., & R. HEINRICH. 1992. Sustaining tropical forests through environmentally sound harvesting practices. Unasylva 43:9-15.

FAABORG, J., W. J. ARENDT, & M. S. KAISER. 1984. Rainfall correlates of bird population fluctuations in a Puerto Rican dry forest: a nine year study. Wilson Bull. 96:575-593.

FEARNSIDE, P. M. 1989. Extractive reserves in Brazilian Amazonia. BioScience 39:387-393.

FRANKLIN, I. R. 1980. Evolutionary change in small populations. Pp. 135-149 in Conservation biology: an evolutionary-ecological perspective (M.E. Soule and B.A. Wilcox, Eds.). Sunderland, Massachusetts, Sinauer Associates.

GARRISON, M., & M. PITA. 1992. An evaluation of silvopastoral systems in pine plantations in the central highlands of Ecuador. Agroforestry Systems 18:1-16.

GOMEZ-POMPA, A. 1991. Learning from traditional ecological knowledge: insights from Mayan silviculture. Pp. 335-341 in Rain forest regeneration and management (A. Gomez-Pompa, T.C. Whitmore, and M. Hadley, Eds.). Man and the Biosphere Series, No. 6. Paris, UNESCO.

GOMEZ-POMPA, A., & A. KAUS. 1990. Traditional management of tropical forests in Mexico. Pp. 45-64 in Alternatives to deforestation: steps toward sustainable use of the Amazon rain forest (A.B. Anderson, Ed.). New York, Columbia Univ. Press.

GOW, D. D. 1992. Forestry for sustainable development: the social dimension. Unasylva 43:41-45.

GRADWOHL, J., & R. GREENBERG. 1988. Saving the tropical forests. Washington, D.C., Island Press.

_____, & _____. 1991. Small forest reserves: making the best of a bad situation. Climatic Change 18:253-256.

GRAINGER, A. 1983. Improving the monitoring of deforestation in the humid tropics. Pp. 387-395 in Tropical rain forest: ecology and management (S.L. Sutton, T.C. Whitmore, and A.C. Chadwick, Eds.). Oxford, U.K., Blackwell.

GREENBERG, R. 1980. Demographic aspects of long-distance migration. Pp. 493-504 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____. 1986. Competition in migrant birds in the nonbreeding season. Current Ornithol. 3:281-307.

_____. 1992. Forest migrants in non-forest habitats on the Yucatan Peninsula. Pp. 13-22 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

HAMILTON, L. S. 1991. Tropical forests: identifying and clarifying issues. Unasylva 42:19-27.

HARRIS, L. D. 1984. The fragmented forest. Chicago, Univ. Chicago Press.

HARTSHORN, G. S. 1990. Natural forest management by the Yanesha Forestry Cooperative in Peruvian Amazonia. Pp. 128-138 in Alternatives to deforestation: steps toward sustainable use of the Amazon rain forest (A.B. Anderson, Ed.). New York, Columbia Univ. Press.

_____. 1992. Forest loss and future options in Central America. Pp. 13-22 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

HOLDRIDGE, L. R. 1947. Determination of world plant formations from simple climatic data. Science 105:367-368.

_____. 1970. Natural vegetation and reservation prospects in northern Latin America. Pp. 27-33 in The avifauna of northern Latin America (H.K. Buechner and J.H. Buechner, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____, W. GRENKE, W. HATHEWAY, T. LIANG, & J. TOSI. 1971. Forest environments in tropical life zones: a pilot study. Elmsford, New York, Pergamon.

HOLMES, R. T., T. W. SHERRY, & L. REITSMA. 1989. Population structure, territoriality and overwinter survival of two migrant warbler species in Jamaica. Condor 91:545-561.

HUTTO, R. L. 1980. Winter habitat distribution of migratory land birds in western Mexico with special reference to small, foliage-gleaning insectivores. Pp. 181-204 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____. 1988. Is tropical deforestation responsible for the reported declines in neotropical migrant populations? Am. Birds 42:375-379.

_____. 1989. The effect of habitat alteration on migratory land birds in a west Mexican tropical deciduous forest: a conservation perspective. Conserv. Biol. 3:138-148.

_____. 1992. Habitat distributions of migratory landbird species in western Mexico. Pp. 211-239 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____, S. M. PLETSCHET, & P. HENDRICKS. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593-602.

HOUGH, J. L. 1988. Obstacles to effective management of conflicts between national parks and surrounding human communities in developing countries. Environ. Conserv. 15:129-136.

JANZEN, D. H. 1973. Sweep samples of tropical foliage insects: effects of seasons, vegetation types, elevation, time of day, and insularity. Ecology 54:687-708.

_____. 1986. The future of tropical ecology. Ann. Rev. Ecol. Syst. 17:305-324.

_____. 1988. Tropical dry forests: the most endangered major tropical ecosystem. Pp. 130-137 in Biodiversity (E.O. Wilson and F.M. Peter, Eds.). Washington, D.C., National Academy Press.

JENKINS, R. E. 1988. Information management for the conservation of biodiversity. Pp. 231-239 in Biodiversity (E.O. Wilson and F.M. Peter, Eds.). Washington, D.C., National Academy Press.

KARR, J. R. 1976. On the relative abundance of migrants from the north temperate zone in tropical habitats. Wilson Bull. 88:433-458.

KATTAN, G. H. 1992. Rarity and vulnerability: the birds of the Cordillera Central of Colombia. Conserv. Biol. 6:64-70.

KEAST, A. 1980. Spatial relationships between migratory parulid warblers and their ecological counterparts in the neotropics. Pp. 109-130 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

KETTERSON, E. D., & V. NOLAN, JR. 1983. The evolution of differential bird migration. Current Ornithol. 1:357-402.

KIERNAN, M., M. PERL, D. MCCAFFREY, R. J. BUSCHBACHER, & G. BATMANIAN. 1992. Pilot natural forest management initiatives in Latin America: lessons and opportunities. Unasylva 43:16-23.

LAND, H. C. 1970. Birds of Guatemala. Wynnewood, Pennsylvania, Livingston.

LANLY, J. P. 1982. Tropical forest resources. Forestry Paper No. 30. Rome, Food and Agriculture Organization.

LAURANCE, W. F. 1991. Edge effects in tropical forest fragments: application of a model for the design of nature reserves. Biol. Conserv. 57:205-219.

_____, & E. YENSEN. 1991. Predicting the impacts of edge effects in fragmented habitats. Biol. Conserv. 55:77-92.

LECK, C. F. 1972a. The impact of some North American migrants at fruiting trees in Panama. Auk 89:842-850.

_____. 1972b. Observations of birds at *Cecropia* trees in Puerto Rico. Wilson Bull. 84:498-500.

LEONARD, H. J. 1987. Natural resources and economic development in Central America: a regional environmental profile. New Brunswick, New Jersey, Transaction Books.

LOISELLE, B. A., & J. G. BLAKE. 1991. Temporal variation in birds and fruits along an elevational gradient in Costa Rica. Ecology 72:180-193.

LOPEZ ORNAT, A., & R. GREENBERG. 1990. Sexual segregation by habitat in migratory warblers in Quintana Roo, Mexico. Auk 107:539-543.

LOVEJOY, T. E., R. O. BIERREGAARD, K. S. BROWN, L. H. EMMONS, & M. E. VAN DER VOORT. 1984. Ecosystem decay of Amazon forest fragments. Pp. 295-325 in Extinctions (M.H. Niteki, Ed.). Chicago, Univ. Chicago Press.

LUGO, A. E. 1990. Development, forestry, and environmental quality in the eastern Caribbean. Pp. 317-342 in Sustainable development and environmental management of small islands (W. Beller, P. d'Ayala, and P. Hein, Eds.). Man and the Biosphere Series, Volume 5. Paris, UNESCO.

LYNCH, J. F. 1989. Distribution of overwintering nearctic migrants in the Yucatan Peninsula, I: general patterns of occurrence. Condor 91:515-544.

_____. 1992. Distribution of overwintering nearctic migrants in the Yucatan Peninsula, II: use of native and human-modified vegetation. Pp. 178-196 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____, E. S. MORTON, & M. E. VAN DER VOORT. 1985. Habitat segregation between the sexes of wintering Hooded Warblers (Wilsonia citrina). Auk 102:714-721.

_____, & D. F. WHIGHAM. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. Biol. Conserv. 28:287-324.

MABBERLEY, D. J. 1992. Tropical rain forest ecology. New York, Chapman and Hall.
MACCLINTOCK, L., R. F. WHITCOMB, & B. L. WHITCOMB. 1977. Island biogeography and "habitat islands" of eastern forest. II. Evidence of the value of corridors and minimization of isolation in preservation of biotic diversity. Am. Birds 31:6-16.
MAHAR, D. J. 1989. Government policies and deforestation in Brazil's Amazon region. Washington, D.C., The World Bank.
MAINI, J. S. 1992. Sustainable development of forests. Unasylva 43:3-8.
MARGULES, C., & M. B. USHER. 1981. Criteria used in assessing wildlife conservation potential: a review. Biol. Conserv. 21:79-109.
MARTIN, T. E. 1992. Breeding productivity considerations: what are the appropriate habitat features for management? Pp. 455-473 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.
MCELROY, J. L., B. POTTER, & E. TOWLE. 1990. Challenges for sustainable development in small Caribbean islands. Pp. 299-316 in Sustainable development and environmental management of small islands (W. Beller, P. d'Ayala, and P. Hein, Eds.). Man and the Biosphere Series, Volume 5. Paris, UNESCO.
MELILLO, J. M., C. A. PALM, R. A. HOUGHTON, G. M. WOODWELL, & N. MYERS. 1985. A comparison of two recent estimates of disturbance in tropical forests. Environ. Conserv. 12:37-40.
MILLS, E. D., & D. T. ROGERS, JR. 1992. Ratios of neotropical migrants and neotropical resident birds in winter in a citrus plantation in central Belize. J. Field Ornithol. 63:109-116.
MOORE, F. R., & P. KERLINGER. 1987. Stopover and fat deposition by North American wood-warblers (Parulinae) following spring migration over the Gulf of Mexico. Oecologia 74:47-54.
_____, _____, & T. R. SIMONS. 1990. Stopover on a gulf coast barrier island by spring trans-gulf migrants. Wilson Bull. 102:487-500.
MOREAU, R. E. 1972. The Palaearctic-African bird migration systems. New York, Academic.
MORSE, D. H. 1971. The insectivorous bird as an adaptive strategy. Ann. Rev. Ecol. Syst. 2:177-200.
_____. 1980. Population limitation: breeding or wintering grounds? Pp. 505-516 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.
MORTON, E. S. 1992. What do we know about the future of migrant landbirds? Pp. 579-589 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.
MURPHY, P. G., & A. E. LUGO. 1986. Ecology of tropical dry forest. Ann. Rev. Ecol. Syst. 17:67-88.
MYERS, N. 1979. The sinking ark: a new look at the problem of disappearing species. Oxford, U.K., Pergamon.
_____. 1980. Conversion of tropical moist forests. Washington, D.C., National Academy of Sciences.
_____. 1981. Deforestation in the tropics: who gains, who loses? Pp. 1-21 in Where have all the flowers gone?: deforestation in the Third World (V.H. Sutlive, N. Altshuler, and M.D. Zamora, Eds.). Williamsburg, Virginia, College of William and Mary.
_____. 1987. Population, environment, and conflict. Environ. Cons. 14:15-22.
_____. 1991. Tropical forests: present status and future outlook. Climatic Change 19:3-32.
NATIONAL RESEARCH COUNCIL. 1982. Ecological aspects of development in the humid tropics. Washington, D.C., National Academy Press.
NOSS, R. F. 1987a. From plant communities to landscapes in conservation inventories: a look at the Nature Conservancy (USA). Biol. Conserv. 41:11-37.
_____. 1987b. Corridors in real landscapes: a reply to Simberloff and Cox. Conserv. Biol. 1:159-164.
OCANA-VIDAL, J. 1992. Natural forest management with strip clear-cutting. Unasylva 43:24-27.
OPLER, P. A., H. G. BAKER, & G. F. FRANKIE. 1977. Recovery of tropical lowland forest ecosystems. Pp. 379-421 in Recovery and restoration of damaged ecosystems (J. Cairns, Jr., K.L. Dickson, and E.E. Herricks, Eds.). Charlottesville, Univ. Virgina Press.
ORIANS, G. H., & J. F. WITTENBERGER. 1991. Spatial and temporal scales in habitat selection. Am. Nat. 137:S29-S49.
PARNELL, J. F. 1969. Habitat relations of the parulidae during spring migration. Auk 86:505-521.
PARSONS, J. J. 1976. Forest to pasture: development or destruction? Rev. Biol. Trop. (Suppl. 1) 24:121-138.
PEARSON, D. L. 1980. Bird migration in Amazonian Ecuador, Peru, and Bolivia. Pp. 273-283 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.
PETIT, D. R. 1991. Habitat associations of migratory birds wintering in Belize, Central America: implications for theory and conservation. Ph.D. dissertation, Fayetteville, Univ. Arkansas.
_____, L. J. PETIT, & K. G. SMITH. 1992. Habitat associations of migratory birds overwintering in Belize, Central America. Pp. 246-256 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.
RABINOWITZ, D., S. CAIRNS, & T. DILLON. 1986. Seven forms of rarity and their frequency in the flora of the British Isles. Pp. 182-204 in Conservation biology: the science of scarcity and diversity (M. E. Soule, Ed.). Sunderland, Massachesetts, Sinauer Associates.

RAMOS, M. A., & D. W. WARNER. 1980. Analysis of North American subspecies of migrant birds wintering in Los Tuxtlas, southern Veracruz, Mexico. Pp. 173-180 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

RAPPOLE, J. H., & D. W. WARNER. 1980. Ecological aspects of avian migrant behavior in Veracruz, Mexico. Pp. 353-393 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____, E. S. MORTON, T. E. LOVEJOY, III, & J. L. RUOS. 1983. Nearctic avian migrants in the neotropics. Washington, D.C., U.S. Fish and Wildl. Serv.

_____, M. A. RAMOS, & K. WINKER. 1989. Wintering Wood Thrush movements and mortality in southern Veracruz. Auk 106:402-410.

RAVEN, P. H. 1988. Our diminishing tropical forests. Pp. 119-122 in Biodiversity (E.O. Wilson and F.M. Peter, Eds.). Washington, D.C., National Academy Press.

REED, J. M. 1992. A system for ranking conservation priorities for neotropical migrant birds based on relative susceptibility to extinction. Pp. 524-536 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

ROBBINS, C. S., D. BYSTRAK, & P. H. GEISSLER. 1986. The breeding bird survey: its first fifteen years, 1965-1979. Resour. Publ. No. 157. Washington, D.C., U.S. Fish and Wildl. Serv.

_____, D. K. DAWSON, & B. A. DOWELL. 1989b. Habitat area requirements of breeding forest birds of the middle Atlantic States. Wildl. Monogr. 103:1-34.

_____, B. A. DOWELL, D. K. DAWSON, J. COLON, F. ESPINOZA, J. RODRIGUEZ, R. SUTTON, & T. VARGAS. 1987. Comparison of neotropical winter bird populations in isolated patches versus extensive forest. Acta Oecol./Oecol. Gen. 8:282-292.

_____, B. A. DOWELL, D. K. DAWSON, J. A. COLON, R. ESTRADA, A. SUTTON, R. SUTTON, & D. WEYER. 1992. Comparison of neotropical migrant landbird populations wintering in tropical forest, isolated forest fragments, and agricultural habitats. Pp. 207-220 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____, J. R. SAUER, R. S. GREENBERG, & S. DROEGE. 1989a. Population declines in North American birds that migrate to the neotropics. Proc. Natl. Acad. Sci. 86:7658-7662.

RUBINOFF, I. 1983. A strategy for preserving tropical forests. Pp. 465-476 in Tropical rain forest: ecology and management (S.L. Sutton, T.C. Whitmore, and A.C. Chadwick, Eds.). Oxford, U.K., Blackwell.

SAAB, V. A., & D. R. PETIT. 1992. Impact of pasture development on winter bird communities in Belize, Central America. Condor 94:66-71.

SADER, S. A., & A. T. JOYCE. 1988. Deforestation rates and trends in Costa Rica. Biotropica 20:11-19.

SALAZAR, M. 1990. Forest fire control in Honduras. Unasylva 41:13-16.

SAUER, J. R., & S. DROEGE. 1992. Geographic patterns in population trends of neotropical migrants in North America. Pp. 26-42 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

SAUNDERS, D. A. 1990. Problems of survival in an extensively cultivated landscape: the case of Carnaby's Cockatoo *Calyptorhynchus funereus latirostris*. Biol. Conserv. 54:277-290.

_____, R. J. HOBBS, & C. R. MARGULES. 1991. Biological consequences of ecosystem fragmentation: a review. Conserv. Biol. 5:18-32.

SCOTT, D. A., & M. DE L. BROOKE. 1985. The endangered avifauna of southeastern Brazil: a report on the BOU/WWF expeditions of 1980/81 and 1981/82. Pp. 115-140 in Conservation of tropical forest birds (A.W. Diamond and T.E. Lovejoy, Eds.). ICBP Tech. Publ. No. 4.

SHAFFER, M. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.

SHANE, D. R. 1986. Hoofprints on the forest. Philadelphia, Pennsylvania, Institute for the Study of Human Issues.

SIMBERLOFF, D. S. 1983. Mangroves. Pp. 273-276 in Costa Rican natural history (D.H. Janzen, Ed.). Chicago, Univ. Chicago Press.

_____. 1986. Are we on the verge of a mass extinction in tropical rain forests? Pp. 165-180 in Dynamics of extinction (D.K. Elliott, Ed.). New York, John Wiley and Sons.

STAUFFER, D. F., & L. B. BEST. 1986. Effects of habitat type and sample size on habitat suitability index models. Pp. 71-77 in Wildlife 2000: modeling habitat relationships of terrestrial vertebrates (J. Verner, M.L. Morrison, and C.J. Ralph, Eds.). Madison, Univ. Wisconsin Press.

STILES, F. G. 1985. Conservation of forest birds in Costa Rica: problems and perspectives. Pp. 141-168 in Conservation of tropical forest birds (A.W. Diamond and T.E. Lovejoy, Eds.). ICBP Tech. Publ. No. 4.

_____, & A. F. SKUTCH. 1989. A guide to the birds of Costa Rica. Ithaca, New York, Cornell Univ. Press.

TERBORGH, J. 1974. Preservation of natural diversity: the problem of extinction prone species. BioScience 24:715-722.

TERBORGH, J. W. 1980. The conservation status of neotropical migrants: present and future. Pp. 21-30 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

_____, & J. R. FAABORG. 1980. Factoring affecting the distribution and abundance of North American migrants in the eastern Caribbean region. Pp. 145-156 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

THELEN, K. D. 1990. Networking to share technical knowledge on wildlife management in Latin America. Unasylva 41:33-38.

THIOLLAY, J.-M. 1992. Influence of selective logging on bird species diversity in a Guianan rain forest. Conserv. Biol. 6:47-63.

UHL, C., D. NEPSTAD, R. BUSCHBACHER, K. CLARK, B. KAUFFMAN, & S. SUBLER. 1990. Studies of ecosystem response to natural and anthropogenic disturbances provide guidelines for designing sustainable land-use systems in Amazonia. Pp. 24-42 in Alternatives to deforestation: steps toward sustainable use of the Amazon rain forest (A.B. Anderson, Ed.). New York, Columbia Univ. Press.

U.S. CONGRESS, OFFICE OF TECHNOLOGY ASSESSMENT. 1992. Combined summaries: technologies to sustain tropical forest resources and biological diversity. OTA-F-515, Washington, D.C., U.S. Govt. Printing Office.

U.S. FISH AND WILDLIFE SERVICE. 1990. Conservation of avian diversity in North America. Washington, D.C., U.S. Fish and Wildl. Serv.

VAN HORNE, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893-901.

VON MAYDELL, H.-J., G. BUDOWSKI, H. N. LeHOUEROU, B. LUNDGREN, & H. A. STEPPLER. 1982. What is agroforestry? Agroforestry Systems 1:7-12.

WAIDE, R. B. 1980. Resource partitioning between migrant and resident birds: the use of irregular resources. Pp. 337-352 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

WHITCOMB, R. F., C. S. ROBBINS, J. F. LYNCH, B. L. WHITCOMB, M. K. KLIMKIEWICZ, & D. BYSTRAK. 1981. Effects of forest fragmentation on avifauna of eastern deciduous forest. Pp. 125-205 in Forest island dynamics in man-dominated landscapes (R.L. Burgess and D.M. Sharpe, Eds.). New York, Springer-Verlag.

WHITMORE, T. C. 1991. An introduction to tropical rain forests. Oxford, U.K., Clarendon.

WIENS, J. A. 1977. On competition and variable environments. Amer. Sci. 65:590-597.

WILLIAMS-LINERA, G. 1990. Vegetation structure and environmental conditions of forest edges in Panama. J. Ecol. 78:356-373.

WILLIS, E. O. 1974. Population and local extinctions of birds on Barro Colorado Island, Panama. Ecol. Monogr. 44:153-169.

_____. 1979. The composition of avian communities in reminiscent woodlots in southern Brazil. Papeis Avulsos de Zoologia 33:1-25.

_____. 1980. Ecological roles of migratory and resident birds on Barro Colorado Island, Panama. Pp. 205-225 in Migrant birds in the neotropics: ecology, behavior, distribution, and conservation (A. Keast and E.S. Morton, Eds.). Washington, D.C., Smithsonian Inst. Press.

WILSON, E. O. 1988. The current state of biological diversity. Pp. 3-18 in Biodiversity (E.O. Wilson and F.M. Peter, Eds.). Washington, D.C., National Academy Press.

_____, & F. M. PETER (Eds.). 1988. Biodiversity. Washington, D.C., National Academy Press.

WORLD COUNCIL ON ENVIRONMENT AND DEVELOPMENT. 1987. Our common future. Oxford, U.K., Oxford Univ. Press.

WORLD RESOURCES INSTITUTE. 1985. Tropical forests: a call for action. Part I: the plan. Washington, D.C., World Resources Institute.

WUNDERLE, J. M. 1992. Sexual habitat segregation in wintering Black-throated Blue Warblers in Puerto Rico. Pp. 299-307 in Ecology and conservation of neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Washington, D.C., Smithsonian Inst. Press.

Appendix A. Methods used to estimate vulnerability of migratory species due to destruction of tropical broadleaved forests.

We used approximately 50 publications that examined habitat use by individual species across at least two habitat types. Reports derived from study of single vegetation types were not used, as those provided no information as to habitat "selection", which we define operationally as differential abundance of a species in one habitat relative to others. Data from some studies were presented qualitatively (e.g., Land 1970, Stiles and Skutch 1989) and others quantitatively (e.g., Waide 1980, Lynch 1989, Blake and Loiselle 1992, Hutto 1992). Habitats used outside the wintering period (for example during migration) were excluded when possible. Thus, for each species observed in a given study, two types of information were extracted: (1) all "possible" habitats where the species could occur in the study area (defined by the author), and (2) the habitat(s) that contained a disproportionate number of individuals or that were stated by the author to be "preferred" by the species. A total of 11 habitats were identified for this study: moist forest, wet forest, cloud forest, mangroves, advanced second-growth, forest edge, open woodlands/forest, coniferous/mixed-coniferous forest, early second-growth, residential, and grassland/pasture. Thus, for each species we derived the number of both "available" and "used" sites for each habitat type; the proportion of available sites that were used (used/available) provided an indication of the extent of use of each habitat type. For each habitat type for each species, proportions ranged from 0 (species never occurred there or was less common than expected) to 1.0 (species always occurred there). Habitats with indices between 0.5 and 1.0 were considered "primary" habitats, those between 0.25 and 0.49 "secondary" habitats, and those used in <25% of the studies by a given species were regarded as marginal habitats.

Most species exhibited a wide range of habitat occupancy during winter, with only 25% of the migrants restricted to <4 categories. Here, we concentrate on those migratory species that are most likely to be impacted by moderate (current?) alteration and fragmentation of tropical broadleaved forests. (Effects of complete or nearly complete deforestation is a moot point since it will affect nearly all species dependent upon trees.) A simple ranking scheme was devised that accounted for both the distribution and relative abundance (primary or secondary habitat) of each species in broadleaved habitats and the number of habitats in which each species occurred. All undisturbed and lightly disturbed broadleaved, forested habitats (i.e., moist forest, dry forest, cloud forest, and mangroves) were given scores (S) of 2; disturbed forested habitats (advanced second-growth, forest edge, open woodlands/forest) received scores of 1. Open or nonbroadleaved habitats (residential, coniferous, early second-growth, grassland) were not used in calculations here (but, see below). Each forested association (broadleaf) that represented a primary habitat for a given species was weighted by a factor (W) of 2 (large factor because we assumed that this was a preferred habitat and that a greater proportion of individuals occurred there); secondary habitats were weighted by a factor of 1; habitats classified as marginal (see above) were weighted by 0. Thus, for each of the h species, we calculated a measure (F_h) reflecting the species' use of undisturbed forests: $F_h = \Sigma(S_i \times W_i)$, where i equals the ith habitat type. In this analysis, Fh could take values from 0 (no forested habitats used) to 22 (all forested habitats were primary).

Because breadth of habitat use can influence the impact of habitat loss on population demographies (Rabinowitz et al. 1986), we devised a simple weighted measure of habitat breadth (B_h). B_h was calculated as the sum of the weights of all habitats (not only forested habitats) used by each of the h species (that is primary habitats = 2, secondary habitats = 1): $B_h = \Sigma(W_i)$. Theoretically, B_h could range between 1 (only one secondary habitat used) and 22 (all habitats were primary). The ratio F_h/B_h, then, describes the extent to which each species was restricted to undisturbed, broadleaved habitats and could range between 0 (species not dependent upon forests or woodland) and 2 (species dependent upon undisturbed, broadleaved forests). Finally, we incorporated F_h/B_h into an index of vulnerability (V_h): $(F_h/B_h) \times (1 - \log_{10}[n_h])$, where n is the number of habitats occupied by species h (for analyses, n was given values from 1 to 5 which represented 1-2, 3-4, 5-6, 7-8, and >8 habitats). The latter term in the equation was added to account for the absolute number of habitats used by each species. F_h/B_h reflects only how narrowly a species was restricted to undisturbed, broadleaved habitats, not how many distinct habitats it occupied. As habitat breadth increases probability of extinction decreases (Rabinowitz et al. 1986). $(1 - \log_{10}[n_h])$ was chosen to estimate the probability of severe population decline because this inverse, decelerating function places the greatest significance (i.e., most rapid declines) between successive numbers of habitats when few habitats are occupied. For instance, this relationship implies that the change in the probability of extinction should be less between 7 and 8 habitats occupied compared to 2 and 3 habitats occupied. A linear function would have resulted in equal changes in extinction probabilities for all successive habitat breadths (i.e., number of habitats occupied).

Management Implications of Cowbird Parasitism on Neotropical Migrant Songbirds

Scott K. Robinson[1], Joseph A. Grzybowski[2], Stephen I. Rothstein[3], Margaret C. Brittingham[4], Lisa J. Petit[5], and Frank R. Thompson[6]

Abstract — Populations of brood parasitic Brown-headed Cowbirds (*Molothrus ater*) have increased to the point where they pose a potential threat to populations of many neotropical migrant songbirds. Because cowbirds mostly feed in short grass (e.g., pastures and lawns) or on bare ground (e.g., row crops), they benefit directly from human activities. Cowbirds commute up to 7 km between feeding areas and habitats where they search for host nests, often favoring forest edge or secondary growth. Several neotropical migrants with restricted geographical ranges are endangered, at least partly as a result of cowbird parasitism (e.g., Kirtland's warbler *Dendroica kirtlandii*, Black-capped Vireo *Vireo atricapillus*). Cowbird control using baited decoy traps has reduced the percent of nests parasitized, increased nesting success, and may be essential for the continued survival of these endangered species. It is not clear, however, whether cowbird trapping would be effective at a broader scale in reducing parasitism in extensively fragmented landscapes such as in the Midwest where many neotropical migrants are experiencing very high levels of parasitism. Cowbird trapping should be viewed as a stop-gap measure to protect specific endangered populations. We recommend instead the development of broader-scale approaches, perhaps in combination with local trapping. One approach to controlling cowbirds is landscape-level management such as consolidation of ownership to preserve large tracts, eliminating potential cowbird feeding areas within large tracts, and minimizing edge habitat. A second possible approach is large-scale cowbird eradication at winter roosts, but this approach may be too diffuse to help specific sensitive species or areas with high parasitism levels. Any management plan should be preceded by cowbird monitoring and preliminary data on levels of parasitism.

[1]*Natural History Survey, 607 E. Peabody Drive, Champaign, IL 61820.*

[2]*Department of Biology, University of Central Oklahoma, Edmond, OK 73034.*

[3]*Department of Biological Sciences, University of California, Santa Barbara, CA 93106.*

[4]*Pennsylvania State University, 320 Forest Resources Building, University Parks, PA 16802.*

[5]*Smithsonian Migratory Bird Center, National Zoological Park, Washington, D.C. 20008.*

[6]*North Central Forest Experimental Station, 1-26 Agriculture Building, University of Missouri, Columbia, MO 65211.*

BACKGROUND

Parasitism by the Brown-headed Cowbird (*Molothrus ater*) has become one of the major threats to populations of neotropical migrants on the breeding grounds (Mayfield 1977, Brittingham and Temple 1983). The Brown-headed Cowbird is a generalist brood parasite that lays its eggs in the nests of over 240 known host species (Friedmann and Kiff 1985), the majority of which are neotropical migrants. Historically, cowbirds were largely confined to the mid-continental prairies where they presumably followed herds of nomadic bison. Cowbirds mainly search for seeds and insects in short grass and on bare ground and may have depended upon grazing by large ungulates to create suitable feeding conditions. Since the clearing of forests for agriculture and the widespread introduction of livestock, however, cowbirds have expanded their geographical range eastward and westward as new feeding areas became available (Mayfield 1965). Similarly, cowbird populations have increased within their range as a result of increasing winter food supply (primarily waste grain in agricultural fields) and higher reproductive rates as cowbirds have come in contact with new hosts that lack defenses against parasitism (Mayfield 1965, Brittingham and Temple 1983). Cowbird populations have continued to increase in most sections of the United States (with the notable exception of the northeast: Robbins et al. 1986).

Increasing cowbird populations pose a potential threat to many hosts because of the cowbird's extraordinary fecundity and the extent to which cowbird parasitism reduces host productivity. Female cowbirds lay at least 30-40 eggs per season on average (Rothstein et al. 1986). Dan Roby (pers. comm.) found that individuals in captivity can lay up to 77 eggs in a season. Relatively small numbers of cowbirds can therefore parasitize many nests. Cowbird parasitism reduces host productivity for the following reasons: (1) female cowbirds remove host eggs (usually one) from 33% to 90% of all parasitized nests (Friedmann 1963, Weatherhead 1989, Sealy 1992); (2) cowbird eggs are unusually thick and, when laid, often break those of the host (Spaw and Rohwer 1987, Roskaft et al. 1990); (3) cowbird eggs have a short incubation period of 11 days compared with 12-14 days for most hosts (Nice 1953, Friedmann 1963), which gives nestling cowbirds a head start; (4) cowbirds usually parasitize hosts smaller than themselves, which gives cowbird nestlings a further advantage in competition with host young; and (5) cowbird nestlings grow faster, beg more loudly and have larger gapes than host nestlings (Friedmann 1929, Ortega and Cruz 1991). As a result of these factors, small hosts with long incubation periods usually fail to produce any of their own young if a single cowbird egg hatches (Rothstein 1975, May and Robinson 1985). For larger hosts and those with shorter incubation periods, cowbird parasitism is less costly (Smith 1981, Roskaft et al. 1990, Friedmann et al. 1977), except when the nests are multiply parasitized (i.e., two or more cowbird eggs are laid).

Neotropical migrants are especially vulnerable to cowbird parasitism. Most neotropical migrants build open-cup nests, which are the most frequent target of cowbirds (Friedmann 1929). The cowbird egg-laying period generally extends from mid-April until mid-July (Friedmann 1929, Scott 1963, Robinson, unpubl. data), which also coincides with the major period of egg-laying in most neotropical migrants (Whitcomb et al. 1981). Resident and short-distance migrants generally have longer breeding seasons that only partially overlap that of the cowbird.

Cowbird hosts with restricted geographical ranges can be particularly vulnerable to parasitism. Cowbird parasitism is considered one major cause (along with habitat loss) of population declines and the endangered status of the Kirtland's Warbler (*Dendroica kirtlandii*) (Walkinshaw 1983), Least Bell's Vireo (*Vireo belli pusillus*) (Franzreb 1989), Southwestern Willow Flycatcher (*Empidonax traillii extimus*) (Unitt 1987, Brown 1988), and Black-capped Vireo (*Vireo atricapillus*) (Grzybowski et al. 1986). Cowbird hosts with larger ranges may be less vulnerable because heavily parasitized populations can be "rescued" by immigrants produced from populations in areas where parasitism levels are lower. Local extinctions of wide-ranging species, however, have occurred in Oklahoma (Orchard Oriole, *Icterus spurius*) (J. Grzybowski, pers. obs.) and in the lower Rio Grande Valley (J. Arvin, pers. comm.) and may be linked to heavy parasitism.

The parasitic life history of cowbirds enables them to occupy a wider range of habitats than any other North American passerine. Because cowbirds do not tend their own offspring, their two main activities during the breeding season, feeding and searching for hosts, can be uncoupled and carried out in different locations. Cowbirds can therefore occupy habitats that fulfill only one of these needs (Rothstein et al. 1984) and regularly commute up to 7 km between feeding and nest-searching sites (fig. 1, see also Rothstein et al. 1984). In southern Illinois and central Missouri, for example, cowbirds that searched for nests in forests fed 0.1-4.0 km away in pastures, feedlots for livestock (pigs, horses, and cattle), mowed roadsides, lawns, recently plowed and planted row crop fields, campgrounds, gravel roadsides, bird feeders, and logging roads (fig. 1). In the Sierra Nevada of California, recently arrived cowbirds commuted on average once a day between horse corrals and feeding areas. Rothstein et al. (1984) estimated that this single corral made it possible for cowbirds to parasitize hosts over an area of 154 km^2 that contained no other suitable feeding sites.

In southern Illinois, where there are many potential feeding sites, cowbirds fed throughout the day (fig. 2). Perhaps because of the proximity of feeding and nest-searching areas, cowbirds tend to be most abundant in heterogeneous "fragmented" landscapes in which grassy areas are intermixed with shrubby old fields and/or forests. Cowbird control may be much more difficult in landscapes where human activities have created many potential feeding areas (Rothstein et al. 1987; see below).

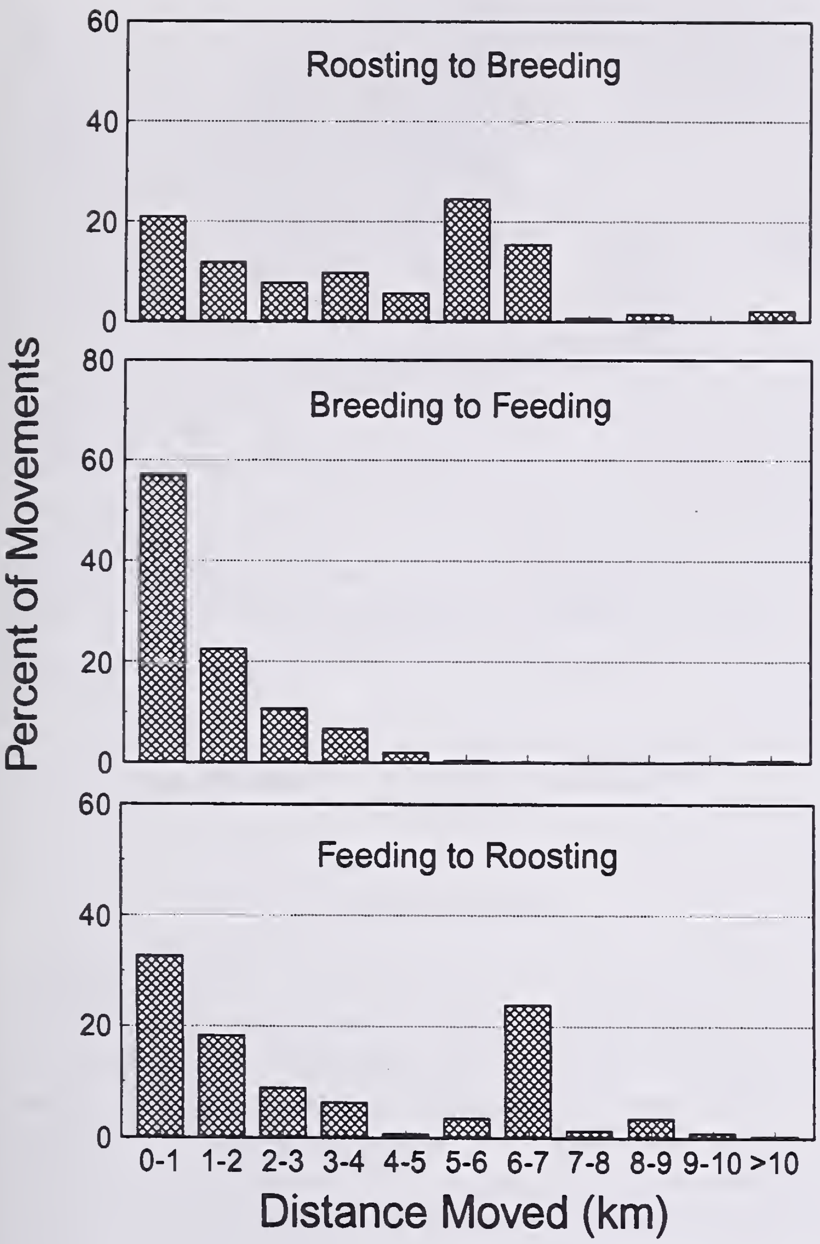


Figure 1. — Movements patterns of breeding female Brown-headed Cowbirds in Illinois and Missouri. Movements are presented as the percent of total movements from roosting to breeding, breeding to feeding, and feeding to roosting locations in 1 km distance classes, and are based on 1,160 movement by 96 radio-tagged Cowbirds during 1991 and 1992 (Thompson, In Review).

CONDITIONS FAVORING COWBIRD PARASITISM

Numbers of cowbirds and rates of parasitism within the Eastern deciduous forest vary with distance from edges (Gates and Gysel 1978, Chasko and Gates 1982, Brittingham and Temple 1983). In an extensively forested area of Wisconsin, for example, Brittingham and Temple (1983) and Temple and Cary (1988) found that percent of parasitized nests declined from 65% within 99 m of an edge to less than 18% at >300 m. Brittingham and Temple (1983) argued that forest fragmentation leads to higher levels of parasitism by increasing the ratio of forest edge (>300 m from an edge) to forest interior (300 m from an edge). In a moderately (50%) forested area of the Shawnee National Forest in southern Illinois, however, Robinson et al. (in review) and Trine et al. (in review) found no appreciable decrease in parasitism levels even 800 m from the nearest edge. Apparently, cowbird populations have saturated the available forest in this area. In contrast, the percent of nests parasitized is low (<10%) throughout extensively (>80%) forested sections of the Mark Twain and Hoosier National Forests (John Faaborg and Don Whitehead, pers. comm.). Similarly, Hoover (1992) found no evidence of an edge effect in central Pennsylvania where cowbird populations are generally low. The magnitude of the "cowbird edge effect" therefore varies within and among regions, apparently in response to landscape-level variation in fragmentation and cowbird abundance.

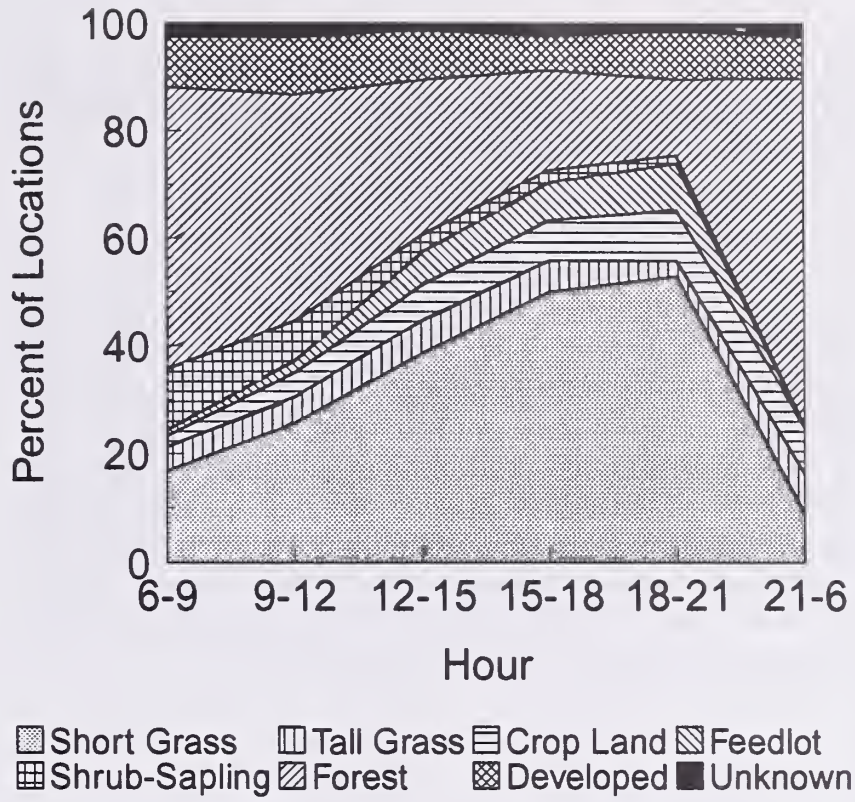


Figure 2. — Diurnal patterns in habitat use by breeding female Brown-headed Cowbirds in Missouri and Illinois. Habitat use was determined from 3,584 locations of 96 radio-tagged female Cowbirds in 1991 and 1992 (Thompson, In Review).

There is little information on differences between "internal" edges, such as those around clearcuts or "wildlife" openings, and "external" edges such as agricultural fields. Overcash and Roseberry (1987) found cowbird abundance to be 4-5 times higher around small (<4 ha) wildlife openings in the Shawnee National Forest of southern Illinois, but have no data on nest parasitism. Don Whitehead (pers. comm.) found higher parasitism levels along clearcuts than in forest interior in the Hoosier National Forest even though there is no feeding habitat for cowbirds in clearcuts. Brittingham and Temple (1983) found that levels of parasitism were just as high near openings of 0.2 ha as they were near agricultural openings. Robinson is currently studying the effects of small (≤0.2 ha) openings created by selective logging on cowbird parasitism.

Corridors such as powerlines within forest habitats also create internal edges. Gates and his colleagues looked at whether numbers of cowbirds and levels of parasitism are higher near these openings and compared these results with natural corridors created by streams (Chasko and Gates 1982, Gates and Giffen 1991). They found numbers of cowbirds and levels of parasitism were higher near both types of corridors, but also found higher host densities near corridors. Gates is continuing his research on cowbird use of these edges. Johnson and Temple (1990) also found that cowbird parasitism was higher near woody corridors and edges in tallgrass prairie habitat.

Livestock

Not surprisingly, availability of local feeding areas such as livestock corrals is associated with high levels of brood parasitism. Verner and Ritter (1983) and Rothstein et al. (1980) found that areas near pack stations, livestock corrals, and free-ranging livestock in the Sierra Nevada had higher numbers of cowbirds and parasitized nests. Cowbirds were rare in areas far from pack stations or other human disturbances. In the Shawnee National Forest, telemetry studies showed that cowbirds visit pastures and feedlots even in the morning (fig. 2).

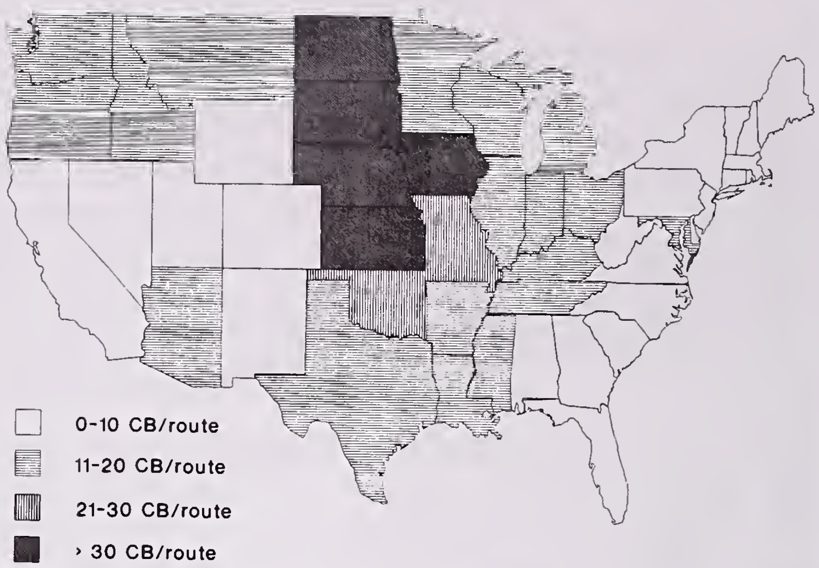


Figure 3. — Distribution and abundance of brown-headed cowbirds according to the Breeding Bird Survey.

Structure of the Vegetation

Within a site, the percent of nests parasitized can vary with the structure of the vegetation. Cowbirds are frequently observed perched or displaying at the top of dead snags. Anderson and Storer (1976), working within relatively open jack pine (*Pinus banksiana*) habitat, found parasitism of Kirtland's Warbler nests to be more likely when a dead snag was near the nest. Brittingham and Temple (unpubl. data) found no such relationship with snag proximity in a deciduous woods. Freeman et al. (1990) also found that cowbirds were more efficient at finding active nests in marshes with a high density of trees around the perimeter. Apparently, female cowbirds used trees as perches to locate nests and observe host behavior. Because of interspecific differences in host nest placement, however, it is unlikely that changes in vegetation structure will affect incidence of parasitism for all species in a community in the same way. Thus, we are not yet in a position to recommend general ways of managing vegetation structure to reduce cowbird parasitism.

Geographic Variation

Levels of cowbird parasitism are not homogeneous over large geographical areas. Wood Thrushes (*Hylocichla mustelina*), for example, experience much greater parasitism in midwestern than in eastern North America (Hoover and Brittingham, in press) where cowbirds are less abundant (fig. 3). The same is true of Red-winged Blackbirds (*Agelaius phoeniceus*; Freeman et al. 1990). The effects of cowbird parasitism on neotropical migrants may therefore be most severe in the Midwest, and approaches to reducing parasitism should perhaps be the focal issue in the conservation of forest-dwelling neotropical migrants in that region.

MANAGEMENT OF COWBIRDS

Baseline Data

In the cases of a few species (e.g., Kirtland's Warbler, Black-capped Vireo, Golden-cheeked Warbler [*Dendroica chrysoparia*]) with small populations that are already threatened or endangered and are known to be severely affected by cowbird parasitism, immediate and intense management of cowbird populations may be necessary (see Cowbird Trapping below). However, because parasitism levels vary geographically for most other host species, local data on cowbird abundance, distribution, and levels of nest parasitism should be gathered to determine the extent to which cowbird management efforts are necessary. When monitoring bird populations, cowbirds should be given special attention. During point-counts, cowbirds heard giving their distinctive "rattle" call should be recorded separately from those giving other calls. The rattle call is usually given by females (Rothstein et al. 1988), whereas the other two calls are primarily or exclusively given by males. Because cowbirds have a strongly male-biased sex ratio (Rothstein et al. 1986, Yokel 1989), many males present in nest-searching areas are likely to be unmated and may be searching for mates rather than nests. Females, on the other hand, are more likely to be searching for nests. The distribution and abundance of female cowbirds is therefore potentially a better indicator of local variation in the intensity and spatial distribution of nest parasitism.

It is possible that the ratio of female cowbirds to hosts detected in fixed-radius point counts can be used as a crude index of parasitism intensity at the community level. In Illinois, ratios of 0.05-0.10 cowbird females:host males detected within fixed-radius point counts corresponded with very high levels (60-80% of all nests) of brood parasitism for most neotropical migrants (Robinson and Wilcove, in review, Robinson, unpubl. data). Because species vary enormously in susceptibility to parasitism (May and Robinson 1985), however, census data cannot be used to estimate parasitism frequencies for any one species. Rather, census data are best used to locate areas where parasitism is most likely to be a problem and in need of further study (see below). For this reason, census efforts should include points near edges (including openings created by logging, wildlife management, and agriculture) as well as in the interior of habitats (e.g., Brittingham and Temple 1983).

Data on distribution of local cowbird feeding areas is essential for designing and predicting effectiveness of cowbird control efforts (Rothstein et al. 1987). Radio-telemetry of cowbirds provides the best data on use of both feeding and breeding areas (Rothstein et al. 1980, 1984, F. Thompson, unpubl. data), but is expensive (ca. $140/transmitter) and labor intensive. F. Thompson estimated that tracking 35-40 female cowbirds fitted with transmitters with a crew of three for a two-month period costs $25,000-35,000/site/year. If telemetry is too expensive, cowbirds can be censused by visiting potential feeding sites, especially at mid-day and in the afternoon. If cowbird feeding areas are restricted, cowbird trapping is much more likely to be effective (Rothstein et al. 1987). There are also some indications that female cowbirds may roost together even during the breeding season in some areas (F. Thompson, unpubl. data), which might provide further opportunities for local control.

Once cowbirds have been determined to be present in an area, pilot studies should be initiated to obtain parasitism estimates for the most potentially sensitive species. Percent parasitism can be estimated from a sample of nests (Pease and Grzybowski, in review) or the relative frequencies with which hosts are seen feeding their own fledglings versus cowbird fledglings. If the level of parasitism is high (>25% of nests), the species most likely does not reject cowbird eggs (Rothstein 1975) and may be threatened by cowbird parasitism.

Once a potential threat has been established, one should then ideally assess the assumption that the presence of cowbirds is reducing host reproductive success to levels below that needed to compensate for adult mortality. The critical parameters to measure are: (1) parasitism frequency, (2) nest predation frequency, (3) frequency of abandonment of parasitized and unparasitized nests, (4) the number of host young fledged from parasitized and unparasitized nests that escape predation, (5) the length of the nest cycle, (6) the length of the incubation period, and (7) the length of the breeding season (May and Robinson 1985, Pease and Grzybowski, in review). The last three parameters can often be obtained from the general ornithological literature. The first four parameters, however, can only be obtained by hiring a crew of skilled field workers. With these data, managers can estimate the average seasonal productivity per pair, given renestings. In general, host populations must produce 2.0-2.5 young/pair/season to maintain a positive population growth rate, assuming adult and juvenile survival rates of 40-60% and 20-35% respectively. As more demographic studies of color-marked populations are conducted, estimates of survival rates will improve as will our ability to estimate the productivity necessary to maintain positive population growth rates.

The levels of brood parasitism that a population can tolerate (i.e., maintain a positive growth rate) vary with the parameters described above. Species with high nest predation, low abandonment of parasitized nests, long incubation periods, and short breeding season relative to the length of the nest cycle can tolerate only low levels of parasitism. Conversely, species with low nest predation rates, high abandonment rates of parasitized nests (e.g., Prairie Warbler *Dendroica discolor*: Nolan 1978), short incubation periods and long nesting season might be able to tolerate high levels of parasitism. Managers should consult with researchers studying bird demographies when the threat posed by parasitism is unclear.

Cowbird Trapping

Trap Design

Trapping cowbirds has been successfully used to manage several neotropical migrants with small populations and local geographical ranges. Cowbird trapping, however, is unlikely to be effective over large areas such as national forests, which require landscape-level management (see below). Here we summarize methods used to trap cowbirds in situations where it is most likely to be effective. Traps used for removing cowbirds are referred to as cowbird decoy traps. They are typically outdoor cages which range in size from very portable versions with dimensions as small as 2 X 2.5 X 1.5 m to larger cages 5 X 5 X 2 m. The latter size is more often used to remove large numbers of blackbirds from areas of concentration during the winter months. They can be constructed into panels which can be quickly assembled and disassembled if there is a need to move them from location to location. They should also have a small side box with a removable side opening into the cage at a top corner wall no more than an arm's length deep into which cowbirds can be collected and thus removed. The basic design is described in a USDI leaflet (1973); other designs and recommendations for construction from inexpensive materials are provided.

Free-ranging cowbirds are attracted to the live-decoy cowbirds in the trap and a food source, and enter through some funnel or slit entrance, normally dropped from the ceiling of the cage. Once inside, cowbirds will usually attempt to leave the trap by moving upward, but toward the side walls, rather than directly up through the funnels. Thus most, if not all never find an exit.

The funnels, however, should be dropped to such an extent that cowbirds seeking an exit along the top sides of the trap have enough room to circle around the funnel, but above the funnel entrance. The funnel should have some wire mesh across it and below its top wide enough for cowbirds to pass through, but not presenting an obvious open hole when viewed from the floor of the cage.

Slit designs, modeled after Australian Crow traps, can also be used. Slits of 1-1/2" width allow a cowbird to drop through with open or closed wings, but are narrow enough to make it inconspicuous as the exit, and, because the cowbird has to fly directly upward, too narrow for the cowbird to pass through with open wings. To some extent, slit designs have been more successful in preventing escapes (D. Steed, pers. comm.).

Larger cages from 3 X 2.5 to 2 m have been uniformly successful in capturing cowbirds. The smaller sizes have also been successful but not as successful as larger ones (Hesterberg et al. 1985).

Materials typically used are 1 X 1" chicken wire or 1/2" hardware cloth. One caution: Some chicken wire sold as 1 X 1" is actually 1 X 1-1/2". This slightly larger size is large enough to allow female cowbirds, particularly of the dwarf race (*M. a. obscurus*), to escape. Panels can be constructed with inexpensive 2 X 2" boards, and panels can be assembled using bolts with butterfly nuts. Designs using metal braces, PVC tubing, among other materials are possible and are more resilient to long-term deterioration, weathering and persistent predators (such as raccoons, mink, and feral cats) which may be attracted to the traps. Designs for the latter have been developed by personnel at the Kerr Wildlife Management Area in Texas (Rte. 1, Box 180, Hunt, TX 78024) and the Wichita Mountains Wildlife Refuge in Oklahoma (Rte 1, Box 448, Indiahoma, OK 73552). Mobile versions for areas with roads can also be constructed on a small trailer bed.

Operating the Traps

Food should be placed directly under the funnel entrance, but not in large piles that may look foreign to a cowbird. Water and perches should be provided to the sides, preferably at points where the opening of the funnel entrance is not directly visible from the perch or water dish. Perches can often be hung from the cage ceiling or supported by the sides. The cage floor should be weed and grass-free at all times. Cages with the ground scraped bare in grassland or field settings will often attract and capture free-ranging cowbirds without decoy cowbirds, or even bait. Bait can be a variety of grains or other seeds including wheat, millet, cracked corn, or sunflower seeds.

Decoy cowbirds should be a combination of males and females. Use of at least two female decoys with males substantially improved capture of females. Decoy sex ratios favoring females had the greatest success, with the male:female ratio of the captured population improving from 3.3:1 to 1.37:1 (Collins et al. 1989; Beezley and Rieger 1987). The improved capture of females with female decoys far outweighs the concerns of an occasional escaping female parasitizing nests of sensitive species. By clipping the wings of female decoys, escapes can be minimized or made inconsequential. However, females should not be clipped to such an extent as to appear injured, as this may affect the capture of additional birds.

Another consideration in trapping is the length of time decoy cowbirds are in the trap. Decoys held for more than two weeks may change their behavior in ways that actually deter capture of additional cowbirds. This happens when the cowbirds in the trap show anxiety for joining potential incoming birds. Thus, decoys should be marked, removed periodically, and replaced with recently captured birds.

Trap Placement and Effectiveness

The effectiveness of individual traps in breeding areas often extends less than 0.8 km from the trap (Grzybowski, unpubl. data). On Fort Hood, Texas during 1991, 52 traps were operated to protect a population containing 152 scattered Black-capped Vireo territories (Hayden and Tazik, unpubl. data). In the Wichita Mountains, nine traps are used to protect approximately 75 vireo territories (Grzybowski, unpubl. data). The ratio of traps to territories of sensitive species can be even higher for smaller and moderately dispersed groupings. Thus, unless the population of concern is small and therefore already in serious trouble, trapping must be widespread, and therefore expensive.

Trap placement can play an influential role in enhancing cowbird capture. Traps should be placed in partly open settings, near taller potential perches, but not directly under them. Collins et al. (1989) indicated that traps placed in dense riparian habitat were less effective than those located in open areas immediately adjacent to such habitats. As a general rule, traps should be placed so that a cowbird resting on the floor of the cage cannot see a potential perch through the funnel entrance.

The daily movements of cowbirds may be one of the most important considerations. A strategy of effective trap placement is to place them between the cowbird feeding sites and the areas requiring protection from parasitism. Many cowbirds in hilly terrain travel up or down draws and hollows or across saddles when moving between morning breeding areas and afternoon feeding areas. Traps placed at the entrances of these areas or in the saddles may be more effective in some settings. In the Wichita Mountains, Oklahoma, for example, traps placed in the middle of Black-capped Vireo nesting areas reduced observed parasitism from approximately 70% to 30% with only a doubling or tripling of reproductive success. When traps were placed on the perimeters of the vireo nesting areas, however, the observed parasitism declined to less than 20%, and seasonal fecundity increased six to eight fold above that in untrapped areas (Grzybowski 1990a).

Another strategy is to place traps near cowbird feeding areas, especially where livestock are concentrated. Capture rates of females near cattle or buffalo were 2.14 per trap day (for the initial trap operation period) compared with 0.14 per trap day away from these animals (Grzybowski 1990a). However, if livestock are dispersed, effectiveness is compromised (Rothstein et al. 1987, Tazik and Cornelius unpubl. data).

A modification of this approach has been used with rotational grazing systems, a system where cattle are moved from pasture to pasture on a rotational basis. At the Kerr WMA in Texas, cattle were placed immediately adjacent to Black-capped Vireo nesting areas (containing traps) at the beginning of the nesting season. Capture rates of females improved dramatically for the trap closest to the cattle, observed parasitism was the lowest recorded, and vireo reproductive success the highest (Grzybowski 1990b).

Capture rates at traps are often high at the beginning of the trapping effort, and drop substantially after an initial capture period of two to four weeks. Most of the cowbirds are normally removed in this initial period, although traps operated near cowbird feeding sites continue catching cowbirds for most of the season.

Cowbird Shooting

Female cowbirds can be attracted to taped calls and removed by shooting. Shooting has been used in conjunction with trapping on Fort Hood (Hayden and Tazik unpubl. data), but the specific effects of shooting were not isolated from those of trapping. About 247 female cowbirds were removed, some of which may have been later trapped if not shot. Nonetheless, the technique can be used to remove a substantial number of cowbirds, and may be useful and more cost-effective in some areas with small or scattered groupings of sensitive species. Cowbirds, however, are sensitive to activity near the traps, including extended human visitation. Thus, shooting should not be conducted at the trap locations themselves.

Control at Roosts

Because cowbirds gather in large roosts during the nonbreeding season, they are potentially vulnerable to large-scale control efforts (e.g., Johnson et al. 1980). Such control efforts, however, should be considered carefully before they are implemented. Previous eradication programs have had little apparent effect on national populations of cowbirds, possibly because birds from many regions gather in the same roosts. The effects of control at winter roosts are therefore likely to be diffuse and may not protect any specific endangered population. Control efforts may also work only for a few years if they select for cowbirds that avoid large roosts. Nevertheless, control at winter roosts may offer the most practical way to reduce cowbird populations in fragmented landscapes where local trapping is too expensive. Even if many of the cowbirds killed would be from areas where they pose little threat, the enhanced productivity of host species throughout their range might increase the pool of immigrants available to recolonize areas with heavier rates of parasitism. Martin (1992), however, has argued that in most areas the effects of nest predation on host population dynamics far outweigh the consequences of brood parasitism. Landscape management that reduces both cowbird and nest predator populations (Temple and Cary 1988) may therefore still be the best long-term solution to preserving populations of neotropical migrants (see below). The ethical implications of large-scale eradication of a native songbird also need to be considered before such a program is considered. Even among the authors of this paper, opinions are divided about the value of control at winter roosts.

Landscape and Habitat Management

Perhaps the best and most permanent way to reduce the impact of cowbirds on neotropical migrants is through landscape-level management, which can be effective at a much larger scale than trapping. Because cowbirds are frequently associated with agriculture, human settlements, and internal and external edges, the best management strategy is to maintain large areas of contiguous habitat. Unfortunately, we cannot provide one specific guideline for minimum area requirements for reducing cowbird impacts because edge effects vary among landscapes and cowbirds can commute long distances when searching for nests (fig. 1). *As a general rule, however, bigger tracts are preferable to small ones, wider riparian strips are better than narrow ones, and compact shapes are preferable to complex shapes with high ratios of edge to interior.*

Managers must also keep in mind the landscape surrounding the area being managed. Landscapes with few feeding opportunities for cowbirds may not have problems with cowbird parasitism even along edges and small openings. Landscapes with abundant cowbird feeding habitat may have cowbird populations that saturate breeding habitat regardless of proximity to edge. Ultimate solutions to the increasing threat of cowbird parasitism to neotropical migrants must involve changing land-use practices and configurations that reduce cowbird feeding areas. Below we provide more specific guidelines.

Forest Habitat

1. Where possible, managers should seek to maintain and establish large areas of contiguous forest cover that include core areas of forest interior. Estimates of areas necessary to sustain populations of neotropical migrants vary regionally. Robbins et al. (1989), for example, suggest maintaining at least 3000 ha of contiguous forest as the minimum required to retain local populations of forest songbirds in the mid-Atlantic states. Data from moderately fragmented areas of the Midwest suggest that areas of 20,000-50,000 ha may be necessary because the landscape supports very high cowbird populations and parasitism rates remain high even two km from feeding areas (Robinson, unpubl. data). The Biological Advisory Team (1990) of Balcones Canyonlands Habitat Conservation Plan in Texas recommended establishing tracts of 2000-5000 ha to minimize the effects of cowbird parasitism and nest predation for the endangered Golden-cheeked Warbler. We strongly recommend that land acquisition should focus on consolidation of ownership of the largest tracts within a region and the restoration of forest habitat to eliminate cowbird feeding areas. In riparian corridors, we also advocate land acquisition and restoration to provide habitat patches that are wide enough to maintain populations of Bell's Vireos and Willow Flycatchers (Smith 1977). Consolidation of ownership in large tracts is particularly likely to be effective in moderately fragmented landscapes where larger tracts could represent potential sources of immigrants to recolonize smaller fragments.

2. Managers should avoid agricultural or suburban developments that result in the creation of forest islands and increase cowbird populations. When agricultural and suburban development already dominate the landscape, plans should be made to retain woodlots that have compact shapes instead of ones that are long and narrow.

3. Within large tracts, managers should avoid any practice that creates cowbird feeding opportunities such as mowing roadsides and campgrounds, feeding birds, establishing corrals or pack stations, and allowing grazing. If this is not possible or practical, potential feeding sites should be concentrated as much as possible and cowbird trapping programs established. Even if cowbird parasitism rates are low in large tracts, the reduction of reproductive success near cowbird feeding areas might substantially reduce the supply of immigrant neotropical migrants available to recolonize smaller patches.

4. In severely fragmented landscapes where land acquisition and restoration are not possible and/or practical, site-specific trapping may be the only way to protect remnant populations of sensitive species. Such trapping, however, is likely to be expensive because of the availability of so many feeding areas. In these habitats, trapping might be more effective when targeted at breeding rather than feeding sites.

5. In forested areas managed for timber use, logging practices should vary depending upon the landscape. In extensively forested areas such as the Missouri Ozarks, Thompson et al. (1992) found that cowbirds preferred clearcut edges, but were no more abundant overall in areas with and without clearcuts. In these areas, the kinds of logging practices used may have little impact on cowbird parasitism levels because cowbird populations are likely to be limited by feeding habitat availability. Similarly, in severely fragmented forests with extensive feeding habitat, cowbirds might saturate the breeding habitat regardless of the method of timber harvest. Logging practices are most likely to be an important issue in moderately fragmented landscapes where opening gaps in the canopy might provide cowbirds with additional access to hosts. We recommend that low-volume, single-tree selection be used instead of group selection or small clearcuts in severely and moderately fragmented landscapes. Group selection cuts of 0.1-1 ha have the potential to increase parasitism frequency because they maximize edge habitat. Data from a fragmented forest in southern Illinois (Robinson, unpubl. data) showed higher parasitism levels for some, but not all species in tracts subjected to group selection logging within the last five years. Unfortunately, we have no data on the effect of single-tree selection on incidence of cowbird parasitism.

6. If clearcuts are used, the establishment of new edge should be minimized. Clustering cuts near existing edges, making one large cut rather than many small ones, and avoiding irregularly shaped cuts might reduce parasitism.

7. Logging roads and rights-of-way should be as narrow as possible and should be revegetated to avoid creating cowbird feeding habitat.

Tall Grass Prairie

1. Managers should maintain and restore extensive areas of contiguous prairie habitat that include core areas of prairie interior. Land acquisition should focus on acquiring inholdings to minimize fragmentation and cowbird feeding habitat.

2. Agricultural and suburban development that creates prairie islands should be avoided. When this is not possible, plan development to retain prairie fragments that have compact shapes.

3. Woody fence rows, snags, and corridors within and adjacent to prairie should be removed unless they also provide critical nesting habitat for sensitive species.

Livestock Management

Because pastures and feedlots provide the best feeding areas for cowbirds, research directed at methods of raising livestock that minimize feeding opportunities for cowbirds should be initiated. Perhaps feedlots could be designed to reduce waste grain. Similarly, pasture rotations that reduce the availability of very short grass might reduce local cowbird populations.

Winter Food Availability

Because increased availability of waste grain in winter might be increasing cowbird survival rates (Brittingham and Temple 1983), more efficient harvest methods might reduce cowbird populations. Decreasing availability of waste grain, however, might also reduce populations of geese and other game animals, which would create a potential conflict for managers.

Concluding Comments

As researchers, we feel obligated to emphasize the need for continued studies of the population dynamics of neotropical migrants. In some respects, our knowledge of the impacts of parasitism on hosts is still in its infancy. There have been few demographic studies of forest or grassland passerines of the kind necessary to determine how much parasitism neotropical migrants can tolerate. Similarly, there are no published studies on the impacts of logging on productivity of long-distance migrants. Until these gaps begin to be filled, the management guidelines provided above should be viewed as provisional.

LITERATURE CITED

Anderson, W.L., and R.W. Storer. 1976. Factors influencing Kirtland's Warbler nesting success. Jack-Pine Warbler 54:105-115.

Beezley, J.A., and J.P. Rieger. 1987. Least Bell's Vireo management by cowbird trapping. Western Birds 18:55-62.

Biological Advisory Team. 1990. Comprehensive report of the Biological Advisory Team for the Balcones Canyonlands Habitat Conservation Plan. Environmental Division, City of Austin, Austin, Texas. 80 p.

Brittingham, M.C., and S.A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31-35

Brown, B.T. 1988. Breeding ecology of a Willow Flycatcher population in Grand Canyon, Arizona. Western Birds 19:25-33.

Chasko, G.G., and J.E. Gates. 1982. Avian habitat suitability along a transmission-line corridor in an oak-hickory forest region. Wildlife Monographs 82:1-41.

Collins, C.T., L.R. Hays, M. Wheeler, and D. Willick. 1989. The status and management of the Least Bell's Vireo within the Prado Basin, California, during 1989. Orange County Water District, Fountain Valley, California. 53 p.

Franzreb, K.E. 1989. Ecology and conservation of the endangered Least Bell's Vireo. US Fish and Wildlife Service, Biological Report 89(1). 17 pp.

Freeman, S., D.F. Gori, and S. Rohwer. 1990. Red-winged Blackbirds and Brown-headed Cowbirds: Some aspects of a host-parasite relationship. Condor 92:336-340.

Friedman, H. 1929. The cowbirds: a study in the biology of social parasitism. C. Thomas, Springfield, IL.

Friedmann, H. 1963. Host relations of the parasitic cowbirds. US National Museum Bulletin 233.

Friedmann, H., L.F. Kiff, and S.I. Rothstein. 1977. A further contribution to knowledge of the host relations of the parasitic cowbirds. Smithsonian Contributions Zoology 235.

Friedmann, H., and L.F. Kiff. 1985. The parasitic cowbirds and their hosts. Proceedings Western Foundation Zoology 2:226-304.

Gates, J.E., and L.W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-883.

Gates, J.E., and N.R. Giffen. 1991. Neotropical migrant birds and edge effects at a forest-stream ecotone. Wilson Bulletin 103:204-217.

Grzybowski, J.A., R.B. Clapp, and J.T. Marshall, Jr. 1986. History and population status of the Black-capped Vireo in Oklahoma. American Birds 40:1151-1161.

Grzybowski, J.A. 1990a. Ecology and management of the Black-capped Vireo (*Vireo atricapillus*) in the Wichita Mountains, Oklahoma - 1990. Wichita Mountains, Wildlife Refuge. U.S. Fish and Wildlife Service, Indiahoma, Oklahoma. 28 p.

Grzybowski, J.A. 1990b. Population and nesting ecology of the Black-capped Vireo - 1990. Resource Protection Division, Texas Parks and Wildlife Department, Austin, TX. 39 p.

Heisterberg, J.F., F.N. Garcia, and A.D. Perez. 1985. Evaluating Shiny Cowbird control techniques in eastern Puerto Rico. Progress Report, Denver Wildlife Research Center, Bird Damage Research Report No. 354, Denver.

Hoover, J.P. 1992. Factors influencing Wood Thrush (*Hylocichla mustelina*) nesting success in a fragmented forest. M.S. Thesis, The Pennsylvania State University, University Park, PA.

Hoover, J.P., and M.C. Brittingham. 1993. Regional variation in cowbird parasitism of wood thrushes. Wilson Bulletin (in press).

Johnson, D.M., G.L. Stewart, M. Corley, R. Ghrist, J. Hagner, A. Ketterer, B. McDonnell, W. Newsom, E. Owen, and P. Samuels. 1980. Brown-headed Cowbird (*Molothrus ater*) mortality in an urban winter roost. Auk 97:299-320.

Johnson, R.G., and S.A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal Wildlife Management 54:106-111.

Martin, T.E. 1992. Breeding productivity considerations: what are the appropriate habitat features for management. Pp. 455-473 *in* J.M. Hagan and D.W. Johnston (eds.). Ecology and consideration of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C.

May, R.M., and S.K. Robinson. 1985. Population dynamics of avian brood parasitism. American Naturalist 126:475-494.

Mayfield, H.F. 1965. The Brown-Headed Cowbird with Old and New Hosts. Living Bird 4:13-28.

Mayfield, H.F. 1977. Brown-headed cowbird: agent of extermination? American Birds 31:107-113.

Nice, M.M. 1953. The question of ten-day incubation periods. Wilson Bulletin 65:81-93.

Nolan, V., Jr. 1978. The ecology and behavior of the Prairie Warbler *Dendroica discolor*. Ornithological Monographs No. 26. American Ornithologists' Union, Washington, D.C.

Ortega, C.P., and A. Cruz. 1991. A comparative study of cowbird parasitism in Yellow-headed Blackbirds and Red-winged Blackbirds. Auk 108:16-24.

Overcash, J.L., and J.L. Roseberry. 1987. Evaluation of Shawnee National Forest wildlife openings. Final Report W-94-R, Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale. 121 p.

Pease, C.M., and J.A. Grzybowski. MS. A Model for assessing the consequences of brood parasitism on seasonal fecundity in passerine birds. Ecology (submitted).

Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The breeding bird survey: Its first fifteen years, 1965-1979. USFWS Res. Publ. 157, Washington, D.C.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. 1989. Habitat area requirements of breeding forest birds of the middle Atlantic states. Wildlife Monographs 103:1-34.

Robinson, S.K., and D.S. Wilcove, in review. Forest fragmentation in the temperate zone and its effects on migratory songbirds. *In*: K. Young and M.A. Ramos (eds.), The conservation of migratory birds in the Neotropics. International Council for Bird Preservation, Washington, D.C.

Roskaft, E., G.H. Orians, and L.D. Beletsky. 1990. Why do Red-winged Blackbirds accept eggs of Brown-headed Cowbirds? Evolutionary Ecology 4:35-42.

Rothstein, S.I. 1975a. An experimental and teleonomic investigation of avian brood parasitism. Condor 77:250-271.

Rothstein, S.I., J. Verner, and E. Stevens. 1980. Range expansion and diurnal changes in dispersion of the Brown-headed Cowbird in the Sierra Nevada. Auk 97:253-267.

Rothstein, S.I., J. Verner, and E. Stevens. 1984. Radio-tracking confirms a unique diurnal pattern of spatial occurrence in the parasitic Brown-headed Cowbird. Ecology 65:77-88.

Rothstein, S.I., D.A. Yokel, and R.C. Fleischer. 1986. Social dominance, mating and spacing systems, female fecundity, and vocal dialects in captive and free-ranging Brown-headed Cowbirds. Current Ornithology 5:127-185.

Rothstein, S.I., J. Verner, E. Stevens, and L.V. Ritter. 1987. Behavioral differences among sex and age classes of the Brown-headed Cowbird and their relation to the efficacy of a control program. Wilson Bulletin 99:322-327.

Rothstein, S.I., D.A. Yokel, and R.C. Fleischer. 1988. The agonistic and sexual functions of vocalizations of male Brown-headed Cowbirds, *Molothrus ater*. Animal Behavior 36:73-86.

Scott, D.M. 1963. Changes in the reproductive activity of the Brown-headed Cowbird within the breeding season. Wilson Bulletin 75:123-239.

Sealy, S.G. 1992. Removal of Yellow Warbler eggs in association with cowbird parasitism. Condor 94:40-54.

Smith, F. 1977. A short review of the status of riparian forests in California. Pp. 1-2 *in* A. Sands (ed.). Riparian forests in California: their ecology and conservation. Institute for Ecology Publication 15. 122 p.

Smith, J.N.M. 1981. Cowbird parasitism, host fitness, and age of the host female in an island Song Sparrow population. Condor 83:152-161.

Spaw, C.D., and S. Rohwer. 1987. A comparative study of eggshell thickness in cowbirds and other passerines. Condor 89:307-318.

Temple, S.A., and J.R. Cary. 1988. Modeling dynamics of habitat-interior bird populations in fragmented landscapes. Conservation Biology 2:340-347.

Thompson, F.R, III, W.D. Dijak, T.G. Kulowiec, and D.A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. Journal of Wildlife Management 56:23-30.

Thompson, F.R, III. Spatial and temporal patterns of breeding Brown-headed Cowbirds in the Midwest United States. In Review.

Unitt, P. 1987. *Empidonax trailllii extimus* : an endangered subspecies. Western Birds 18:137-162.

USDI. 1973. Building and operating a decoy trap for live-capturing cowbirds and other birds. U.S. Department Interior, Fish and Wildlife Service, Twin Cities, Minn. Leaflet AC 211. 4 p.

Verner, J., and L.V. Ritter. 1983. Current status of the Brown-headed Cowbird in the Sierra National Forest. Auk 100:355-368.

Walkinshaw, L.H. 1983. Kirtland's Warbler. Bloomfield Hills, Cranbrook Institute of Science.

Weatherhead, P.J. 1989. Sex ratios, host-specific reproductive success, and impact of Brown-headed Cowbirds. Auk 106:358-366.

Whitcomb, R.F., C.S. Robbins, J.F. Lynch, B.L. Whitcomb, K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pp. 125-205 *in* R.L. Burgess and D.M. Sharpe (eds.), Forest island dynamics in man-dominated landscapes. Springer-Verlag, New York.

Yokel, D.A. 1989. Intrasexual aggression and the mating behavior of Brown-headed: their relation to population densities and sex ratios. Condor 91:43-51.

Incorporating Effects of Natural Disturbances in Managed Ecosystems

John T. Rotenberry[1], Robert J. Cooper[2], Joseph M. Wunderle[3], and Kimberly G. Smith[4]

Abstract — We briefly review the effects of climate (particularly drought and hurricanes), insect outbreaks, and fire on populations of migrant birds. An important feature of all of these natural disturbances is that they occur over a variety of spatial and temporal scales, thus precluding any simple generalization of their effects or of methods for mitigating those effects. We recognize that (1) natural catastrophic phenomena will inevitably occur; (2) an ecosystem will consist of a mosaic of patches that reflects the recurrence time and spatial extent of these disturbances; and (3) after some period a disturbed patch will recover. We therefore recommend that an appropriate goal is to have as a management unit a sufficiently large area (not necessarily contiguous) to contain some minimum number of patches that will be in a recovered state. This "incorporation" of disturbance is facilitated by increasing the size of the management unit or altering the size and/or frequency of disturbance. We suggest that the most pressing research need is to determine the characteristic scale of disturbances that are important and relevant to the species and habitats that we have an interest in preserving.

INTRODUCTION

Populations of migrant birds are affected by natural changes in weather, climate, and habitat, and by unpredictable events like drought, hurricanes, fire, and insect infestations. In this chapter we briefly review the effects of potentially "catastrophic" natural events on bird populations and discuss methods for managing, or at least mitigating, those effects. As natural phenomena, these events are integral features of every ecosystem (more frequent in some than in others), and coping with their occurrence in any managed ecosystem is not a question of "if" they occur, but of "when." The effects of these events on populations of neotropical migrant birds are discussed in greater detail in Rotenberry et al. (1993).

Although there is obviously a great diversity of potential natural disasters, we restrict our discussion to three major classes - climate (particularly drought and hurricanes), insect outbreaks, and fire. Unfortunately, generalization about these events and their effects is complicated by the strong interrelationships among them. For example, periods of extended drought are often associated with both an increased likelihood of fires and epidemic outbreaks of insects (e.g., Mattson and Haack 1987). Likewise, insect outbreaks contribute to the development of a fuel complex that makes fires more probable (Knight 1987), and, in turn, trees scarred by fire serve as epicenters for outbreaks of insects (Knight and Wallace 1989 and references

[1]*Natural Reserve System and Department of Biology, University of California, Riverside, California 92507.*

[2]*Department of Biology, Memphis State University, Memphis, Tennessee 38152.*

[3]*Institute of Tropical Forestry, U.S. Forest Service, Palmer, Puerto Rico 00721.*

[4]*Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701.*

therein). Finally, changes in vegetation cover, particularly the loss of vegetation due to fire or infestation, may affect regional patterns of climate, especially precipitation (e.g., Shukla et al. 1990).

CLIMATE

One of the salient features about climate is that variation in weather can be expressed over a variety of spatial and temporal scales (Michaels and Hayden 1987). Drought, for example, is only manifest over a period of months or even years, whereas a tropical storm may intensify to hurricane strength, make landfall, then dissipate within a week. Likewise, climatic effects on birds can also be observed over extremes of scales. There is ample evidence for the effects of drought on bird populations, and these effects may extend over tens of thousands of square kilometers (e.g., DeSante 1992). Although some individuals die of water stress, in most cases the effects are indirect, mediated through the direct effects of water scarcity on food availability and habitat suitability (Smith 1982, George et al. 1992). During the breeding season, drought effects are particularly manifest in reproductive success (e.g., Marr and Raitt 1983, Petersen et al. 1986, Rotenberry and Wiens 1991, George et al. 1992). In contrast to the large scale effects of drought, a single hailstorm may arise in a few hours on a hot afternoon, and the resulting pounding may destroy all open nests within a few tens of hectares. During the non-breeding season, average annual rainfall influences overall neotropical migrant abundance, particularly in the Caribbean, with relatively drier areas, whether scrub or forest habitat, having consistently lower numbers of individuals (Wunderle and Waide 1992, Terborgh and Faaborg 1980, Askins et al. 1992). The most obvious management strategy to lessen the impact of drought on wintering migrants in the Caribbean is to preserve moist and mesic forests, particularly in drought-prone regions.

Hurricanes also cause declines in wintering or passage migrants in the southeastern U.S. and Caribbean (e.g., Walkinshaw 1983, Hamel 1986). Since most hurricanes occur early in the migratory period, migrant birds are not likely to suffer directly from hurricanes, but are more likely to suffer from secondary effects, which often involve massive habitat alteration (Wunderle et al. 1992). Furthermore, this alteration has a disproportionate impact on certain foraging guilds, especially frugivores and nectar feeders. The most effective mitigation strategies involve habitat corridors between montane forest reserves, which are especially susceptible to storm damage, and lowland forest reserves to which montane forest inhabitants can migrate after hurricanes (Wunderle 1990, Waide 1991). Lowland vegetation, because of its rapid growth rate, can recover faster than montane vegetation, and thus can serve as refugia for montane species in a storm's aftermath.

INSECT OUTBREAKS

Whereas the effect of the habitat destruction wrought by a hurricane can from most perspectives be viewed as a catastrophe, the effects of other forms of potential disturbance on birds may be much more equivocal. For example, most neotropical migratory birds inhabiting eastern forests are insectivorous during the breeding season. It is, therefore, not surprising that many species of neotropical migrants increase in both density and productivity in response to outbreaks of defoliating caterpillars (e.g., Morris et al. 1958, Zach and Falls 1975, Morse 1978, Sealy 1979, Holmes et al. 1986, Crawford and Jennings 1989). Fluctuations in abundance of caterpillars accounted for some major fluctuations in bird populations observed by Holmes and his colleagues in New Hampshire (Holmes et al. 1986). Low caterpillar densities apparently caused poor reproductive success and low survival of several species, and led Holmes and his colleagues to suggest that birds at their site were normally food limited except during caterpillar outbreaks, when release from food limitation occurred. Insect outbreaks may also affect birds negatively, however, in that excessive tree mortality caused by an insect outbreak may decrease overall habitat suitability for some species, and further contribute to increasing edge habitat in temperate forests. Also, the primary method of managing outbreaks of serious forest pests is pesticide application, which has deleterious effects on birds, especially when applied over thousands of hectares. In general, the question of how management of forest insect pests affects populations of neotropical migratory birds has hardly been addressed. Of particular concern is the gypsy moth (*Lymantria dispar*), an introduced species still expanding its range into the Southeast and Midwest. It can have a serious impact on habitat quality (e.g., Thurber 1992), and is not a major prey item for many bird species (Smith 1985). Fortunately, there are silvicultural alternatives to pesticides that are effective in simultaneously managing for forest birds and insect pests.

FIRE

Historically, fires were common on the prairies of North America and in the coniferous forests of the Southeast. In many ecosystems fire normally occurs with sufficient frequency that both plants and animals are well-adapted to its passage; indeed, some species may require fire-maintained vegetation or habitat for their continued existence (Van Lear and Waldrop 1989). Fires may maintain openings within forests that may be important to birds (Taylor and Taylor 1979). Fire suppression activities can retard the natural frequency of burns in such systems, which may in turn adversely affect those species whose persistence depends on its periodic occurrence (e.g., Mayfield 1960, Remsen 1986).

Fire can have many impacts upon an ecosystem, including changes in local climate and microclimatic conditions, composition and structure of the vegetation, and animal abundances and distributions (Bendell 1974). Fires may vary in intensity, duration, frequency, location, shape, and extent, and effects may differ with season, nature of fuel, and properties of the site and soil. Because of the wide variation that occurs in fires and their effects, it has been difficult to generalize about the relationship between fire and birds (Bendell 1974, Sousa 1984). However, Wright and Bailey (1982) summarized results of several studies and presented a list of birds, many of which are neotropical migrants, that are favored by open plant communities caused by fires and those that are more common in unburned areas. More recently, regional reviews and computer simulations of impacts of fire on bird communities have appeared (e.g., Landers 1987, Kerpez and Stauffer 1989, McMahon and Calestra 1990). The results of these studies are described more fully in Rotenberry et al. (1993).

After humans arrived in North America, the use of fire, both purposefully and carelessly (Smith and Petit 1988) greatly intensified its effects and frequency, particularly in grasslands (Wright and Bailey 1982) and coniferous forests (Van Lear and Waldrop 1989, Baker 1992). Currently, both prescribed burning and suppression of natural fires are important management tools (Wade and Lundsford 1990). In some instances, prescribed burning may mimic the effects of naturally occurring fires, while in others, effects of wildfires may be quite different from prescribed burning (Baker 1992). When wildfires do occur after a long period of fire suppression, as a result of extra fuel buildup they may escape to burn a larger area and at a greater intensity than they would otherwise, transforming a normal ecological event into a catastrophe. For example, high intensity canopy fires probably occurred less frequently before settlement of the western United States (Baker 1992), but those kinds of fires can have a great impact on the structure of the post-fire bird community (R. Hutto, unpubl. data).

Even under a normal fire regime, local habitat conditions are altered, and may become temporarily unsuitable for some species (Wright and Bailey 1982). Additionally, fire may enhance the invasion of exotic plant species, such as cheatgrass (*Bromus tectorum*) in Great Basin shrubsteppe, which may in turn prevent the normal post-fire successional pathway or recovery process (e.g., West 1979). Unfortunately, our review (Rotenberry et al. 1993) indicates a lack of many long term controlled studies of the effects on passerine birds of fire frequency, habitat type, timing, and weather conditions, all important considerations in developing a burn prescription (Stoddard 1962).

MANAGEMENT ISSUES

Each of these phenomena has the ability to alter the number of individuals present in a local or regional population of birds, either through direct effects on survivorship, or indirectly by modifying the abundance of prey and/or suitable habitat. While these phenomena are often viewed from a human perspective as catastrophes, their effects on birds may be either positive or negative. It is difficult to determine, however, the degree to which this represents a natural "regulation" of population size (Sherry and Holmes 1992). In the case of large scale climatic patterns (as opposed to localized "disasters"), the answer is almost trivially "yes" - species do not occur where the climate is routinely unfavorable for their particular life history and physiology, or creates a habitat type to which they are not adapted. To the extent that a species is dependent upon a fire-maintained habitat type or any "sub-climax" or early successional habitat, then its distribution, if not its actual population size, is regulated by fire or disturbance.

Perhaps more important from the perspective of a land manager charged with the responsibility of preserving a particular species or habitat type is not whether a population's abundance is "regulated" by some particular disturbance, but whether such a disturbance could cause the extinction of that population. Such can clearly be the case, for the local extinction of several species of terrestrial island birds in the Caribbean due to the passage of hurricanes has been documented (Raffaele 1977, Hamel 1986, Wauer and Wunderle 1992). Indeed, we may have just lost 5-6 species of Hawaiian Islands endemics, whose last known populations (most less than 50 individuals; Scott et al. 1986) occurred in the Alakai Swamp on Kauai, just devastated by Hurricane Iniki on 11 September 1992.

Apart from the shop-worn observation that smaller populations are more at risk than larger ones, theoretical predictions of the effects of disturbances on populations are few. We would like to provide a more general model of managing for disturbance based on emerging theory from landscape ecology (e.g., Forman and Godron 1985, Turner 1986, Urban et al. 1987), part of the "new paradigm" in ecology described by Maurer (Maurer et al., this volume). We recognize that certain natural phenomena that adversely affect bird populations will inevitably occur even in the most intensively managed ecosystem, and that these phenomena tend to occur over characteristic spatial and temporal scales (e.g., Michaels and Hayden 1987). We further recognize that these ecosystems will (or should) consist of a mosaic of patch types (of an average size reflecting the characteristic spatial scale of the disturbance), and that these patch types will vary depending on the time since last disturbance - after some period of time, depending on the type of disturbance, a patch will "recover," or be returned to its pre-disturbance state (assuming it is possible to do so). The goal is to have as a managed ecosystem a sufficiently large area (not necessarily contiguous) to contain some minimum number of patches (i.e., some minimum area, which will depend on the life history of the species of management interest) that will be in a recovered state. In other words, the disturbance is "incorporated" as a natural part of the managed ecosystem (Urban et al. 1987). Not only should this provide protection for species characteristic of undisturbed or recovered areas, but allows for the persistence of other species that may depend upon disturbed areas or ecotones.

In the simplest case, incorporation can be passive - a disturbance is incorporated simply by increasing the size of the managed unit (Urban et al. 1987). The management question is whether a particular region such as a park, a reserve, a Forest District, or a Management Area is of sufficient scale to incorporate a given disturbance. A rule of thumb relevant to habitats containing neotropical migrants has been developed from forest simulation modelling, which suggests that the focal area should be about 50 times the average size of the disturbance of interest (Shugart and West 1981). A managed landscape that is large enough to incorporate the factors that disturb its component patches will have a constant frequency distribution of patches of all types at all times; this is called an "equilibrating landscape" (Shugart and West 1981). A smaller "nonequilibrating landscape" is unable to incorporate a disturbance and has a transient frequency distribution of patch types, which changes in response to each disturbance event.

Perhaps the greatest effect of humans on landscapes has been to rescale patterns in time and space (Urban et al 1987). Most important, the size of managed landscapes has been reduced via habitat fragmentation, rendering them less able to incorporate natural disturbances of a given size and/or frequency. Less apparent has been the inadvertent increase in the size of otherwise "natural" disturbances, as in the control of fire (see above). By increasing the size of fires, humans may transform an equilibrial landscape into a nonequilibrating one, even with no alteration of the size of the managed ecosystem. Another example is the establishment of forest plantation monocultures, such as southern pines, which are not only more susceptible to pine beetle infestations (a species of relatively low palatability to birds), but also spread those impacts over a larger area.

In many cases, increasing the size of a management unit will not be feasible. Nonetheless options do exist to reduce the size of natural disturbances. As an example, a land manager could prescribe numerous small burns in a bounded area that has been reduced in size and has become thereby more susceptible to larger natural fires (Urban et al. 1987). In this case, block or patch burning may be better than one large burn (Givens 1962). Wright and Bailey (1982) thought that the most important concern for maximizing diversity was to have a wide variety of relatively small different-aged burns interspersed among areas that had not been burned for several hundred years. Wildfires deemed likely to cause excessive damage can be actively suppressed. Likewise, rather than attempting to eradicate a pest infestation throughout its entire extent, insect suppression activities could be concentrated at the periphery of the outbreak, limiting its spread. An integrated approach involving several pest management techniques should produce a landscape with a relatively small area of highly disturbed habitat. Although changing disturbance patch sizes may not restore a landscape to its original mosaic pattern (Baker 1992), it may nonetheless achieve a dynamic equilibrium. Clearly, the most pressing research need is to determine the scale of disturbances that are important and relevant to the species and habitats that we have an interest in preserving.

ACKNOWLEDGEMENTS

We thank D. Bolger and M. Zuk for thoughtful comments on a previous draft of this paper. We also thank numerous participants at the conference for their comments on our original presentation.

LITERATURE CITED

Askins, R.A., D.N. Ewert, and R.L. Norton. 1992. Abundance of wintering migrants in fragmented and continuous forests in the U.S. Virgin Islands. Pp. 197-206 in J.M. Hagen and D.W. Johnson (eds). Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C.

Baker, W.L. 1992. Effects of settlement and fire suppression on landscape structure. Ecology 73:1879-1887.

Bendell, J. F. 1974. Effects of fire on birds and mammals. Pp. 73-138 in T. T. Kozlowski and C. E. Ahlgeren (eds.). Fire and Ecosystems. Academic Press, New York.

Crawford, H. S., and D. T. Jennings. 1989. Predation by birds on spruce budworm Choristoneura fumiferana: functional, numerical, and total responses. Ecology 70:152-163

DeSante, D. 1992. The Monitoring Avian Productivity and Survivorship (MAPS) program: overview and progress. This volume.

Forman, R.T.T., and M. Godron. 1986. Landscape ecology. John Wiley and Sons, New York, NY.

George, T.L., A.C. Fowler, R.L. Knight, and L.C. McEwen. 1992. Impacts of a severe drought on grassland birds in western North Dakota. Ecol. Appl. 2:275-284.

Givens, L. S. 1962. Use of fire on southeastern wildlife refuges. Tall Timbers Fire Ecol. Conf. 1:121-126.

Hamel, P.B. 1986. Bachman's Warbler: a species in peril. Smithsonian Institution Press, Washington, D.C.

Holmes. R. T., T. W. Sherry, and F. W. Sturges. 1986. Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Brook. Ecol. Monogr. 56:201-220.

Kerpez, T. A. and D. F. Stauffer. 1989. Avian communities of pine-hardwood forests in the southeast: characteristics, management, and modeling. Pp. 156-168 in T.A. Waldrop (ed.). Proceedings of pine-hardwood mixtures: a symposium on management and ecology of the type. U.S.D.A. For. Serv. Gen. Tech. Rep. SE-58.

Knight, D.H. 1987. Parasites, lightning, and the vegetation mosaic in wilderness landscapes. Pp. 59-83 in M.G. Turner (ed.). Landscape heterogeneity and disturbance. Springer-Verlag, Berlin.

Knight, D.H., and L.L. Wallace. 1989. The Yellowstone fires: issues in landscape ecology. Bioscience 39:700-706.

Landers, J. L. 1987. Prescribed burning for managing wildlife in southeastern pine forests. Pp. 19-27 in J. G. Dickson and O. E. Maugh (eds.). Managing southern forests for wildlife and fish -- a proceedings. U.S.D.A. For. Serv. Gen. Tech. Rep. SO-65.

Marr, T.G., and R.J. Raitt. 1983. Annual variations in patterns of reproduction of the Cactus Wren (*Campylorhynchus brunneicapillus*). Southwest. Natur. 28:149-156.

Mattson, W.J., and R.A. Haack. 1987. The role of drought in outbreaks of plant-eating insects. Bioscience 37:110-118.

Maurer, B., F. Samson, and F. Knopf. 1992. Biological diversity, ecological integrity, and neotropical migrants: new perspectives for wildlife management. This volume.

Mayfield, H.F. 1960. The Kirtland's Warbler. Bull. Cranbrook Inst. Sci. 40:1-242.

McMahon, T. E. and D. S. de Calesta. 1990. Effects of fire on fish and wildlife. Pp. 233-250 in J. D. Walstad, S. R. Radosevich, and D. V. Sandberg (eds.). Natural and prescribed fire in Pacific Northwest forests. Oregon State Univ. Press, Corvallis.

Michaels, P.J., and B.P. Hayden. 1987. Modeling the climate dynamics of tree death. Bioscience 37:603-610.

Morris, R. F., W. F. Cheshire, C. A. Miller, and D. G. Mott. 1958. The numerical response of avian and mammalian predators during a gradation of the spruce budworm. Ecology 39:487-494.

Morse, D. H. 1978. Populations of bay-breasted and Cape May warblers during an outbreak of the spruce budworm. Wilson Bull. 90:404-413.

Petersen, K.L., L.B. Best, and B.M. Winter. 1986. Growth of nestling Sage Sparrows and Brewer's Sparrows. Wilson Bull. 98:535-546.

Raffaele, H.A. 1977. Comments on the extinction of *Loxigilla portoricensis grandis* in St. Kitts, Lesser Antilles. Condor 79:389-390.

Remsen, J. V., Jr. 1986. Was Bachman's Warbler a bamboo specialist? Auk 103:216-219.

Rotenberry, J.T., R.J. Cooper, J.M. Wunderle, and K.G. Smith. 1993. When and how are populations limited: the roles of insect outbreaks, fire, and other natural perturbations. In press in T.E. Martin and D. Finch (eds.). Ecology and management of neotropical migratory birds: a synthesis and review of critical issues. Oxford University Press.

Rotenberry, J.T., and J.A. Wiens. 1991. Weather and reproductive variation in shrubsteppe sparrows: a hierarchical analysis. Ecology 72:1325-1335.

Scott, J.M., S. Mountainspring, F.L. Ramsey, and C.B. Kepler. 1986. Forest bird communities of the Hawaiian Islands: their dynamics, ecology, and conservation. Stud. Avian Biol. 6:1-431.

Sealy, S. G. 1979. Extralimital nesting of bay-breasted warblers: response to forest tent caterpillars? Auk 96:600-603.

Sherry, R.T., and R.W. Holmes. 1992. Where and how are populations of neotropical landbirds limited: breeding, passage, or wintering habitats. This volume.

Shugart, H.H., and D.C. West. 1981. Long-term dynamics of forest ecosystems. Amer. Sci. 69:647-652.

Shukla, J., C. Nobre, and P. Sellers. 1990. Amazon deforestation and climate change. Science 247:1322.1325.

Smith, H. R. 1985. Wildlife and the gypsy moth. Wildl. Soc. Bull. 13:166-174.

Smith, K.G. 1982. Drought-induced changes in avian community structure along a montane sere. Ecology 63:952-961.

Smith, K. G., and D. R. Petit. 1988. Breeding birds and forestry practices in the Ozarks: Past, present, and future relationships. Bird Conserv. 3:23-49.

Sousa, W.P. 1984. The role of disturbance in natural communities. Ann. Rev. Ecol. Syst. 353-391.

Stoddard, H. L., Sr. 1962. Use of fire in pine forests and game lands of the Deep Southeast. Tall Timbers Fire Ecol. Conf. 1:31-42.

Taylor, C. M. and W. E. Taylor. 1979. Birds of upland openings. Pp. 189-197 in R. M. DeGraaf (tech. coord.). Proceedings of the workshop on management of northcentral and northeastern forests for nongame birds. U.S.D.A. For. Ser. Gen. Tech. Rep. NC-51.

Terborgh, J.W., and J.R. Faaborg. 1980. Factors affecting the distribution and abundance of North American migrants in the eastern Caribbean region. Pp. 145-155 in A. Keast and E.S. Morton (eds.). Migrant birds in the neotropics:ecology, behavior, distribution, and conservation. Smithsonian Institution Press, Washington, D.C.

Thurber, D. K. 1992. Impacts of a gypsy moth outbreak on bird habitats and populations. Ph.D. Dissertation, West Virginia University, Morgantown.

Turner, M.G. (ed.). 1987. Landscape heterogeneity and disturbance. Springer-Verlag, Berlin.

Urban, D.L., R.V. O'Neill, and H.H. Shugart. 1987. Landscape ecology. Bioscience 37:119-127.

Van Lear, D. H., and T. A. Waldrop. 1989. History, uses and effects of fire in the Appalachians. U.S.D.A. For. Ser. Gen. Tech. Rep. SE-54.

Wade, D. D., and J. Lundsford. 1990. Fire as a forest management tool:prescribed burning in the southern United States. Unasylva 41:28-38.

Waide, R.B. 1991. The effect of Hurricane Hugo on bird populations in the Luquillo Experimental Forest, Puerto Rico. Biotropica 23(4a):475-480.

Walkinshaw, L.H. 1983. Kirtland's Warbler. Bull. Cranbrook Inst. Sci. 58:1-207.

Wauer, R.H., and J.M. Wunderle. 1992. The effects of Hurricane Hugo on bird populations on St. Croix, U.S. Virgin Islands. Wilson Bull., in press.

West, N.E. 1979. Basic synecological relationships of sagebrush-dominated lands in the Great Basin and the Colorado Plateau. Pp. 33-41 in The sagebrush ecosystem: a symposium. Utah State University, College of Natural Resources, Logan, Utah.

Wright, H. A., and A. W. Bailey. 1982. Fire Ecology. John Wiley & Sons. New York. 501pp.

Wunderle, J.M. 1990. The effects of Hurricane hugo on bird populations in a Puerto Rican rainforest. Abstract, Wilson Ornithological Society meeting, Norton, Massachusetts.

Wunderle, J.M., D.J. Lodge, and R.B. Waide. 1992. Short-term effects of Hurricane Gilbert on terrestrial bird populations on Jamaica. Auk 109:148-166.

Wunderle, J.M., and R.B. Waide. 1992. Distribution of overwintering nearctic migrants in the Bahamas and Greater Antilles. Submitted to World Wildlife Fund-US.

Zach, R., and J. B. Falls. 1975. Response of the ovenbird (Aves: Parulidae) to an outbreak of the spruce budworm. Can. J. Zool. 53:1669-1672.

The Partners in Flight Species Prioritization Scheme

William C. Hunter[1], Michael F. Carter[2], David N. Pashley[3], and Keith Barker[2]

Abstract — The prioritization scheme identifies those birds at any locality on several geographic scales most in need of conservation action. Further, it suggests some of those actions that ought to be taken. Ranking criteria used to set priorities for Neotropical migratory landbirds measure characteristics of species that make them vulnerable to local and global extinction. Ranking parameters are global abundance, global extent of breeding and non-breeding distributions, threats during breeding and non-breeding periods, population trend, and the importance of the area under consideration for conservation of the species. Supplemental scores assigned to each species can indicate needs for greater survey and inventory, monitoring, research, or management effort. Species that share broadly classified habitats can be grouped to identify those habitats most in need of conservation attention. Management and acquisition strategies for efficient conservation of Neotropical migratory birds for a specific area, ranging in geographic scale from global to a small management unit, can then be developed.

INTRODUCTION

Clearly stated goals and objectives are the cornerstones of any conservation effort. To be successful, a conservation effort requires systems that set priorities for allocation of limited logistical and financial resources. A well-designed priority scheme should utilize available information to assist in making informed decisions among conflicting objectives.

The species targeted by Partners in Flight are linked on the basis of a single criterion - they all breed (at least partially) in North American temperate zones and migrate (at least partially) south of the continental United States during non-breeding seasons. Otherwise, the geographical distributions, life history traits, and taxonomic affinities of Neotropical migratory landbirds cover the range of avian biological potential. Some of these species are declining seriously and their continued survival is in doubt, others are still relatively numerous but show signs of recent widespread decline, while others are doing relatively well. Differentiating among species on the basis of their status and needs and identification of effective conservation actions should be the objectives of a prioritization scheme.

Conservation efforts to date have largely been aimed at individual species (e.g., game, endangered, or management indicator species) rather than ecosystems. However, there is increasing awareness that declines of individual species result from overall degradation of biological communities. The intent of a this priority scheme is to avoid single-species management by focusing attention on habitats used by suites of vulnerable species. Habitat-based approaches that combine information on individual species encourage efficient use of limited financial and logistical resources. Conservation plans can benefit suites of Neotropical migrants (and, hopefully, other birds and elements of biological diversity) in prioritized habitats. Highly vulnerable species dependent on habitats not otherwise among the highest priorities for conservation action can still be identified and appropriate measures implemented where necessary.

The following discussion provides a baseline for development of conservation strategies for Neotropical migrants. Readers (especially those who will be using this scheme) should

[1]*U.S. Fish and Wildlife Service, 75 Spring Street, SW, Atlanta, Georgia 30303.*

[2]*Colorado Bird Observatory, 13401 Piccadilly Road, Brighton, Colorado 80601.*

[3]*The Nature Conservancy, P.O. Box 4125, Baton Rouge, Louisiana 70821.*

be concerned less about assigning scores (which are to be provided by regional or local coordinators) and more about what the scores mean. Hopefully, all of the parameters will undergo rigorous examination in upcoming years. Elements of this scheme are all subject to modification and improvement as experience is gained through direct application. Users should remain in communication with appropriate Partners in Flight working groups and coordinators to be aware of and provide input into these changes. Even though this scheme is by no means perfect, it should provide approximate guidance in the absence of other useable tools. The intent of this scheme is to complement (and not compete with) existing lists of legally protected species at state and federal levels, candidates for legal protection, species of management (or special) concern, and sensitive species.

DEVELOPMENT OF A PRIORITIZATION SCHEME FOR NEOTROPICAL MIGRANTS

Background

Earlier conservation prioritization schemes that have influenced the evolution of this effort (Master 1991, Millsap et al. 1990, Rabinowitz 1981, Reed 1992) are not simultaneously applicable at different spatial scales. These schemes also do not allow consideration of the annual cycle of species with shifting seasonal distributions. The present scheme has been designed specifically for the unique conservation problems posed by migratory species.

The Management Steering Committee of Partners in Flight defined seven criteria that reflect a species' potential to be extirpated. These criteria include general aspects of the species' biology and factors operating at the various designated geographic scales important in the prioritization scheme (Table 1). Conservation planning should focus on local issues (species, habitats, status, trends, etc.), but efforts undertaken at local levels should be consistent with goals and objectives set at larger spatial scales (physiographic area, state, region, hemisphere). The emphasis of this scheme is geographical rather than taxonomic. Thus, evaluation of all the species occurring within a given region is of higher precedence than evaluation of all the regions within the range of a given species.

The geographic scale treated in this paper, the smallest for which reliable data are often available, can be defined either ecologically (physiographic area, based largely on the Breeding Bird Survey) or politically (state or province). Nations, commonwealths, and territories of the West Indies and smaller Latin American nations should be treated on the same scale as a physiographic area or state. Priorities can also be assigned at local, regional, and global geographic scales. Regions in temperate North America are based on the four Partners in Flight regional management working groups that follow the geographic structure of the International Association of Fish and Wildlife Agencies.

Table 1. — Spatial scales considered in setting priorities for Neotropical migratory landbirds, with examples for each scale underlined.

Scale	Examples
Global=hemispheric	Western Hemisphere (i.e., entire distribution of the species in the Western Hemisphere)
Regional	
1. Subsections of a subcontinent	As with temperate North America:
	Northeast
	Southeast
	Midwest
	West
2. Multinational	As within the West Indies:
	Bahamas
	Greater Antilles
	Lesser Antilles
Stratum, state or province, nation, commonwealth, teriitory	
1. Physiographic Area	As in Southern Piedmont
2. State or Province	As in Georgia
3. Nation, Commonwealth, Territory	As in Jamaica, Puerto Rico, U.S. Virgin Islands
Local	
1. Southern Piedmont of Georgia	Defined land management unit or group of cooperating land management units, as in Piedmont National Wildlife Refuge, Oconee National Forest, Hitchiti Experimental Forest
2. Wet tropical highlands in Puerto Rico	Defined land management unit or group of cooperating land management units, as in the Caribbean National Forest and surrounding properties

Concern Score

Seven factors are considered in ranking each species relative to other species at the state or physiographic area level (Table 2). A species is assigned a rank score in each category ranging from "1" (low concern) to "5" (extremely high concern). Globally determined factors are (1) global abundance, (2) extent

Table 2. — Seven factors considered within regional and state or physiographic area spatial scales for ranking Concern Scores for individual bird species. Each factor is scored from a minimum of "1" to a maximum of "5" points with total scores ranging from 7 to 35. The columns below represent only two of the spatial scales listed in Table 1, and it is important to consider that different types of information enter into the scoring process at each spatial scale.

Region	Physiographic area or state
Global abundance	Global abundance
Global breeding distribution	Global breeding distribution
Global wintering distribution	Global wintering distribution
Threats to breeding within region when known, global when not known	Threats to breeding within state or physiographic area when known, global when not known
Threats to non-breeding within region when known, global when not known	Threats to non-breeding within state or physiographic area when known, global when not known
Regional population trend	Physiographic area or state population trend
Area importance; percentage of global distribution	Area importance; abundance and distribution relative to global range

of breeding distribution, and (3) extent of winter distribution. For rankings in areas in which a bird breeds, (4) threat during the breeding season is determined specifically for the area of interest, whereas (5) threat during the non-breeding season is a constant value across all areas where each species breeds. For ranking a species in wintering habitat, (4) threats breeding is constant and (5) threats non-breeding would be based on local conditions. Two factors always scored locally are (6) population trend and (7) importance of the area to the species. A total species concern score can thus range from 7 to 35. Scores are site-specific, and will vary for a species across its range based upon varying local conditions.

Supplemental Scores

There is variability in the confidence with which concern scores are assigned. Reliability in population trend estimates is particularly questionable where Breeding Bird Survey data are limited. As another example, degrees of threat in specific areas may be derived solely on inference from larger spatial scales (Ehrlich et al. 1988, Finch 1991, Gradwohl and Greenberg 1989, Hagan and Johnston 1992).

As a result, a system of supplemental scores (action scores *sensu* Millsap et al. 1990) has been devised whereby reliable scores can be differentiated from scores in which there is less confidence. Each supplemental variable is scaled from "1" (little need for more information or action) to "5" (great need for more information or action).

Supplemental scores indicate the extent and location of gaps in our knowledge of Neotropical migratory bird biology. Where there is high uncertainty, effort must be invested to more accurately determine conservation needs. High supplemental scores can highlight needs for better survey (distribution) information, increased monitoring or research efforts, or for more intensive management than presently applied (Table 3). Supplemental scores also can protect managers from premature investment of resources on a species with a high concern score that is based on insufficient information.

CONCERN SCORE CRITERIA DEFINITIONS

Global Abundance

Global abundance, a constant used at all spatial scales, is a crude measure of a species' (hereafter to include subspecies and populations specifically identified for conservation purposes) vulnerability to catastrophic stochastic environmental events and, to some extent, demographic stochasticity. This presumes that more abundant species are more capable of absorbing adverse environmental and internal population dynamic impacts. Because total population sizes of all but the rarest species are unknown, global abundance is based on relative abundance in appropriate habitat and distribution of that habitat within the range of the species, relative to all other species (Table 4).

Breeding Distribution

Breeding distribution, another constant used at all spatial scales, is based on a review of range maps in various field guides, the American Ornithologists' Union Checklist of North American Birds (1983), and other sources (particularly, Rappole et al. 1983; Table 5). This and the following criterion also measure a species' vulnerability to stochastic environmental variation. Generally, species with wide distributions are less subject to naturally occurring or human-induced local effects. A species such as the Barn Swallow (*Hirundo rustica*) that is very widespread would receive the minimum score of "1," while a species such as the Colima Warbler (*Vermivora crissalis*) with a very local breeding range would receive the maximum score of "5." Locally occurring species (score of "4") include such birds as the Mountain Plover (*Charadrius montanus*) and Swainson's Warbler (*Limnothlypis swainsonii*) that occur locally within a wide distribution.

Table 3. — Supplemental rank scores addressing need for additional monitoring, survey/inventory, research, and management at any spatial scale. Adapted primarily from Millsap et al. (1990). These supplemental scores are intended to assist directing financial and logistical resources where they would be most needed; i.e., towards specific needs of species or groups of species in concert with their Concern Scores.

Criteria/Subcriteria	SCORE
Survey/inventory needs	
Distribution is extrapolated from a few localities or knowledge limited to general range maps	5
Some range limits or habitat associations are known, but local or regional occurrences cannot be predicted accurately	4
Broad range limits or habitat associations are known, but local occurrences cannot be predicted accurately	3
Distribution is generally well known and occurrences can be accurately predicted most of the time throughout range	2
Distribution is well known and occurrences can be accurately predicted throughout the range	1
Monitoring needs (population trend uncertainty)	
Not currently monitored, but monitoring needed	5
Areawide monitoring, but not with statistical sensitivity	4
Monitored locally with statistical sensitivity, but not areawide	3
Areawide monitoring with minimum sample size for statistical sensitivity	2
Areawide monitoring with statistical sensitivity, nearly complete census, or areawide monitoring deemed unnecessary	1
Research needs (identify breeding and non-breeding threats separately)	
Factors affecting population size and distribution, necessary for effective management, are unknown or unsubstantiated	5
A few factors affecting population size and distribution are known, but 1 or more factors are unknown hindering management efforts	4
Some factors affecting population size and distribution are known allowing for some effective management, but 1 or more important factors remain unknown	3
Most major factors affecting population size and distribution are known allowing for reasonably effective management	2
All major factors affecting population size and distribution are known or there is little perceived need to discover these factors	1
Management needs	
None or little directed at species, but management likely needed	5
Management mostly related to enforcement of conservation laws, deemed inadequate for recovery	4
Some direct or indirect (habitat or ecosystem level) management activities in addition to enforcement of conservation laws	3
Direct management intensively applied to taxon, some additional attention may be needed	2
None directed at species, with little perceived need	1

Table 4. — Definitions of rank scores for the Global Abundance criterion.

Rank Score	Definition
1	Abundant.
2	Common (to include locally abundant).
3	Uncommon to Fairly Common (to include locally common).
4	Rare to Uncommon (to include locally fairly common).
5	Very Rare to Rare (to include locally uncommon).

Table 5. — Definitions of rank scores for the Global Breeding Distribution criterion.

Rank Score	Definition
1	Very widespread -- ≥ 76-100% of temperate North America.
2	Widespread -- 51-75% of temperate North America.
3	Intermediate -- 26-50% of temperate North America.
4	Local -- 11-25% of temperate North America.
5	Very Local -- ≤ 10% of temperate North America.

Winter Distribution

Winter distribution, also a constant value, is generally not as well-delineated as breeding distribution for Neotropical migratory species. Therefore, actual examples of wintering distributions for each rank are used rather than some percentage of a subcontinent (Rappole et al. 1983; Table 6).

The distribution of species during migration, a factor that should be evaluated separately from breeding and winter distribution, is not herein considered (however, see Rappole et al. 1979). Consensus on how to produce a single score for distributions that vary within a migration period and that often differ between vernal and autumnal movements does not exist.

Threats During Breeding Season

This criterion, adapted from Millsap et al. (1990), is a measure of threat to each species in the area of interest (Table 7). It can incorporate three different aspects of the breeding biology of the species in question: demographic vulnerability, ecological vulnerability, and habitat loss and disruption. Demographic vulnerability assesses the ability of a species to recover from population loss on the basis of reproductive rate and/or juvenile mortality. Species with strict habitat limitations, or with specialized feeding and breeding requirements, are given a higher rank for ecological vulnerability. Habitat loss and

Table 6. — Definitions of rank scores for the Global Wintering Distribution criterion.

Rank Score	Definition
1	Very widespread -- southern latitudes of the U.S. through middle America into northern South America; or all of South America.
2	Widespread -- southern latitudes of the U.S. through Central America; or southern Central America into most of Southern America.
3	Intermediate -- throughout, but only in, Mexico; the entire Caribbean Basin and Caribbean Slope of Central America and southern Mexico; the Middle American highlands; or the entire Amazon Basin.
4	Local -- Caribbean Basin alone; Caribbean Slope of Middle America alone; Pacific Slope of Middle America alone; the Mexican Highlands; or the Andean Ridge of northern South America.
5	Very Local -- e.g., Bahamas only; Guatemala, Honduras, and Nicaragua highlands only; States of Jalisco, Michoacan, and Guerrero in Mexico; southern Sinoloa and southern Baja California in Mexico.

Table 7. — Definitions of rank scores for Threats during Breeding Season criterion when specific data are not available, but there is general consensus on threats (to include habitat loss, predation, parasitism, contaminants, persecution).

Rank Score	Definition
1	No known threat -- habitat increasing or stable, species with high reproductive potential, and ecological generalist.
2	Minor threat -- habitat loss between 1 and 10%, moderate generalist.
3	Moderate threat -- habitat loss between 11 and 25%, species with moderate reproductive potential and ecological specialization.
4	Extensive threat -- habitat loss between 26 and 50%, ecological specialist.
5	Extirpation likely -- habitat loss exceeding 50%, species with low reproductive potential, and ecological specialist.

disruption can result from certain forest management, water management, development, mining, and grazing practices. Habitat loss is often the most severe of these threats.

This criterion, particularly habitat loss, should be analyzed specifically for the area of consideration (Table 8). However, because local information is not available for most species in most areas, breeding threat scores set at higher spatial scales will generally be applied locally until better local information becomes available. Needs for clarification of breeding threats can be identified under the research supplemental score (Table 3).

Table 8. — An example format for threat during breeding at any scale of interest, when data are available, as adapted from Millsap et al. (1990). Rank scores for insertion into priority scheme could be: 5=33-40 pts., 4=25-32 pts., 3=17-24 pts., 2=9-16 pts., 1=0-8 pts. Also see Table 3.

Criteria/subcriteria	Score
<u>Distribution/habitat trend</u> (range 0-10 points)	
Area/habitat declined 51-100% 10	
Area/habitat declined 26-50% 8	
Area/habitat declined 11-25% 6	
Area/habitat declined 1-10% 3	
Area/habitat stable or increasing 0	
<u>Population concentrations</u> (range 0-10 points)	
Majority concentrates at a very few separate locations (for example, ≤ 20 at state or physiographic area, or smaller scale, and ≤ 50 at regional scale or larger	
Widespread but locally occurring 8	
Numbers concentrated over moderately wide range	
Numbers concentrated over a wide range	
Does not concentrate 0	
<u>Reproductive potential for recovery</u> (range 0-10 points)	
A) Average number of offspring produced after depredation and parasitism	
1 offspring/female/year 5	
2 offspring/female/year 3	
3 offspring/female/year 1	
3 offspring/female/year 0	
B) Average number of years female expected to reproduce	
1 year 5	
2 years 3	
3 years 1	
3 years 0	
<u>Ecological and behavioral specialization</u> (range 0-10 points)	
A) Dietary specialization (for example, feeds on a few specific food items)	
Decline, no shift to other resources, when primary resource declines	3.3
Substantial shift when primary resource declines	0
B) Reproductive specialization (for example, dependency on cavities, narrow physiological tolerances to climate for nesting)	
Decline, no shift to other resources, when primary resource declines	3.3
Substantial shift when primary resource declines	0
C) Other ecological or behavioral specialization not covered in A) or B) above (for example, requires exposed perch for foraging, specificroosting requirements)	
Highly specialized	3.3
Moderately specialized	1.7
Not specialized	0

Threats During the Non-breeding Seasons

Threats during migration and overwintering include two of three factors discussed under breeding threats (ecological specialization and habitat loss/disruption) (Table 9). This score remains constant for a species for areas in which it primarily breeds, and also can be constant in areas where it winters or through which it migrates where local data are not available (Table 10). Vulnerability due to distributional constraints during migration can be addressed indirectly under this criterion. Needs for additional data on threats during the non-breeding seasons, identified under research supplemental scores (Table 3), should generally be high.

Table 9. — Definitions of rank scores for Threats during Non-breeding Seasons criterion when specific data are not available, but there is general consensus on threats (to include habitat loss, predation, parasitism, contaminants, persecution).

Rank Score	Definition
1	No known threat -- habitat increasing or stable, ecological generalist during both migration and winter.
2	Minor threat -- habitat loss between 1 and 10%, moderate generalist during both migration and winter.
3	Moderate threat -- habitat loss between 11 and 25%, moderate ecological specialization during migration and/or winter.
4	Extensive threat -- habitat loss between 26 and 50%, ecological specialist during migration and/or winter.
5	Extirpation likely -- habitat loss exceeding 50%, ecological specialist during both migration and/or winter.

Population Trend

Population trend is determined independently in each area considered. Of the various population trend tracking approaches in use, only the Breeding Bird Survey (hereafter BBS) has broad utility across landscape, state/physiographic area, and regional spatial scales (Robbins et al. 1986). There are generally adequate BBS data available in the eastern 1/3 of temperate North America for assessment of population status at least to the state or physiographic area level. Although BBS data are also available throughout central and western temperate North America, interpretation of these data below the grossest spatial levels is problematic and nearly impossible for the many species occurring in riparian habitats or high elevations.

Localized monitoring studies (e.g., bird-banding, Breeding Bird Censuses, Christmas Bird Counts) can provide insight into population trends. Unfortunately, trend data in the tropics are non-existent beyond localized study sites. Even where local monitoring exists, great caution should be employed in applying these data beyond specific study areas.

Table 10. — An example format for threat during non-breeding at any scale of interest, when data are available. Also see Tables 3 and 8.

Criteria/subcriteria	Score
Distribution/habitat trend (range 0-10 points)	
Area/habitat declined 51-100%	10
Area/habitat declined 26-50%	8
Area/habitat declined 11-25%	6
Area/habitat declined 1-10%	3
Area/habitat stable or increasing	0
Population concentrations (range 0-10 points)	
Majority concentrates at a very few separate locations (for example, ≤ 20 at state or physiographic area, or smaller scale, and 50 at regional scale or larger	10
Widespread but locally occurring	8
Numbers concentrated over moderately wide range	6
Numbers concentrated over a wide range	3
Does not concentrate	0
Specialization (range 0-20 points)	
A) Dietary specialization during winter	
Decline, no shift to other resources, when primary resource declines	3.3
Substantial shift when primary resource declines	0
B) Other ecological or behavioral specialization during winter not covered in "A)" above (for example, requires exposed perch for foraging, specific roosting requirements, thermal tolerances, sexual or age specific habitat segregation)	
Highly specialized	3.3
Moderately specialized	1.7
Not specialized	0
C) Percent of southern U.S. border crossed by 90% of all individuals	
25% of border	3.3
26-75% of border	1.7
76-100% of border	0
D) Typical location for crossing into the Neotropics during migration	
Trans-Gulf of Mexico/Atlantic Ocean	3.3
Circum-Gulf or western riparian zones	1.7
Many locations for crossing	0
E) Ecological or behavioral specialization during migration	
Highly specialized	3.3
Moderately specialized	1.7
Not specialized	0
F) Typical time of migration flight	
Nocturnal	3.3
Diurnal	1.7
Both nocturnal and diurnal	0

The high degree of variability in the quality and quantity of population trend data results in a variety of means of scoring this criterion. In states or physiographic areas where there are adequate sample sizes for discerning population trends, a simple interpretation of BBS data, or other data sets, is possible (Table 11). Significance of trend and/or consistency of trend among samples are sufficient to determine rank scores where sample size is adequate.

Table 11. — Definitions of rank scores for Population Trends criterion, generally when sample size for BBS or other data sets allows for simple interpretations of trend magnitude and/or consistency.

Rank Score	Definition
1	Significant or definite increase -- significant overall increase or widespread signs of increase across a majority of sample units regardless of detection rate.
2	Possible increasing trend -- non-significant increasing trend or signs of increase especially in sample units where species is most frequently detected.
3	Apparently stable or trend unknown -- overall balance of increasing and decreasing trends among all sample units regardless of detection rates <u>or</u> data are unavailable or inadequate for interpretation.
4	Possible decreasing trend -- non-significant decreasing trend or signs of decrease especially in sample areas where species is most frequently detected.
5	Significant or definite decrease -- significant overall decrease or widespread signs decrease across all sample units regardless of detection rate.

Table 12. — Definitions of rank scores for Population Trends criterion, specifically where sample size for BBS does not allow for simple interpretations of trend magnitude and/or consistency.

Rank Score	Definition
1	Large increase -- (a) stable or increasing with fourteen or more routes with statistical significance and significant proportion of increasing routes agree with overall trend or (b) ≥ 5% annual increase with fourteen or more routes with statistical significance and proportion of increasing routes agreeing with overall trend.
2	Increase -- (a) stable or increasing with fourteen or more routes without statistical significance and/or the proportion of increasing routes corresponding with overall trend or (b) fourteen or more routes without statistical significance and/or the proportion of increasing routes do not agree with overall trend, with trend being ≥ 1% annual increase.
3	Trend unknown -- (a) non-significant trend is between -1.0 and 1.0% exclusive and/or sample size for species from Breeding Bird Survey is insufficient or (b) no quantitative monitoring information exists for species in the area.
4	Decrease -- (a) decreasing with fourteen or more routes without statistical significance and/or the proportion of decreasing routes corresponding with overall trend or (b) fourteen or more routes without statistical significance and/or the proportion of decreasing routes do not agree with overall trend, with the trend being 1% annual decrease.
5	Large decrease -- (a) decreasing with fourteen or more routes with statistical significance and significant proportion of decreasing routes agree with overall trend or (b) ≥ -5% annual decrease with fourteen or more routes with statistical significance and proportion of decreasing routes agreeing with overall trend.

Assessment of change in population status where sample sizes are small requires more care. Where sample sizes are small, trends must meet guidelines of reliability and magnitude in order to warrant either a very high or a very low score for population trend. Trend reliability will be affected by sample size, statistical significance, and consistency across BBS routes in the area of interest. A minimum sample size of 14 BBS routes for a state/physiographic area is recommended (B. Peterjohn and J. Sauer 1992, pers. comm.). Even where birds are recorded on a sufficient number of routes, data where average abundances are low (<1 bird per route) should be viewed with caution. Spatial consistency of trends within an area (among routes) is reflected in the values and significance test for the percentage of routes showing increases versus those showing decreases. A trend is considered numerically consistent if the majority of routes agree with the annual percent change trend, and even more consistent if the proportion of routes in agreement is significant.

Trend magnitude refers to the degree of population change per year. With high reliability, a 1% decline per year over a 20-year period results in an overall 18.2% population loss, which may not signal a need for emergency conservation action but should indicate that the species requires management attention. However, a 5% decline per year over a 20-year period, equating to an overall 64.2% population loss, suggests a need for emergency conservation action to avoid extirpation of the species from the area of interest. This urgency should be considered even if uncertainty values are high (Table 12).

Temporal consistency of BBS trend information can provide insight into a species' conservation needs. Not all population changes mandate a conservation response. For example, a species that decreased over the long-term (25+ years) period, but increased over the short-term (the last 10 years) might not be of immediate conservation concern if other information indicates that the species is undergoing natural population fluctuations or is showing recovery. In contrast, species that increased over the long-term, but have severely decreased recently could be of concern if decreases are due to rapid habitat loss or other catastrophic effects. Trends consistent in one direction and significant over long and short time frames are more reliable than trends that have changed over time. Although it is not obvious how to combine the two time frames for population trend into a single score that does justice to the species, a "combination score" can be developed (see approach taken by Thompson and Lewis, these proceedings).

Interpretation of these and other trend data is clearly a complex issue and the degree of reliability of data sets must be identified through the monitoring needs supplemental score (Table 3).

Importance of Area

The importance of area criterion, determined specifically for the area under consideration, is based upon the abundance and distribution of a species within the area relative to its abundance and distribution in other parts of its total range. Importance of an area will need to be calculated independently for breeding and non-breeding seasons where a species may be found throughout the year. This parameter is evaluated for a regional geographic scale on the basis of the percentage of the total distribution of the bird encompassed by the region under consideration (Table 13). Scores at the physiographic area/state scale are based on average detection rate and sample size among BBS routes relative to all other physiographic areas or states within the range of the bird (Table 14). Where reliable BBS data are unavailable, this criterion must be scored based on the consensus opinion of local experts. An understanding of the extent of optimal, suitable, and marginal habitat for each species in an area is useful in scoring this factor.

Table 13. — Definitions of rank scores for Importance of Area criterion for the regional spatial scale.

Rank Score	Definition
1	Very low -- < 1% of species' total distribution.
2	Low -- 1-10% of species' total distribution.
3	Moderate -- 11-25% of species' total distribution.
4	High -- 26-50% of species' total distribution.
5	Very High -- 51-100% of species' total distribution.

A species restricted in distribution to the area under consideration and another species that is globally widespread but abundant within the same area relative to the rest of its range both would receive high scores under this criterion. Recognizing high importance of an area for both types of species focuses conservation efforts on both local and widespread species. Nonetheless, the total concern score for the first species probably would include higher scores for both distribution parameters, global abundance, and levels of potential threat.

Because an area's importance is always evaluated relative to the rest of a bird's range, this value will initially be scored by regional and national coordinators and consistently and provided to states and physiographic areas for verification. Need for additional information on distribution, range of habitats used, and relative abundance can be identified in the survey/inventory supplemental score (Table 3).

IMPLEMENTATION OF THIS PRIORITY SYSTEM

Regional reports for these proceedings (Carter and Barker, Hunter et al., Thompson and Lewis, Smith et al.) that outline the use of this prioritization scheme at regional, physiographic area, and/or state spatial scales demonstrate the overall usefulness of this system. However, there are some general issues of use that should be expanded upon here.

Table 14. — Definitions of rank scores for Importance of Area criterion for the state/physiographic area spatial scale.

Rank Score	Definition
1	Very Low -- individual or isolated reports of breeding (or during migration or winter) of the species on an irregular or occasional basis.
2	Low (marginal)-- widespread but very local, "naturally" rare, or peripheral populations as defined by populations occurring on the extreme edge of geographical range or ecological tolerance and not considered significant overall to the species, but may be considered more important locally; this may include species with small and local populations occurring just within a physiographic area or state that are more widespread in adjacent areas, or species that are widespread within a physiographic area or state but occur in very low numbers.
3	Moderate (suitable, significant populations) -- populations important for representing the full genetic and ecological variation inherently found within the species, but are not populations with the highest rates of detection or relative abundance.
4	High -- important isolated populations as defined by a very local but relatively stable population or populations, often within a specific mountain range or river system, that should receive local attention but may not be of specific interest elsewhere within the physiographic area or state.
5	Very High (optimal) -- (a) a center of the species' abundance as defined by a high relative rate of detection on Breeding Bird Survey routes, (b) known optimal habitat is widespread within the area (in the absence of reliable data on relative abundance), (c) the only place or one of a few where the species is found, or (d) the species (historically numerous and widespread) is now extirpated or nearing extirpation.

Temperate Migrants and Permanent Residents

The focus of Partners in Flight is generally on long-distance migrants that breed primarily north of the Mexican-United States International Boundary and spend non-breeding seasons primarily south of this border (the "A" species list; Gauthreaux 1992). In addition, those Neotropical migratory species whose breeding ranges extend from primarily south of this border into the American Southwest and south Texas ("C" species list) and Peninsular Florida ("D" species list) also are receiving international conservation attention.

Calculation of concern scores should not be limited to these "A", "C", and "D" species. Other truly migratory birds include temperate migrants that winter entirely or primarily north of the

Mexican-United States International Boundary. Many of these species include some populations or individuals that spend boreal winters south of that border and are technically considered Neotropical migrants ("B" species list). There are also many other "Neotropical migrants" that rarely or never occur in the United States (Mexican and Caribbean breeding migrants, austral migrants, altitudinal migrants, etc.).

Concern scores also can be calculated for those species generally resident within the same geographical range throughout their annual cycle. The majority of residents requiring conservation attention occur in areas where Neotropical migrants spend boreal winters. Application of the prioritization scheme to residents and wintering migrants in Puerto Rico reveals the residents (and especially the endemics) are in much greater need of conservation attention than are the majority of migrants (Table 15). The general need to address conservation of Neotropical endemics as a priority over wintering Neotropical and temperate migrants is clearly justified. Moreover, conservation efforts for tropical endemics should result in benefits for vulnerable migrants as well and would make Partners in Flight a truly international and holistic conservation program.

Temperate migrants and permanent residents should not be ignored in inventory, monitoring, management, and other conservation efforts focused on Neotropical migrants. Segregation of data among species group can occur during analysis when desired. Comparison of trends between these and co-occurring Neotropical migratory species can be instructive.

Table 15.—Numbers of terrestrial bird species occurring in Puerto Rico within each of 5 concern score categories.

Range in concern score and definition	Caribbean residents	Neotropical migrants	Temperate migrants
30-35 Extremely High Priority	5(5*)	1	0
24-29 Very High Priority	23(10*)	9	0
19-23 High Priority	9(1*)	32	0
13-18 Moderate Priority	6	16	8
7-12 Low Priority	1	3	5

*Number of species endemic to Puerto Rico.

Comparisons Among States and Physiographic Areas

A standardized prioritization scheme applied nationwide can highlight conservation objectives that may not be obvious from a strictly local perspective. Where physiographic area boundaries cross into several states, shared ecological information can increase efficiency and effectiveness of management policies. Although comparisons among states and physiographic areas can assist in searches for patterns in the development of conservation plans, concern scores should not be used to pit states or physiographic areas against each other in setting priorities. Because unique sets and combinations of Neotropical migrants and habitats occur in each state and physiographic area, concentration on one area more highly rated than another could lead to unfortunate gaps in overall conservation efforts.

Developing Priorities for Habitats

Priorities for habitats are set by identifying the habitats used by each species and determining the sum of the concern scores for all species in each habitat type within a state or physiographic area. Rankings based on this procedure identify those habitats most in need of focused attention for effective Neotropical migrant conservation. Each regional working group has been charged with the identification of habitats requiring conservation attention and the reader is referred to the regional reports for these proceedings. Habitat-specific conservation planning, including management recommendations, is one of the upcoming goals for Partners in Flight. Note that progress toward habitat-specific efforts is hampered by the lack of consensus as to what constitutes a habitat and how they are classified regionally, nationally, and globally.

Next Steps

As indicated in the regional reports accompanying this paper, tentative prioritized lists for the breeding season for most regions of the United States, the physiographic areas of the Southeast and West, and the states of the West are currently available. These lists need to be revised on the basis of reviews of assigned values and greater national consistency in assessment of the above parameters. Temperate migrants (including "B" species) and permanent residents need to be added, and separate winter lists developed. Physiographic areas and states not currently treated should be completed and efforts should be started to apply this scheme to wintering grounds in the Neotropics. Greater attention needs to be directed toward evaluation and conservation of key stopover sites for in-transit migrants.

In the meantime, there are many specific steps that land managers and others interested in the conservation of these birds can take. A basic need on much public and most private land across the continent is inventory, initially of breeding and wintering species and habitat types. Nationally mandated criteria for monitoring programs are essentially available, and monitoring should be instigated in appropriate situations. Where inventory is incomplete or there are not clear and measurable management objectives for populations or habitats, however, a monitoring program may be premature.

In general, the supplemental scores are designed to direct conservation activity. High monitoring needs scores for many species in a given area may suggest a need for more BBS routes or other monitoring techniques for areas and habitats poorly served by BBS methodology. High management needs scores may stimulate specific actions by land managers. As management plans are devised and implemented, local monitoring may suggest a need for research into, for example, responses to land use practices.

The prioritization scheme can also guide land acquisition activities to some extent. Conservation agencies and organizations should include Neotropical migratory bird habitat as a criterion along with other issues of protection of biological diversity in making acquisition decisions. To the extent that birds are considered, habitat that is highly prioritized should be preferable to areas of lesser value.

There is no question that a certain amount of subjectivity is employed in assigning values, that more good data on the natural history of these birds is badly needed, and that the prioritization scheme needs to be applied and used and then modified where appropriate. Development of this scheme has been a dynamic process to date, and there is no intent for it to become a static entity with the publication of this document.

CONCLUSION

We agree with Millsap et al. (1990) that priority ranking systems should not replace human judgement in the allocation of conservation resources. Priority schemes should (1) serve as guides to resources in greatest need of conservation attention, (2) help identify where there are gaps in information, and (3) be flexible in allowing for revision when new and better information becomes available. We believe the scheme presented here fulfills these needs by addressing issues of identification of species, groups of species, or habitats of concern, of the primary causes leading to high concern scores, and of some potentially appropriate conservation responses.

ACKNOWLEDGMENTS

Many individuals have played significant roles in the development of this scheme and in the review of preliminary concern scores at national, regional, state, and physiographic area levels. We apologize for not being able to list all their names, but we do extend our sincerest appreciation for their help and patience in the review of what may have appeared to be an endless stream of numbers. We do wish to single out Beau McClure for his leadership of the Management Steering Committee for Partners in Flight; without his support, consensus on a single approach for setting priorities would have been much more difficult. John Dunning, Rob Marshall, Lisa Petit, John Sauer, Stanley Senner, Charles Smith, and Peter Stangel kindly provided comments that greatly improved the content and presentation of the manuscript.

LITERATURE CITED

American Ornithologists' Union. 1983. Checklist of North American birds, 6th edition and supplements. American Ornithologists' Union, Washington, D.C. Carter, M. and K. Barker. this volume. Setting conservation priorities for western Neotropical migrants.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook--a field guide to the natural history of North American birds. Simon and Schuster, Inc., New York.

Finch, D.M. 1991. Population ecology, habitat requirements and conservation of Neotropical migratory birds. Gen. Tech. Rept. RM-205. Ft. Collins, CO: U.S.D.A. For. Serv. Rocky Mountain Forest and Range Experiment Station.

Gauthreaux, S. 1992. Preliminary lists of migrants for *Partners in Flight* Neotropical Migratory Bird Conservation Program. National Fish and Wildlife Foundation's Partners in Flight Newsletter 2:30.

Gradwohl, J., and R. Greenberg. 1989. Conserving nongame migratory birds: a strategy for monitoring and research. Pp. 297-330 *in* Audubon Wildlife Report 1989/1990 (W.J. Chandler, ed.). Academic Press, Inc., San Diego.

Hagan, J. M., III, and D.W. Johnston, eds. 1992. Ecology and conservation of Neotropical migratory landbirds. Smithsonian Institution Press, Washington, D.C.

Hunter, W.C., D.N. Pashley, and R.E.F. Escano. this volume. Neotropical migratory landbird species and their habitats of special consideration within the Southeast region.

Master, L. 1991. Assessing threats and setting priorities for conservation. Cons. Biol. 5:559-563.

Millsap, B.A., J.A. Gore, D.E. Runde, and S.I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildl. Monogr. 111.

Rabinowitz, D. 1981. Seven forms of rarity. Pp. 205-217 *in* The biological aspects of rare plant conservation (H. Synge, ed.). Wiley, New York.

Rappole, J.H., E.S. Morton, T.E. Lovejoy, III, and J.L. Ruos. 1983. Nearctic avian migrants in the Neotropics. U.S. Fish and Wildlife Service, Washington, D.C.

Rappole, J.H., M.A. Ramos, R.J. Oehlenschlager, D.W. Warner, and C.P. Barkan. 1979. Timing of migration and route selection in North American songbirds. Pp. 119-214 *in* Proc. First Welder Wildlife Foundation Symposium (D.L. Drawe, ed.). Welder Wildlife Foundation, Sinton, Texas.

Reed, J.M. 1992. A system for ranking conservation priorities for Neotropical migrant birds based on relative susceptibility to extinction. Pp. 524-536 *in* Ecology and conservation of Neotropical migratory landbirds (J.M. Hagan III and D.W. Johnston, eds.). Smithsonian Institution Press, Washington, D.C.

Smith, C.R., D.M. Pence, and R.J. O'Connor. this volume. Status of Neotropical migratory birds in the Northeast: A preliminary analysis.

Thompson, F.R., S.J. Lewis, J. Green, and D. Ewert. this volume. Status of Neotropical migrant landbirds in the Midwest: Identifying species of management concern.

Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The Breeding Bird Survey: Its First Fifteen Years, 1965-1979. U.S. Fish and Wildlife Serv. Resource Pub. 157.

An Interactive Database for Setting Conservation Priorities for Western Neotropical Migrants

Michael F. Carter and Keith Barker[1]

Abstract — We develop and explain a species ranking system for the states and physiographic regions of the Neotropical Migratory Bird Conservation Program's West Working Group. The ranking criteria attempt to measure characteristics of species which make them vulnerable to extirpation, as well as assess the relative importance of different geographic and/or political areas to the species in question. These criteria include: the importance of the area of consideration to the species as a whole (importance of area), global abundance, threats on the breeding grounds, threats on the wintering grounds, extent of breeding distribution, extent of wintering distribution, and the population trend in the area of consideration. We have also designed uncertainty values for some of the criteria: threats to breeding, threats to wintering, and population trend. Considered separately and in various combinations, the criteria and uncertainty values allow the quick, objective determination of a species' status and possible conservation needs. The ranking process is the first step in developing community-oriented conservation efforts. This is accomplished by grouping ranked species by habitat relationships and thus ranking habitats of concern.

INTRODUCTION

The development of conservation priorities is vital to proper targeting of funds and efforts toward areas most in need and most likely to benefit. This is not a simple process, and involves several steps in order to develop priorities which reflect biological reality. In the past, much effort has been aimed at "single-species management," that is, conservation of individual species rather than the biotic communities which support them (Hutto et al. 1987). Often, however, it has been degradation of those very communities that has been the root of the problems confronting individual species. The shift in conservation biology theory, and, to some extent, in practice, has been from species-oriented conservation to a more community-oriented approach.

There are several ways to determine which communities are most in need of conservation (Millsap 1990, Master 1991, Reed 1992). The technique we develop here is the one adopted by Partners in Flight and focuses on neotropical migrants (including most short-distance migratory birds). Our goal is to develop a process that ranks individual species and that can also be used to develop and justify community-based conservation programs.

We first assign objective numeric concern scores across seven criteria for individual species for an area of interest (regions, states and/or physiographic areas). The mean of these scores reflects the species' relative status and vulnerability to extirpation in that area. The second step assigns habitats to each species. These associations are then used to group communities for a cross-community analysis of concern for neotropical migratory birds. Based upon this estimate of community importance for migratory birds, it is possible to determine where community management will benefit the most species for the effort/expenditure involved. It should be noted, however, that community priority-setting should be thoughtfully combined with individual species-oriented priority-setting in order to assure that high priority species which happen to fall into otherwise low-priority community groups are not overlooked.

[1] *Colorado Bird Observatory, 13401 Piccadilly Road, Brighton, Colorado 80601.*

Here, we present examples of priorities at the species level for West Working Group states and physiographic regions with an interactive database. In addition, we use the database to adapt species rankings to a habitat-based prioritization for Colorado.

METHODS

The Partners in Flight (PIF) Management Steering Committee has developed seven criteria that indicate the potential for a species to be extirpated from an area (Hunter et al., this volume). These criteria reflect and expand upon other ranking strategies (Master 1991, Reed 1992), and include general species' biology applicable to a species as a whole, but also factors which allow adjustment of conservation priority to reflect the geographic area of interest. Thus, using these criteria, it is possible to develop species scores at continental, regional, and state/physiographic scales. After modifying these data with habitat information, it is possible to step down from the state/physiographic area level to a local management area, such as a Forest Service forest or Bureau of Land Management district.

The seven criteria selected for the ranking process are: importance of area of consideration to species as a whole (importance of area), global abundance, threats on the breeding grounds, threats on the wintering grounds, extent of breeding distribution, extent of wintering distribution, and the population trend in the area of consideration (see Hunter et al., this volume). An individual species is assigned a score in each of these categories ranging from one (low concern) to five (high concern). We considered weighting the criteria so each could have a different relative effect in the priority rankings. However, in the absence of information suggesting which criteria may be more important, or more accurate in determining conservation priority for a species, we chose to keep the weights equal across criteria. We used mean scores calculated across the seven criteria in developing rankings to allow comparison of scores with different scales (continental, regional or local), that might contain more or less than the seven criteria presented here. Values for importance of area, global abundance, and the extent of breeding and wintering grounds were considered absolutes, with little or no room for variation, except in the long term. Values for wintering and breeding threats, as well as population trend, reflect the actual situation only insofar as research and sampling procedures are extensive and accurate. This is not always, in fact very seldom, the case.

In light of this consideration, we developed uncertainty values associated with threats to breeding, wintering, and population trend, which reflect the extent of our knowledge, and thus our confidence in the estimate presented. Uncertainty values are based, in part, on suggestions by Millsap et al. (1990), who use similar variables to guide their prioritization scheme. These uncertainties are, like the main variables, also scaled from one to five, with one indicating a high degree of confidence in the a value for a criteria, and five indicating a high degree of uncertainty.

We consider uncertainty values vital to the priority-setting process. Uncertainty values protect managers from prematurely investing time and effort on a species based simply upon its high ranking. If a species is high-ranked, but our knowledge of the species is scanty, managers can use caution in developing conservation programs. Conversely, with a species that is high-ranked, with low uncertainty, managers can approach its management with confidence.

Uncertainty scores, more than simply gauging the reliability of concern estimates, indicate extent and location of gaps in our knowledge of neotropical migrant biology. In species with high uncertainty values, we know that more effort must be invested in basic research, or monitoring, to more accurately determine a species' status.

Criteria Definitions

The following is a summary of the PIF ranking process used by the West Working Group. After each criterion is a short explanation of its function and purpose. These criteria follow those set by the Management Steering Committee, with the addition of the uncertainty values described above. These criteria are also being used by the other PIF regions. We modified population trend criterion to reflect the generally sparse information available in the West. Also, we used an interpretation of the importance of area criterion that varies slightly from that used in other regions (see discussion below). Species included in our analysis are listed as types "A", "B", and "C" by Gauthreaux (1991). We added two species, the Osprey and the Golden-crowned Kinglet (marked Supplemental), and marked one species, Lesser Goldfinch, as being of questionable NTMB status (NTMB?) (AOU 1983).

1. Importance of Area of Consideration (IA).

Rank		State/Physiographic Area
1	Very low	(1% of species' total distribution)
2	Low	(1-10% of species' total distribution)
3	Moderate	(11-25% of species' total distribution)
4	High	(26-50% of species' total distribution)
5	Very High	(51-100% of species' total distribution)

This criterion is specific to the area of consideration, in that it reflects species distribution within that area, compared to the total range of the species as reflected by range maps (National Geographic Society 1983) and descriptions (AOU 1983). The species score for this criterion depends both on the size of the considered area and on the size of the species' range (e.g., proportion of the Mountain Plover's range contained by Colorado). This criterion is highest for species whose total range is encompassed by the area of consideration. Comparing the range within the area of interest to the species' entire range allows direct comparison of state/physiographic area scores between regions, as well as comparisons between different areas of interest.

2. Global Abundance of Species (GA).

Rank

1 Abundant

2 Common

3 Uncommon to fairly common (includes locally common)

4 Rare to uncommon (includes locally fairly common)

5 Very rare to rare (includes locally uncommon)

This criterion is adopted from The Nature Conservancy's National Heritage Program rating (Master 1991). It is independent of geographic scale of consideration. Global abundance of a species is a crude measure of vulnerability to catastrophic stochastic environmental events, and to some extent, to demographic stochasticity. In general, species which have the greatest population bases are most capable of absorbing adverse environmental, and internal, population dynamic effects.

3. Threats on breeding ground for area of consideration (TB).

Rank

1 No known threat--Habitat increasing or stable, species with high reproductive potential, ecological generalist.

2 Minor threat--Habitat loss between 1% and 10%, moderate generalist.

3 Moderate threat--Habitat loss between 11% and 25%, species with moderate reproductive potential, ecological specialist.

4 Extensive Threat--Habitat loss between 26% and 50%, ecological specialist.

5 Extirpation likely--Habitat loss exceeding 50%, species with low reproductive potential, ecological specialist.

This criterion incorporates three different aspects of the breeding biology: demographic vulnerability, ecological vulnerability, and habitat loss and disruption. Demographic vulnerability is the inability of a species to recover from population loss by basal reproductive effort, due either to low reproductive rate or high juvenile mortality, or a combination of both. Ecological vulnerability is an index of the species' level of ecological specialization. Thus, species associated with one or a few habitats, or which have specialized feeding or breeding requirements, are given a higher score. Finally, habitat loss and disruption can be caused by any of several factors, including forest cutting and/or fragmentation, flood management practices, and overgrazing. The effects of these practices can be direct (habitat loss) or indirect (increased cowbird parasitism).

If specific information is available, this criterion should be specific to the area of consideration. This could include unpublished data available only locally. In the West, fine-grained population information is generally not available. Thus, in our treatment, the threats to breeding category is used as a non-specific variable and is the same across states.

4. Threats on breeding grounds research uncertainty (TBU).

Rank

1 All major factors affecting population size and distribution are known--many references on breeding ecology.

2 Most factors affecting population size and distribution are known--some specific and several nonspecific references available.

3 Some factors affecting population size and distribution are known, but one or more major factors may be unknown--very few specific, and several nonspecific references available.

4 Very few factors affecting population size and distribution are known--several nonspecific references available.

5 Factors affecting population size and distribution are unknown or unsubstantiated--no major, and few nonspecific references on breeding ecology.

This is the uncertainty value associated with the previous criterion. The uncertainty level primarily reflects quantity and quality of information available. Those species which have received little specific attention to their breeding biology are given high uncertainty levels (i.e. Black Swift), while well-researched species are given lower scores (i.e. Peregrine Falcon). A high score in this category indicates that more research on the breeding biology of this species is required.

5. Threats on winter grounds (TW).

Rank

1 No known threat--Habitat increasing or stable, ecological generalist.

2 Minor threats--Habitat loss between 1% and 10%, moderate ecological generalist.

3 Moderate threats--Habitat loss between 11% and 25%, moderate ecological specialist.

4 Many Threats--Habitat loss between 26% and 50%, ecological specialist.

5 Extirpation likely--Habitat loss between 51% and 100%, extreme ecological specialist.

Two factors, ecological specialization and habitat loss/disruption, are encompassed here, and are essentially the same as those described for breeding threats.

Threats on the winter grounds are very difficult to judge, due primarily to lack of information regarding western migrants in the non-breeding season. In certain cases, studies of winter biology of eastern species may be applicable, but must be used with extreme caution. For example, Rappole and Morton (1985) found Wilson's Warbler sensitive to disturbance of climax forest habitat in eastern tropical Mexico. In contrast, studies focusing on western wintering grounds, and very probably western birds, indicate Wilson's Warbler is an extreme habitat generalist which accepts disturbed habitat (Hutto 1980, 1992).

Since there are few studies documenting important migration stopover sites for western migrants, as with eastern migrants (Moore 1992), we did not include migration threats in our assessment of threats to winter grounds. However, if more information regarding stopover sites and ecology for western migrants becomes available, it should be incorporated as part of the wintering threat or as a new and separate criterion.

6. Threats on winter grounds research uncertainty (TWU).

Rank

1 All major factors affecting population size and distribution are known--many references on wintering ecology.

2 Most factors affecting populations size and distribution are known--some specific and several nonspecific references available.

3 Some factors affecting population size and distribution are known, but one or more major factors are unknown--very few specific, and several nonspecific references available.

4 Very few factors affecting population size and distribution are known--several nonspecific references available.

5 Factors affecting population size and distribution are unknown or unsubstantiated--no major, and few nonspecific references on wintering ecology.

The score for this uncertainty is based upon the same factors as threats to breeding uncertainty. A high score indicates a need for more research into the wintering biology of the species.

7. Breeding Distribution (BD).

Rank		
1	Very Widespread	(≤ 76-100% of temperate North America)
2	Widespread	(51-75% of temperate North America)
3	Intermediate	(26-50% of temperate North America)
4	Local	(11-25% of temperate North America)
5	Very Local	(≥ 10% of temperate North America)

Breeding distribution is another index of a species' vulnerability to stochastic environmental variation. Generally, species with wide distributions are less subject to local effects, be they environmental or human-induced.

8. Winter Distribution (WD).

Rank

1 Very Widespread(Southern latitudes of the U.S. through Central America into northern South America; or all of South America).

2 Widespread(Southern latitudes of the U.S. through Central America; or southern Central America into most of South America).

3 Intermediate(Throughout Mexico; the entire Caribbean Basin and Caribbean Slope of Central America and southern Mexico; the Middle American highlands; or the entire Amazon Basin).

4 Local(Caribbean Basin alone; Caribbean slope of Central America; Pacific slope of Middle America; the Mexican highlands; or the Andean Ridge of northern South America).

5 Very Local(Bahamas only; Guatemala, Honduras, and Nicaragua highlands; States of Jalisco, Colima, Michoacan, and Guerrero in Mexico; southern Sinoloa and southern Baja California in Mexico).

This criterion is included for reasons similar to those noted for breeding distribution, however the scale reflects the relatively compressed nature of western bird's winter grounds (Terborgh 1989) and the terminology coincides with commonly used phrases used in other documents (AOU 1983).

9. Population Trend in Area of Consideration (PT)

Rank

1 Large Increase--Stable or increasing with uncertainty of 1 or ≥ 5% annual increase with certainty of 2.

2 Increase--Stable or increasing with uncertainty of 2 or uncertainty of 3 with ≥ 1% annual increase.

3 Trend Unknown--Trend is between -1.0% and 1.0% exclusive and/or uncertainty is 4 or 5.

4 Decrease--Decreasing with uncertainty of 2 or uncertainty of 3 with ≥ 1% annual decrease.

5 Large Decrease--Decreasing with uncertainty of 1 or > -5% annual decrease with uncertainty of 2.

See the population trend uncertainty discussion below for explanation of the population trend criteria.

10. Population Trend Uncertainty (PTU)

Rank

1 Fourteen or more BBS routes with statistical significance and significant proportion of increasing and decreasing routes agree with overall trend.

2 Fourteen or more BBS routes with statistical significance and proportion of increasing and decreasing routes agreeing with overall trend.

3 Fourteen or more BBS routes without statistical significance and/or the proportion of increasing and decreasing routes do not agree with overall trend.

4 Sample size for species from BBS is insufficient.

5 No quantitative monitoring information exists for species in the area.

For the last two criteria we focused on interpretation of USFWS Breeding Bird Survey (BBS) results (1969-1991 and 1982-1991 periods) since it is the only long term monitoring study available for the entire western U.S. Other data than that provided by the BBS could be used, especially when they address a local area not adequately covered by the BBS (i.e., a Breeding Bird Census site), or a different season (i.e., Christmas Bird Counts).

Using only BBS data, population trend and population trend uncertainty are intimately linked in our prioritization scheme. A population trend must meet two guidelines (reliability and magnitude) to warrant either a very high or a very low score. Reliability refers to several aspects of the population trend we consider first in determining the population trend uncertainty score. These aspects are sample size, statistical significance, and spatial consistency across BBS routes in the area of interest. The first two aspects are usually included in BBS summaries. The minimum sample size of 14 for a state/physiographic area is based upon current BBS recommendations. The third factor, spatial consistency of routes, is reflected in values and a significance test for the number of routes for a species showing increasing versus decreasing trends. A trend is considered consistent if the majority of routes agree with the overall trend, and even more consistent if the proportion is statistically different than 1:1. These three factors are considered for a given trend, and a population trend uncertainty score is assigned. A fourth factor reflecting average abundance of a species on BBS routes may need to be included in future uncertainty scores. For example, low abundance of a species in BBS data () may influence the accuracy (increase uncertainty) of a population trend estimate (Sauer and Droege, in prep.).

Population trend uncertainty is then combined with magnitude (the second guideline) and direction of trend to determine the population trend score. Only population trends of sufficient magnitude and certainty merit assignment of a score other than three. Scores of one or five for population trend must have an uncertainty of one and a magnitude of greater than +/- 1%, or uncertainty of 2 and a magnitude greater than +/- 5%. A 1% decline over 20 years equals a cumulative 18.2% population loss. Judging by past actions under the Endangered Species Act, cumulative declines of 18.2% are generally viewed as insufficient to warrant listing of species but may indicate that the species requires management attention. A 5% decline over 20 years represents a cumulative 64.2% population decline and would probably warrant species listing. Our population trend criteria were picked to alert managers to species with modest but certain population declines and species with potentially catastrophic declines for which we are somewhat uncertain about the trend information. The population trend uncertainty criteria alone can be used to identify species which are not being monitored. For example, species receiving a four or five need monitoring in the area of interest.

In addition to the factors given above is temporal consistency of BBS trend data. For example, a species severely declining over the 26 year BBS period, but increasing over the last ten, might not be a conservation priority, if other information indicates the species is undergoing natural population fluctuations. On the other hand, species increasing over the 26 year period, but decreasing in the last ten years, might be of critical concern because of recent or accelerating lost of habitat, or other catastrophic effects. Trends consistently of one sign and significant over both time frames are more reliable than trends which vary between the two. It is not obvious, however, how to combine two time frames into a number which does justice to species, since significance of either trend must be evaluated not only in statistical terms, but in the light of other information for the species in question. Therefore, we calculated two overall ranks, one using the most recent ten year and one using 26 year BBS trend information. These BBS data and resulting rankings must be carefully interpreted to determine which population trend and ranking are most useful. Due to space limitations, only ranks using ten year BBS trend information are presented here.

RESULTS

Distribution, migratory type (NTMB type) and breeding or migratory status of West Working Group species are listed in Table 1. Values for five criteria that do not change for different areas of interest (area-independent criteria) are listed in Table 2. Values for criteria that do change for different areas of interest (area-dependent criteria) are listed by state in Table 3. Overall rankings are calculated by summing area-independent scores (five) and area-dependent scores (two) and dividing by seven. Overall rankings using ten year period BBS data are listed by state in Table 4. Uncertainty values are not used in this calculation, instead they are averaged separately to calculate a research uncertainty score: RU = (threats to breeding score + threats to wintering score)/2 (Table 2).

DISCUSSION

Using the four tables presented, one can determine species of special concern. Furthermore, it is easy to determine which factors are most responsible for an individual species' ranking. This allows managers to identify both species of concern and the primary causes of concern. In combination with state occurrence information, this can be used to target conservation efforts. For instance, examination of the Mountain Plover's scores indicate that, relative to other species, it is of high concern wherever it occurs (four states) (Table 4). The area-independent (Table 2) scores for the Plover indicates concern because of a highly restricted breeding and winter range and loss of habitat on breeding and winter grounds. In addition, area-dependent scores (Table 3) indicate a majority of Mountain Plover's range is in four states of the WWG: Colorado, New Mexico, Wyoming, and Montana. The other two area dependent scores, population trend and population trend uncertainty (Table 3), indicate more intensive monitoring is needed across its range. It has not been detected by BBS in two states (New Mexico and Montana, PTU=5) and has insufficient sample size in two others (Colorado and Wyoming, PTU=4) (Table 3). Based upon this information, it is easily seen that conservation efforts for the Mountain Plover in the West Working Group should focus on habitat preservation in the four states listed and on wintering grounds, and that monitoring efforts should be increased.

We urge that states not be compared against each other to set conservation priorities. Each state contains unique sets of neotropical migrants and ranking one state above another could lead to gaps in conservation efforts. Also, it is important to note relative numbers of migrants of different classes in each state to gain a good picture of the necessary level of concern. In addition, it is critical to note importance of area scores so that conservation will be directed at states that contain large portions of a species' range rather than peripheral populations. For example, it is useful to examine a state list for species with high importance of area scores (3,4, or 5) and high monitoring uncertainty scores (4 or 5). This combination indicates a species that is not adequately monitored in the core of its range. Finally, even if an individual state looked to be of low average overall concern, this could be deceiving, since monitoring and research uncertainties could be extremely high for species found exclusively in that state.

Using rankings by themselves (Table 4) would encourage single species management. However, if habitat or community membership information is added for each species, then rankings by habitat may be developed. Although means are useful for individual species, they are somewhat misleading for habitats since habitats may contain widely different numbers of neotropical migrants. It may be useful to tally the number of species that fall in various priority ranges (>4.0, 3.5-3.99, 3.00-3.49, etc.) across habitats. For habitats, it may also be useful to calculate a total concern score that sums the concern scores for all species using a particular habitat. These same calculations may be conducted for population trend uncertainty scores to indicate which habitats need more monitoring (Table 5).

We applied this process to data from Colorado (Table 5). This provides an extremely useful example of the need to look at both mean and sum scores when evaluating habitat priorities. For instance, the habitat with highest mean concern score (3.00) in Colorado is pinyon/juniper. However, this habitat has only six neotropical migrant species (Table 5). Looking at summed species ranks for each habitat, it is clear that cottonwood riparian, which supports 29 species, is of much higher priority than pinyon/juniper. However, the shortgrass prairie grouping has only seven fewer species, a comparable sum (64) and a slightly higher mean rank, indicating that it is a habitat of concern nearly equal to the cottonwood riparian. In addition, it is interesting to note that the group of habitat generalists has the lowest mean rank, indicating that most Colorado species of concern are isolated to specific habitats. In addition to examining means and sum for ranks across habitats, we encourage managers to examine the monitoring and research needs of species found within each habitat. Certain habitats may be poorly monitored, while other habitats may be adequately monitored but need other management attention.

A Tool for Managers

It is clear that the Partner's in Flight prioritization scheme ranks species as to conservation priority. In addition the database contains an large amount of information that can be useful in management. We strongly recommend that managers familiarize themselves with the database either by hand or with a computer. We refer managers to the interactive database that allows information to be extracted quickly and easily for any state or physiographic region and allows sorting (ranking) by any criteria. The interactive nature of the database allows users to ask many questions and receive answers regarding the status of species in all of the WWG states and physiographic regions. During the development of the WWG part of the database, we found ourselves not using the rankings alone but sorting the species with nested sorts using two or three criteria at a time. Managers should structure the database to answer question important to management. For example, questions such as which species are declining in an area and is the area important to the species? Answer this by listing species that are declining (PT = 4 or 5) with high importance of area scores (IA = 3, 4, or 5). Or managers may ask if they can only implement monitoring in one habitat in a given year, in which habitat should they start. Answer this by assigning habitat names used by the management area to each species and sort by habitats and tally the number of birds that have been undetected by the BBS, have insufficient sample size and those that are adequately monitored by the BBS per habitat. A manager may choose to implement monitoring in a habitat that has the most unmonitored species or consider implementing monitoring in the habitat with the most unmonitored species with higher overall rankings. There are many questions that can be answered by the database and we encourage managers to ask questions particular to their management area.

Copies of the database are available from the authors by sending them a formatted 3.5 diskette in a return-postage-paid diskette mailer. Managers using Paradox 3.5 or 4.0 will also receive associated Paradox report forms. Others should specify what software they will be using and we will try to export to it.

ACKNOWLEDGEMENTS

We acknowledge the following individuals for their contribution of state list information and/or helpful comments on this paper: Alaska-S. Jones, T. Pogson, C. Handel; Arizona-T. Corman; California-L. Comrack, W. Grenfell, S. Jones; Colorado-H. Kingery; Idaho-V. Saab, C. Groves, Montana-C. Paige; New Mexico-S. Williams III, J. Hubbard; Nevada-G. Herron; Oregon-N. Barrett, S. Jones, S. Latta, M. Nugent, T. Zimmerman; Utah-F. Howe; Washington-J. Pierce; Wyoming-S. Ritter. Additionally, we would like to thank B. McClure, C. Hunter, and D. Pashley for their useful comments throughout the development of the criteria. This paper benefitted from comments received from C. Aid, C. Davidson, C. Hunter, P. Manely, R. Marshall, D. Pashley, B. Peterjohn, C. Paige and C.J. Ralph, J. Sauer, S. Senner, B. Sharpe, and P. Stangel.

LITERATURE CITED

American Ornithologists' Union. 1983. Check-list of North American birds, 6th edition and supplements. Washington, American Ornithologists' Union.

Gauthreaux, S. 1991. Preliminary list of migrants for the Neotropical Migrant Bird Conservation Program. Partners in Flight Newsletter, Vol. 2, No. 1.

Hutto, R.L. 1980. Winter habitat distribution of migratory birds land birds in western Mexico, with special reference to small, foliage-gleaning insectivores. Pp. 181-203 in Migrant birds in the neotropics: ecology, behavior, distribution and conservation. (A. Keast and E.S. Morton, Eds.). Washington, Smithsonian Institution Press.

Hutto, R.L., S. Reel, and P.B. Landres. 1987. A critical evaluation of the species approach to biological conservation. Endang. Spec. Update 4: 1-4.

Millsap, B.A., J.A. Gore, D.E. Runde, and S.I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wild. Mono. 111.

Master, L. 1991. Assessing threats and setting priorities for conservation. Cons. Biol. 5: 559-563.

Moore, F.R. and T.R. Simons. 1992. Habitat suitability and stopover ecology of Neotropical landbird migrants. Pp. 345-355 in Ecology and Conservation of Neotropical Migrant Landbirds. (J. M. Hagen III and D.W. Johnston, Eds.). Washington, Smithsonian Institution Press.

National Geographic Society. 1983. Field guide to the birds of North America. Pp. 104-442. Washington, D.C., National Geographic Society.

Reed, J.M. 1992. A system for ranking conservation priorities for Neotropical migrant birds based on relative susceptibility to extinction. Pp. 524-536 in Ecology and conservation of Neotropical migrant landbirds. (J.M. Hagan III and D.W. Johnson, Eds.). Washington, Smithsonian Institution Press.

Sauer, J.R. and S. Droege. in prep. Geographic and temporal aspects of sampling in the North American Breeding Bird Survey. U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel MD 20708.

Terborgh, J. 1989. Where have all the birds gone? Pp. 155-156. Princeton, N.J., Princeton University Press.

Literature Cited for Table 2
Numbers in brackets refer to literature cited in Table 2.

Terborgh, J. 1989. Where have all the birds gone? Pp. 155-156. Princeton, N.J., Princeton University Press. [1]

Harris, J.H. 1991. Effects of brood parasitism by Brown-headed Cowbirds on Willow Flycatcher nesting success along the Kern River, California. W. Birds 22: 13-26. [2]

Hunter, W.C., R.D. Ohmart, and B.W. Anderson. 1987. Status of breeding riparian-obligate birds in southwestern riverine systems. W. Birds 18: 10-18. [3]

Laymon, S.A., and M.D. Halterman. 1987. Can the western subspecies of the Yellow-billed Cuckoo be saved from extinction? W. Birds 18: 19-25. [4]

Harris, J.H., S.D. Sanders, and M.A. Flett. 1987. Willow Flycatcher surveys in the Sierra Nevada. W. Birds 18: 27-36. [5]

Flett, M.A., and S.D. Sanders. 1987. Ecology of a Sierra Nevada population of Willow Flycatchers. W. Birds 18: 37-42. [6]

Franzreb, K.E. 1987. Endangered status and strategies for conservation of the Least Bell's Vireo (Vireo bellii pusillus) in California. W. Birds 18: 43-49. [7]

Garrison, B.A., J.M. Humphrey, and S.A. Laymon. 1987. Bank Swallow distribution and nesting ecology on the Sacramento River, California. W. Birds 18: 71-76. [8]

Johnson, R.R., L.T. Haight, and J.M. Simpson. 1987. Endangered habitats versus endangered species: a management challenge. W. Birds 18: 89-96. [9]

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook--a field guide to the natural history of North American birds. New York, N.Y., Simon & Schuster, Inc. [10]

Knapton, R.W. 1979. Breeding ecology of the Clay-colored Sparrow. Living Bird, 17: 137-158. (D.A. Lancaster and J.R. Johnson, Eds.). Ithaca, N.Y., Cornell University. [11]

des Granges, J.L. 1979. Organization of a tropical nectar feeding bird guild in a variable environment. Living Bird, 17: 199-236. (D.A. Lancaster and J.R. Johnson, Eds.). Ithaca, N.Y., Cornell University. [12]

Davis, C. M. 1979. A nesting study of the Brown Creeper. Living Bird, 17: 237-263. (D.A. Lancaster and J.R. Johnson, Eds.). Ithaca, N.Y., Cornell University. [13]

Crockett, A.B., and P.L. Hansley. 1977. Coition, nesting, and postfledgling behavior of Williamson's Sapsucker in Colorado. Living Bird, 16: 7-19. (D.A. Lancaster and J.R. Johnson, Eds.). Ithaca, N.Y., Cornell University. [14]

Stewart, R.M., R. P. Henderson, and K. Darling. 1977. Breeding ecology of the Wilson's Warbler in the high Sierra Nevada, California. Living Bird, 16: 83-102. (D.A. Lancaster and J.R. Johnson, Eds.). Ithaca, N.Y., Cornell University. [15]

Goldwasser, S., D. Gaines, and S.R. Wilbur. 1980. The Least Bell's Vireo in California: a de facto endangered race. Am. Birds 34: 742-745. [16]

Tate Jr., J. 1986. The blue list for 1986. Am. Birds 40: 27-236. [17]

Marshall, J.T. 1988. Birds lost from a Giant Sequoia forest during fifty years. Condor 90: 359-372. [18]

Sedgwick, J.A., and F.L. Knopf. 1988. A high incidence of Brown-headed Cowbird parasitism of Willow Flycatchers. Condor 90: 253-256. [19]

Brooks, B.L., and S.A. Temple. 1990. Dynamics of a Loggerhead Shrike population in Minnesota. Wilson Bull. 102: 441-450. [20]

Sauer, J.R., and S. Droege. 1990. Recent population trends of the Eastern Bluebird. Wilson Bull. 102: 239-252. [21]

Gawlik, D.E., and K.L. Bildstein. 1990. Reproductive success and nesting habitat of Loggerhead Shrikes in north-central South Carolina. Pp. 37-48. Lawrence, Kan., Allen Press. [22]

Knowles, C.J., C.J. Stoner, and S.P. Gieb. 1982. Selective use of Black-tailed Prairie Dog towns by Mountain Plovers. Condor 84: 71-74. [23]

Weatherhead, P.J. 1989. Sex ratios, host-specific reproductive success, and impact of Brown-headed Cowbirds. Auk 106: 358-366. [24]

Marvil, R.E., and A. Cruz. 1989. Impact of Brown-headed Cowbird parasitism on the reproductive success of the Solitary Vireo. Auk 106: 476-480. [25]

Morse, D.H. 1989. The wintering season. Pp. 216-245 in American warblers--an ecological and behavioral perspective. Cambridge, Mass., Harvard University Press. [26]

Hutto, R.L. 1987. A description of mixed-species insectivorous bird flocks in western Mexico. Condor 89: 282-292. [27]

Hutto, R.L. 1992. Habitat distribution of migratory landbird species in western Mexico. Pp. 221-239 in Ecology and conservation of neotropical migrant landbirds. (J.M. Hagan III and D.W. Johnston, Eds.). Washington and London, Smithsonian Institution Press. [28]

United States Fish and Wildlife Service. 1987. Migratory nongame birds of management concern in the United States: the 1987 list. Report 25 pp. and appendices 35 pp. [29]

Rappole, J.H., and E.S. Morton. 1985. Effects of habitat alteration on a tropical avian forest community. Ornithol. Monogr. 36: 1013-1021. (M.S. Foster, Ed.). Lawrence, Kans., Allen Press. [30]

Hilty, S.L. 1985. Distribution changes in the Columbian avifauna: a preliminary blue list. Ornithol. Monogr. 36: 1000-1012. (M.S. Foster, Ed.). Lawrence, Kans., Allen Press. [31]

Sedgwick, J.A. 1897. Avian habitat relationships in pinyon-juniper woodland. Wilson Bull. 99: 413-431. [32]

O'Meara, T.E, J.B. Haufler, L.H. Stelter and J.G. Nagy. 1981. Nongame wildlife responses to chaining of pinyon-juniper woodlands. J. Wildl. Manage. 45: 381-389. [33]

Table 1.—Status of neotropical migratory birds within the West Working Group (B=regular breeder; b=irregular breeder, <10 records; M=regular migrant; m=irregular migrant, <10 records; H=historical breeder but now extirpated). Type is migratory status as defined by Gauthreaux (1991).

Species	Type	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Turkey Vulture	B	m	B	B	B	B	B	B	B	B	B	B	B
Osprey (Supp.)	B	B	B	B	B	B	B	b	B	B	B	B	B
American Swallow-tailed Kite	A				m			m					
Mississippi Kite	A		B	M	B			B	m				m
Northern Harrier	B	B	b	B	B	B	B	B	B	B	B	B	B
Sharp-shinned Hawk	B	B	B	B	B	B	B	B	B	B	B	B	B
Cooper's Hawk	B		B	B	B	B	B	B	B	B	B	B	B
Northern Goshawk	B	B	B	B	B	B	B	B	B	B	B	B	B
Common Black-Hawk	C		B	m				B			b		
Gray Hawk	C		B					m					
Red-shouldered Hawk	B		B	B	M			m	m	M	m		
Broad-winged Hawk	A		M	M	M	m	M	M	M	m	M		M
Swainson's Hawk	A	B	B	B	B	B	B	B	B	B	B	B	B
Zone-tailed Hawk	C		B	B				B	m				
Red-tailed Hawk	B	B	B	B	B	B	B	B	B	B	B	B	B
Ferruginous Hawk	B		b	M	B	B	B	B	B	B	B	B	B
Golden Eagle	B	B	B	B	B	B	B	B	B	B	B	B	B
American Kestrel	B	B	B	B	B	B	B	B	B	B	B	B	B
Merlin	A	B	M	M	M	b	B	M	M	M	b	B	B
Peregrine Falcon	A	B	B	B	B	B	B	B	B	B	B	B	B
Prairie Falcon	B		B	B	B	B	B	B	B	B	B	B	B
Killdeer	B	B	B	B	B	B	B	B	B	B	B	B	B
Mountain Plover	A		M	M	B	m	B	B	m	m	M		B
Upland Sandpiper	A	B	m	m	B	B	B	M		B	m	b	B
Long-billed Curlew	A		M	B	B	B	B	B	B	B	B	B	B
Band-tailed Pigeon	A	b	B	B	B	M		B	B	B	B	B	M
White-winged Dove	C	m	B	B	M			B	B	m	B		m
Mourning Dove	B		B	B	B	B	B	B	B	B	B	B	B
Black-billed Cuckoo	A		m	M	B	B	B	M		m	m		B
Yellow-billed Cuckoo	A	m	B	B	B	B	B	B	b	b	B	H	B
Groove-billed Ani	C		M	m	m			m					
Flammulated Owl	A		B	B	B	B	B	B	B	B	B	B	m
Elf Owl	C		B	B				B	B				
Burrowing Owl	A		B	B	B	B	B	B	B	B	B	B	B
Long-eared Owl	B		B	B	B	B	B	B	B	B	B	B	B
Short-eared Owl	B	B	b	B	B	B	B	M	B	B	B	B	B
Lesser Nighthawk	A	m	B	B	m			B	B		B		
Common Nighthawk	A	B	B	B	B	B	B	B	B	B	B	B	B
Common Poorwill	B		B	B	B	B	B	B	B	B	B	B	B
Chuck-will's-widow	A			m				m	m				
Buff-collared Nightjar	C		b					m					
Whip-poor-will	A		B	B				B	b				
Black Swift	A	B	m	B	B	b	B	B	M	b	B	B	m
Chimney Swift	A	m	M	b	B		B	M			m		M
Vaux's Swift	A	B	M	B		B	B	m	M	B	m	B	
White-throated Swift	A		B	B	B	B	B	B	B	B	B	B	B
Broad-billed Hummingbird	C		B	M				B	m		m		
Violet-crowned Hummingbird	C		B	m				B					
Blue-throated Hummingbird	C		B	m	m			M					
Magnificent Hummingbird	C		B		b			B	m		m		m
Lucifer Hummingbird	C		b					B					
Ruby-throated Hummingbird	A			m	m		b	m					
Black-chinned Hummingbird	A		B	B	B	B	B	B	B	B	B	B	M
Anna's Hummingbird	B	m	B	B	m	M	b	M	M	B		B	m
Costa's Hummingbird	A	m	B	B				b	B	b	B		
Calliope Hummingbird	A		M	B	M	B	B	M	B	B	B	B	B
Broad-tailed Hummingbird	A		B	B	B	B	H	B	B	B	B		B
Rufous Hummingbird	A	B	M	B	M	B	B	M	B	B	M	B	B
Allen's Hummingbird	A		M	B				m	m	B			
Elegant Trogon	C		B					M					
Belted Kingfisher	B	B	b	B	B	B	B	B	B	B	B	B	B
Green Kingfisher	C		b										
Lewis' Woodpecker	B		B	B	B	B	B	B	B	B	B	B	B
Yellow-bellied Sapsucker	B	b	M	M	M			M	B	m		m	
Red-naped Sapsucker	B		B	B	B	B	B	B	B	B	B	B	B

Table 1. Continued

Species	Type	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Red-breasted Sapsucker	B	B	M	B					B	B		B	
Williamson's Sapsucker	B		B	B	B	B	B	B	B	B	B	B	B
Northern Flicker	B	B	B	B	B	B	B	B	B	B	B	B	B
Northern Beardless-Tyrannulet	C		B					B					
Olive-sided Flycatcher	A	B	B	B	B	B	B	B	B	B	B	B	B
Greater Pewee	C		B	M				B					
Western Wood-Pewee	A	B	B	B	B	B	B	B	B	B	B	B	B
Eastern Wood-Pewee	A		m		M		m	M					m
Yellow-bellied Flycatcher	A	m	m					M					
Acadian Flycatcher	A		m										
Alder Flycatcher	A	B			m		m			m			
Willow Flycatcher	A	m	B	B	B	B	B	B	B	B	B	B	B
Least Flycatcher	A	b	m	M	B	m	B	M	m	b		b	B
Hammond's Flycatcher	A	B	b	B	B	B	B	B	B	B	B	B	B
Dusky Flycatcher	A	b	B	B	B	B	B	B	B	B	B	B	B
Gray Flycatcher	A		B	B	B	B		B	B	B	B	B	B
Pacific-slope Flycatcher	A	B	M	B				M		B		B	
Cordilleran Flycatcher	A		B	B	B	B	B	B	B	B	B		B
Buff-breasted Flycatcher	C		B					H					
Eastern Phoebe	B	m	M	M	B		m	B	m	m	m		b
Say's Phoebe	B	B	B	B	B	B	B	B	B	B	B	B	B
Vermilion Flycatcher	A		B	B	M			B	B		b		m
Dusky-capped Flycatcher	C		B	M	m			B	m				
Ash-throated Flycatcher	A		B	B	B	B	m	B	B	B	B	B	B
Great Crested Flycatcher	A	m	m	M	B		m	M					m
Brown-crested Flycatcher	C		B	B				B	B		b		
Sulphur-bellied Flycatcher	C		B	m				M					
Tropical Kingbird	C		B	M						M		m	
Couch's Kingbird	C							m					
Cassin's Kingbird	A		B	B	B	m	B	B	B	m	B		B
Thick-billed Kingbird	C		B	m				B					
Western Kingbird	A	m	B	B	B	B	B	B	B	B	B	B	B
Eastern Kingbird	A	m	M	M	B	B	B	B	b	B	B	B	B
Scissor-tailed Flycatcher	A		M		B	m	m	B	m	m	M		m
Rose-throated Becard	C		B										
Horned Lark	B	B	B	B	B	B	B	B	B	B	B	B	B
Purple Martin	A		B	B	B	m	b	B	m	B	B	B	m
Tree Swallow	B	B	B	B	B	B	B	B	B	B	B	B	B
Violet-green Swallow	A	B	B	B	B	B	B	B	B	B	B	B	B
Northern Rough-winged Swallow	A	B	B	B	B	B	B	B	B	B	B	B	B
Bank Swallow	A	B	M	B	B	B	B	B	B	B	B	B	B
Cliff Swallow	A	B	B	B	B	B	B	B	B	B	B	B	B
Cave Swallow	C		b	m				B					
Barn Swallow	A	B	B	B	B	B	B	B	B	B	B	B	B
Brown Creeper	B	B	B	B	B	B	B	B	B	B	B	B	B
Rock Wren	B		B	B	B	B	B	B	B	B	B	B	B
House Wren	A		B	B	B	B	B	B	B	B	B	B	B
Sedge Wren	B			m	M		b	M					m
Marsh Wren	B		B	B	B	B	B	B	B	B	B	B	B
Golden-crowned Kinglet (Supp.)	B	B	B	B	B	B	B	B	b	B	B	B	B
Ruby-crowned Kinglet	B	B	B	B	B	B	B	B	B	B	B	B	B
Blue-gray Gnatcatcher	A		B	B	B	B	m	B	B	B	B		B
Eastern Bluebird	B		B		B		B	B					B
Western Bluebird	B		B	B	B	B	B	B	B	B	B	B	b
Mountain Bluebird	B	B	B	B	B	B	B	B	B	B	B	B	B
Townsend's Solitaire	B	B	B	B	B	B	B	B	B	B	B	B	B
Veery	A	m	b	m	B	B	B	M	M	B	b	B	B
Gray-cheeked Thrush	A	B	m	m	M	m	M	M		m			m
Swainson's Thrush	A	B	B	B	B	B	B	B	b	B	B	B	B
Hermit Thrush	B	B	B	B	B	B	B	B	B	B	B	B	B
Wood Thrush	A		M	m	M		m	M	m	m	m		m
American Robin	B	B	B	B	B	B	B	B	B	B	B	B	B
Gray Catbird	A		B	M	B	B	B	B	M	B	B	B	B
Northern Mockingbird	B	m	B	B	B	B	B	B	B	b	B		b
Sage Thrasher	B		B	B	B	B	B	B	B	B	B	B	B
Bendire's Thrasher	B		B	B	b			B	b		B		
American Pipit	B	B	b	B	B	B	B	B	B	B	B	B	B

Table 1. Continued

Species	Type	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Sprague's Pipit	B		M	M	m		B	M		m			M
Cedar Waxwing	B	B	M	B	B	B	B	M	B	B	B	B	B
Phainopepla	A		B	B	m			B	B	m	B		
Loggerhead Shrike	B		B	B	B	B	B	B	B	B	B	B	B
White-eyed Vireo	A		m	M	m			M			m		
Bell's Vireo	A		B	B	B			B	B	m	B		
Black-capped Vireo	A		m					m					
Gray Vireo	A		B	B	B			B	B		B		
Solitary Vireo	A	m	B	B	B	B	B	B	B	B	B	B	B
Yellow-throated Vireo	A		M	M	M			M	m				m
Warbling Vireo	A	B	B	B	B	B	B	B	B	B	B	B	B
Philadelphia Vireo	A	m	M	M	M		m	M		m			m
Red-eyed Vireo	A	B	M	M	B	B	B	M	m	B	M	B	B
Blue-winged Warbler	A		m	M	M			M		m			
Golden-winged Warbler	A		M	M	M	m		M		m			m
Tennessee Warbler	A	B	M	M	M	m	B	M	m	M	M		M
Orange-crowned Warbler	A	B	B	B	B	B	B	B	B	B	B	B	B
Nashville Warbler	A		M	B	M	B	B	M	B	B	M	B	M
Virginia's Warbler	A		B	B	B	B		B	b	m	B		B
Colima Warbler	C												
Lucy's Warbler	C		B	B	m			B	B	m	B		
Northern Parula	A		M	M	M		m	M	m	M			M
Yellow Warbler	A	B	B	B	B	B	B	B	B	B	B	B	B
Chestnut-sided Warbler	A		M	M	B	m	m	M	m	M			M
Magnolia Warbler	A	m	M	M	M	m	m	M	m	M	m		M
Cape May Warbler	A	m	M	M	M		m	M	m	m			m
Black-throated Blue Warbler	A		M	M	M	m	m	M	M	M	m		M
Yellow-rumped Warbler	B	B	B	B	B	B	B	B	B	B	B	B	B
Black-throated Gray Warbler	A		B	B	B	B	m	B	B	B	B	B	B
Townsend's Warbler	A	B	M	B	M	B	B	M	M	B	M	B	M
Hermit Warbler	A		M	B	M			M	b	B	m	B	m
Black-throated Green Warbler	A		M	M	M		m	M		m			m
Blackburnian Warbler	A		M	m	M		m	M	m	m			M
Yellow-throated Warbler	A		M	M	M		m	M	m	m			m
Grace's Warbler	A		B	M	B			B	B		B		
Prairie Warbler	A	m	m	M	m		m	m		m			
Palm Warbler	A	m	M	M	M	m	m	M	m	M	m	m	m
Bay-breasted Warbler	A		M	M	M	m	m	M	m	m	m		m
Blackpoll Warbler	A	B	M	M	m		m	M	M	M	m		M
Cerulean Warbler	A		m	M	m			m	m				
Black-and-white Warbler	A		b	M	M	M	B	M	M	M	M		M
American Redstart	A	B	b	M	B	B	B	M	M	B	b	B	B
Prothonotary Warbler	A		M	M	M			M	m	m			m
Worm-eating Warbler	A		M	M	M			M	m	m			m
Swainson's Warbler	A		m		m			m					
Ovenbird	A	H	M	M	B	m	B	M	m	M	m		B
Northern Waterthrush	A	B	M	M	M	B	B	M	m	B	M	B	M
Louisiana Waterthrush	A		M	m	m			M					
Kentucky Warbler	A		M	M	M		m	M	m	m			m
Connecticut Warbler	A		m	M	m		m	m	m	m	m		m
Mourning Warbler	A	m	m	M	m		m	M		m			m
MacGillivray's Warbler	A	B	B	B	B	B	B	B	B	B	B	B	B
Common Yellowthroat	A	B	B	B	B	B	B	B	B	B	B	B	B
Hooded Warbler	A		M	M	M			M	M	m			m
Wilson's Warbler	A	B	M	B	B	B	B	B	B	B	B	B	B
Canada Warbler	A	B	m	M	M		m	M		m	m		m
Red-faced Warbler	C		B	M				B	m				m
Painted Redstart	C		B	M	m			B	b		m		
Yellow-breasted Chat	A		B	B	B	B	B	B	B	B	B	B	B
Olive Warbler	C		B					B					
Hepatic Tanager	A		B	B	B			B	b				m
Summer Tanager	A		B	B	M		m	B	B	m	B		m
Scarlet Tanager	A		M	M	M		m	M	m	m	m		
Western Tanager	A	B	B	B	B	B	B	B	B	B	B	B	B
Rose-breasted Grosbeak	A		M	M	B	M	m	M	M	M	M		b
Black-headed Grosbeak	A		B	B	B	B	B	B	B	B	B	B	B
Blue Grosbeak	A	m	B	B	B	B	b	B	B	m	B		B

Table 1. Continued

Species	Type	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Lazuli Bunting	A		B	B	B	B	B	B	B	B	B	B	B
Indigo Bunting	A	m	B	b	B	M		B	M	M	B		B
Varied Bunting	C		B	m				B					
Painted Bunting	A		M	M	M			B		m			m
Dickcissel	A		M	M	B		B	B	m	m	m		B
Green-tailed Towhee	A		B	B	B	B	B	B	B	B	B	B	B
Rufous-sided Towhee	B	m	B	B	B	B	B	B	B	B	B	B	B
Botteri's Sparrow	C		B					M					
Cassin's Sparrow	B		B	m	B			B	m		m		M
Chipping Sparrow	A	B	B	B	B	B	B	B	B	B	B	B	B
Clay-colored Sparrow	A	m	M	M	M	m	B	M	M	M	m		B
Brewer's Sparrow	A		B	B	B	B	B	B	B	B	B	B	B
Black-chinned Sparrow	A		B	B				B	B	m	B		
Vesper Sparrow	B		B	B	B	B	B	B	B	B	B	B	B
Lark Sparrow	A		B	B	B	B	B	B	B	B	B	B	B
Black-throated Sparrow	B		B	B	B	B	m	B	B	B	B	b	m
Sage Sparrow	B		B	B	B	B	B	B	B	B	B	B	B
Lark Bunting	A	m	b	M	B	b	B	B	M	m	B		B
Savannah Sparrow	B	B	B	B	B	B	B	B	B	B	B	B	B
Baird's Sparrow	A		M	m	M		B	M					M
Grasshopper Sparrow	A		B	B	B	B	B	B	b	B	B	B	B
Fox Sparrow	B	B	M	B	B	B	B	M	B	B	B	B	B
Song Sparrow	B	B	B	B	B	B	B	B	B	B	B	B	B
Lincoln's Sparrow	A	B	B	B	B	B	B	B	b	B	B	B	B
Swamp Sparrow	B	m	M	M	M	m	m	M	m	M	M		m
White-throated Sparrow	B	B	M	M	M	M	m	M	M	M	M		M
White-crowned Sparrow	B	B	b	B	B	B	B	B	B	B	B	B	B
Dark-eyed Junco	B	B	B	B	B	B	B	B	B	B	B	B	B
McCown's Longspur	B		M	M	B	m	B	M	M	m			B
Chestnut-collared Longspur	B	m	M	M	B		B	M	M	m	m		B
Bobolink	A		b	b	B	B	B	M	B	B	B	B	B
Red-winged Blackbird	B	B	B	B	B	B	B	B	B	B	B	B	B
Eastern Meadowlark	B		B		M			B					
Western Meadowlark	B	m	B	B	B	B	B	B	B	B	B	B	B
Yellow-headed Blackbird	A	m	B	B	B	B	B	B	B	B	B	B	B
Brewer's Blackbird	B	m	B	B	B	B	B	B	B	B	B	B	B
Bronzed Cowbird	C		B	B	m			B					
Brown-headed Cowbird	B	B	B	B	B	B	B	B	B	B	B	B	B
Orchard Oriole	A		M	M	B		B	B	m	m			B
Hooded Oriole	A		B	B				B	B	m	B		
Northern Oriole	A		B	B	B	B	B	B	B	B	B	B	B
Scott's Oriole	A		B	B	B	b		B	B	m	B		B
Purple Finch	B	m	M	B	M	M	m	M	M	B		B	M
Cassin's Finch	B	m	B	B	B	B	B	B	B	B	B	B	B
Pine Siskin	B	B	B	B	B	B	B	B	B	B	B	B	B
Lesser Goldfinch	B		B	B	B	B		B	b	B	B		M
Lawrence's Goldfinch	B		b	B				M	m	m			
American Goldfinch	B	m	M	B	B	B	B	M	B	B	B	B	B

Table 2.—Summary of area-independent criteria: AB=abundance, TB=threats on breeding grounds, TBR=breeding threats reference(s), TBU=threats on breeding grounds uncertainty, TW=threats on wintering grounds, TWR=threats on wintering grounds reference(s), TWU=threats on wintering grounds uncertainty, BD=breeding distribution, WD=winter distribution, and RU-research uncertainty (RU=(TBU+TWU)/2).

Species	Type	AB	TB	TBR	TBU	TW	TWR	TWU	BD	WD	RU
Turkey Vulture	B	1	2	10	4	2		3	1	1	3.50
Osprey (Supp.)	B	3	4	10	3	3	10	4	1	1	3.50
Mississippi Kite	A	3	2	9,10	3	3		4	3	4	3.50
Northern Harrier	B	4	4	10,17,29	3	4		3	1	1	3.00
Sharp-shinned Hawk	B	3	4	10,17	3	3		4	1	1	3.50
Cooper's Hawk	B	3	4	9,10,17	3	3		4	1	2	3.50
Northern Goshawk	B	3	4	10	4	3		4	2	2	4.00
Common Black-Hawk	C	4	4	10	4	3		4	3	3	4.00
Gray Hawk	C	4	2	10	3	3		4	3	3	3.50
Red-shouldered Hawk	B	3	3	10,17,29	3	3		4	3	3	3.50
Swainson's Hawk	A	3	2	9,10,17	3	3		4	2	3	3.50
Zone-tailed Hawk	C	4	2	9,10	4	3		4	2	2	4.00
Red-tailed Hawk	B	1	1	10	2	2		2	1	1	2.00
Ferruginous Hawk	B	4	4	10,17,29	3	3		3	3	3	3.00
Golden Eagle	B	3	2	10	2	2		2	2	2	2.00
American Kestrel	B	1	1	10	2	2	31	3	1	1	2.50
Merlin	A	4	3	10,17	4	3		4	2	2	4.00
Peregrine Falcon	A	4	3	10	1	4		2	3	2	1.50
Prairie Falcon	B	3	4	10	3	3		4	3	2	3.50
Killdeer	B	1	1	10	2	1		2	1	1	2.00
Mountain Plover	A	4	4	10,23	3	4		4	5	4	3.50
Upland Sandpiper	A	3	3	10,17,29	3	3		4	3	3	3.50
Long-billed Curlew	A	3	4	10,17,29	4	3		4	4	4	4.00
Band-tailed Pigeon	A	3	3	10	3	4	28	4	3	3	3.50
White-winged Dove	C	1	1	10	2	1	28	2	3	3	2.00
Mourning Dove	B	1	1	10	1	1	28	2	1	1	1.50
Black-billed Cuckoo	A	3	3	10	3	3		4	3	4	3.50
Yellow-billed Cuckoo	A	3	5	4,9,10,17	3	3		4	2	3	3.50
Flammulated Owl	A	3	2	10,18	4	2		3	3	4	3.50
Elf Owl	C	3	4	10	4	3		5	4	4	4.50
Burrowing Owl	A	4	5	10,17	4	3		5	3	3	4.50
Long-eared Owl	B	3	2	10	3	3		4	1	1	3.50
Short-eared Owl	B	4	4	10,17	4	4		4	1	1	4.00
Lesser Nighthawk	A	2	3	10	4	2		5	2	2	4.50
Common Nighthawk	A	2	3	10,17	4	2		5	1	1	4.50
Common Poorwill	B	3	2	10	4	3		4	3	3	4.00
Chuck-will's-widow	A	2	2	10	4	3		4	3	3	4.00
Buff-collared Nightjar	C	3	2	10	5	3		5	3	3	5.00
Whip-poor-will	A	3	4	10,17	4	3		5	4	5	4.50
Black Swift	A	4	3	10	4	4		5	5	4	4.50
Chimney Swift	A	1	1	10	3	2		5	2	3	4.00
Vaux's Swift	A	4	2	10	4	2		4	5	4	4.00
White-throated Swift	A	3	2	10	3	2		5	3	3	4.00
Broad-billed Hummingbird	C	3	3	10	4	2	1	3	3	4	3.50
Violet-crowned Hummingbird	C	3	3	10	4	2		4	4	4	4.00
Blue-throated Hummingbird	C	3	3	10	5	2	1	5	4	4	5.00
Magnificent Hummingbird	C	3	3	10	5	2		4	3	3	4.50
Lucifer Hummingbird	C	3	3	10	5	2		4	4	4	4.50
Ruby-throated Hummingbird	A	2	2	10,17	3	2	28	3	2	3	3.00
Black-chinned Hummingbird	A	2	2	9,10	3	2	1,12	4	3	4	3.50
Anna's Hummingbird	B	2	1	10	3	1		3	4	4	3.00
Costa's Hummingbird	A	3	3	9,10	3	2		3	4	4	3.00
Calliope Hummingbird	A	2	3	10	4	2	1	4	4	4	4.00
Broad-tailed Hummingbird	A	2	3	10	3	2	28	4	3	4	3.50
Rufous Hummingbird	A	2	3	10	4	2	1	4	4	4	4.00
Allen's Hummingbird	A	2	3	10	4	3	1	4	5	4	4.00
Elegant Trogon	C	3	2	10	3	3		3	3	3	3.00
Belted Kingfisher	B	2	2	10	2	2		3	1	1	2.50
Green Kingfisher	C	3	2	10	4	2		3	2	2	3.50
Lewis' Woodpecker	B	2	4	10,17	5	3		4	4	3	4.50
Yellow-bellied Sapsucker	B	2	2	10	2	3		4	3	2	3.00
Red-naped Sapsucker	B	2	3	10	3	4	28	4	4	3	3.50
Red-breasted Sapsucker	B	2	3	10	3	3		4	4	4	3.50

Table 2. Continued.

Species	Type	AB	TB	TBR	TBU	TW	TWR	TWU	BD	WD	RU
Williamson's Sapsucker	B	3	3	10,14	3	3		4	4	3	3.50
Northern Flicker	B	1	1	10	1	1		2	1	1	1.50
No. Beardless-Tyrannulet	C	3	3	3,9,10	4	2	28	4	3	3	4.00
Olive-sided Flycatcher	A	3	4	10,18,29	5	4		5	3	4	5.00
Greater Pewee	C	3	2	10	4	3	28	4	3	3	4.00
Western Wood-Pewee	A	2	2	9,10,18	4	3		4	2	4	4.00
Alder Flycatcher	A	3	3	10	4	3		5	2	4	4.50
Willow Flycatcher	A	3	5	2,3,5,6,19	3	3		4	3	3	3.50
Least Flycatcher	A	3	4	10,17	5	4	28	4	2	3	4.50
Hammond's Flycatcher	A	2	3	10	5	4	28	4	4	4	4.50
Dusky Flycatcher	A	2	3	10	4	3		4	4	4	4.00
Gray Flycatcher	A	3	4	10,33	5	4	1,28	4	4	4	4.50
Pacific-slope Flycatcher	A	2	3	10	5	3	28	5	4	4	5.00
Cordilleran Flycatcher	A	2	3	10	4	3	28	5	4	4	4.50
Buff-breasted Flycatcher	C	4	5	10	5	3		5	4	4	5.00
Eastern Phoebe	B	2	3	10,17	4	3		4	2	2	4.00
Say's Phoebe	B	3	2	10	3	3		4	2	3	3.50
Vermilion Flycatcher	A	3	2	10,29	4	2	28	3	1	1	3.50
Dusky-capped Flycatcher	C	3	3	10	3	3		3	2	2	3.00
Ash-throated Flycatcher	A	2	3	9,10	4	1	28	2	3	3	3.00
Great Crested Flycatcher	A	2	3	10	3	4	28	4	3	4	3.50
Brown-crested Flycatcher	C	3	3	3,9	4	3		4	2	2	4.00
Sulphur-bellied Flycatcher	C	3	3	10	5	4		4	3	4	4.50
Tropical Kingbird	C	3	2	10,31	3	2	28	3	2	2	3.00
Cassin's Kingbird	A	3	3	9,10	4	2	28	3	3	4	3.50
Thick-billed Kingbird	C	3	3	3,9,10	4	3	28	3	4	4	3.50
Western Kingbird	A	2	1	10	2	2		2	3	4	2.00
Eastern Kingbird	A	2	2	10	3	3		4	2	3	3.50
Scissor-tailed Flycatcher	A	2	2	10	3	3		3	4	4	3.00
Horned Lark	B	1	1	10	1	1		1	1	1	1.00
Purple Martin	A	2	3	10,17	3	3		4	2	3	3.50
Tree Swallow	B	2	3	10	3	3		4	1	2	3.50
Violet-green Swallow	A	2	3	10	3	2		4	3	3	3.50
No. Rough-winged Swallow	A	3	3	9,10	3	2		3	1	3	3.00
Bank Swallow	A	3	3	8,9,10	4	2		3	1	3	3.50
Cliff Swallow	A	2	3	10,17	4	2		4	1	3	4.00
Cave Swallow	C	3	3	10	4	4	10	5	4	4	4.50
Barn Swallow	A	1	1	10	1	2		2	1	1	1.50
Brown Creeper	B	2	2	10,13	3	2		3	1	1	3.00
Rock Wren	B	3	2	10	2	2		3	3	2	2.50
House Wren	A	1	1	10	1	1	28	1	1	1	1.00
Sedge Wren	B	4	4	10,17	4	3		5	3	2	4.50
Marsh Wren	B	2	4	9,10	4	4		4	3	1	4.00
Golden-crown. Kinglet (Supp.)	B	3	3	10,17	4	2		4	3	2	4.00
Ruby-crowned Kinglet	B	2	2	10	2	3	27,28	4	2	2	3.00
Blue-gray Gnatcatcher	A	2	4	9,10,16,17	4	1	27,28	2	2	3	3.00
Eastern Bluebird	B	2	3	10,17,21	2	3	28	3	3	2	2.50
Western Bluebird	B	2	3	10,17	3	3	28	3	3	3	3.00
Mountain Bluebird	B	2	3	10,33	3	3		3	3	2	3.00
Townsend's Solitaire	B	3	3	10	4	3		4	3	3	4.00
Veery	A	2	3	10	3	3		4	3	3	3.50
Gray-cheeked Thrush	A	3	3	10	4	3		4	3	4	4.00
Swainson's Thrush	A	3	3	10	4	4	18,28	4	2	2	4.00
Hermit Thrush	B	3	3	10,32	4	3	28	3	2	2	3.50
American Robin	B	1	1	10	1	1		1	1	1	1.00
Gray Catbird	A	2	2	10	2	2		3	2	3	2.50
Northern Mockingbird	B	1	1	10	1	1	28	2	2	2	1.50
Sage Thrasher	B	2	2	10	3	2		3	4	3	3.00
Bendire's Thrasher	B	3	3	10	5	3		4	5	4	4.50
American Pipit	B	2	2	10	3	3		4	3	2	3.50
Sprague's Pipit	B	3	3	10	5	3		5	4	3	5.00
Cedar Waxwing	B	2	2	10	3	2	28	2	2	2	2.50
Phainopepla	A	2	3	9,10	3	2	28	3	4	3	3.00
Loggerhead Shrike	B	3	5	9,10,20,22	4	4		4	2	3	4.00
Bell's Vireo	A	3	5	3,7,9,10,16	3	4	1,28	4	3	4	3.50
Gray Vireo	A	3	4	10	4	4		5	5	5	4.50
Solitary Vireo	A	3	4	25,32,33	4	3	27,28	3	2	3	3.50

Table 2. Continued.

Species	Type	AB	TB	TBR	TBU	TW	TWR	TWU	BD	WD	RU
Warbling Vireo	A	2	4	10,16	4	2	27,28	2	2	3	3.00
Red-eyed Vireo	A	1	3	10	4	2		3	2	3	3.50
Tennessee Warbler	A	3	3	10	4	3		3	3	4	3.50
Orange-crowned Warbler	A	3	2	10	4	2	26,27,28	2	3	3	3.00
Nashville Warbler	A	3	2	10	4	3	1,27,28	3	3	4	3.50
Virginia's Warbler	A	2	3	10	5	3	1,27,28	4	5	5	4.50
Colima Warbler	C	4	3	10	5	4		5	5	5	5.00
Lucy's Warbler	C	2	3	3,9,10	5	4	1,28	4	5	5	4.50
Yellow Warbler	A	1	4	3,9,10,18,24	3	2	28	3	1	1	3.00
Yellow-rumped Warbler	B	1	2	10	2	1	26,27,28	2	1	2	2.00
Black-throated Gray Warbler	A	3	4	10,32,33	5	3	27,28	4	3	4	4.50
Townsend's Warbler	A	3	4	10	5	3	27,28	4	4	3	4.50
Hermit Warbler	A	3	4	10	5	3	1,27,28	4	5	5	4.50
Grace's Warbler	A	3	4	10	5	3	27,29	4	3	4	4.50
Blackpoll Warbler	A	2	3	10	3	3		3	3	4	3.00
Black-and-white Warbler	A	2	4	10	3	2	27,28,30	4	2	2	3.50
American Redstart	A	2	2	10	4	3		3	2	3	3.50
Ovenbird	A	2	4	10	4	4	28	3	3	3	3.50
Northern Waterthrush	A	2	3	10	4	4	10	4	2	2	4.00
MacGillivray's Warbler	A	3	3	10	5	3	28	3	4	4	4.00
Common Yellowthroat	A	1	4	10	4	2	26	3	1	2	3.50
Wilson's Warbler	A	3	3	10,15	4	2	27,28	2	3	3	3.00
Canada Warbler	A	2	3	10	4	4		3	3	4	3.50
Red-faced Warbler	C	3	3	10	5	4	1,28	3	4	4	4.00
Painted Redstart	C	3	3	10	4	4	28	3	3	3	3.50
Yellow-breasted Chat	A	2	3	9,10	3	3	26,28	3	2	3	3.00
Olive Warbler	C	3	3	10	4	4	27,28	3	3	3	3.50
Hepatic Tanager	A	3	3	10	4	3	28	3	3	3	3.50
Summer Tanager	A	2	4	3,9,10	4	3	28	4	3	3	4.00
Western Tanager	A	2	3	10	4	2	28	3	3	3	3.50
Rose-breasted Grosbeak	A	2	3	10	4	2	28	3	3	3	3.50
Black-headed Grosbeak	A	2	3	10	4	2	1,28	3	3	4	3.50
Blue Grosbeak	A	3	3	3,9,10	3	2	17	3	2	3	3.00
Lazuli Bunting	A	2	3	10	4	2	1	3	3	4	3.50
Indigo Bunting	A	1	2	9,10	3	2	17	3	3	3	3.00
Varied Bunting	C	3	4	9,10	3	2	28	3	3	3	3.00
Painted Bunting	A	3	3	9,10	4	3	28	3	4	3	3.50
Dickcissel	A	2	4	10,17	3	2		4	3	4	3.50
Green-tailed Towhee	A	3	2	10,32	3	2		3	4	3	3.00
Rufous-sided Towhee	B	1	3	10,32	4	2	28	2	2	2	3.00
Botteri's Sparrow	C	4	5	10	4	3	1	4	4	4	4.00
Cassin's Sparrow	B	4	4	10	5	3		4	4	4	4.50
Chipping Sparrow	A	1	3	10,33	4	2	28	3	1	2	3.50
Clay-colored Sparrow	A	3	2	10,11	4	2		4	4	4	4.00
Brewer's Sparrow	A	2	3	10,17	4	4	28	4	3	3	4.00
Black-chinned Sparrow	A	3	3	10	5	3	1	4	3	4	4.50
Vesper Sparrow	B	3	2	10,33	4	2	28	3	2	2	3.50
Lark Sparrow	A	3	2	10	3	2	28	3	2	3	3.00
Black-throated Sparrow	B	3	2	10	4	3		3	3	3	3.50
Sage Sparrow	B	3	3	10	4	3		3	4	4	3.50
Lark Bunting	A	2	4	10	5	3		4	4	3	4.50
Savannah Sparrow	B	3	3	10	4	3		4	1	2	4.00
Baird's Sparrow	A	4	5	10,29	4	4		5	5	4	4.50
Grasshopper Sparrow	A	3	4	10,17	4	2	28	3	2	3	3.50
Fox Sparrow	B	3	2	3,10	3	2		3	2	2	3.00
Song Sparrow	B	1	3	3,9,10	3	1		2	1	1	2.50
Lincoln's Sparrow	A	2	2	10,18	3	2	28	4	3	2	3.50
White-throated Sparrow	B	1	2	10	2	1		2	3	3	2.00
White-crowned Sparrow	B	2	2	10	1	1		2	2	2	1.50
Dark-eyed Junco	B	1	2	10	2	1		2	1	1	2.00
McCown's Longspur	B	3	5	10	4	4		4	5	4	4.00
Chestnut-collared Longspur	B	3	5	10	4	4		4	4	4	4.00
Bobolink	A	2	4	10	3	3	10	3	3	4	3.00
Red-winged Blackbird	B	1	2	10	1	1		1	1	1	1.00
Eastern Meadowlark	B	1	3	10,17,31	4	3	31	4	1	1	4.00
Western Meadowlark	B	1	3	10	3	3		3	2	1	3.00
Yellow-headed Blackbird	A	3	4	10	3	3		4	3	3	3.50

Table 2. Continued.

Species	Type	AB	TB	TBR	TBU	TW	TWR	TWU	BD	WD	RU
Brewer's Blackbird	B	2	2	10	5	2		3	3	2	4.00
Bronzed Cowbird	C	3	2	9,10	2	1		2	3	3	2.00
Brown-headed Cowbird	B	1	1	10,18	1	1		1	1	2	1.00
Orchard Oriole	A	3	4	10,17	4	2	28	3	3	3	3.50
Hooded Oriole	A	2	2	3,9,10	3	2	28	3	3	3	3.00
Northern Oriole	A	2	3	3,9,10	3	2	28	3	3	3	3.00
Scott's Oriole	A	3	3	10	4	3	1,28	4	3	4	4.00
Purple Finch	B	2	3	10	4	2	10	4	3	3	4.00
Cassin's Finch	B	2	3	10	2	2		3	3	2	2.50
Pine Siskin	B	1	1	10	3	1		2	2	1	2.50
Lesser Goldfinch (NTMB?)	B	2	2	9,10,31	4	2	28,31	1	3	3	2.50
Lawrence's Goldfinch	B	3	3	9,10	4	2		4	5	5	4.00
American Goldfinch	B	1	2	10	3	1		1	1	1	2.00

Table 3.—Summary of area-dependent criteria. Under each state the population trend score (PT), population trend uncertainty score (PTU) using the last 10 years of the BBS, and importance of area score (IA) are listed (PT-PTU IA).

Species	Type	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Turkey Vulture	B	0-0 0	1-2 2	1-2 2	2-3 2	3-4 1	3-4 1	2-3 2	4-3 2	4-3 2	3-4 2	2-3 2	2-3 1
Osprey (Supp.)	B	3-5 3	3-5 1	4-2 1	3-5 2	3-4 2	3-4 2	3-4 1	3-5 2	3-3 2	3-5 2	1-1 2	3-4 2
Mississippi Kite	A	0-0 0	3-5 2	0-0 0	3-5 1	0-0 0	0-0 0	3-5 3	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Northern Harrier	B	3-5 2	3-5 1	4-3 2	3-3 1	3-3 1	3-3 1	3-4 1	3-4 2	2-3 2	4-3 2	4-3 2	2-3 1
Sharp-shinned Hawk	B	3-5 3	3-5 1	4-3 1	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2
Cooper's Hawk	B	0-0 0	3-4 2	5-1 2	3-4 1	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2
Northern Goshawk	B	3-5 3	3-4 2	3-4 1	3-4 2	3-4 2	3-5 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2	3-4 2
Common Black-Hawk	C	0-0 0	3-5 2	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0
Gray Hawk	C	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Red-shouldered Hawk	B	0-0 0	3-5 1	4-3 2	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Swainson's Hawk	A	3-5 1	3-4 2	3-4 2	4-3 2	2-3 2	1-1 2	1-2 2	1-2 2	3-4 2	2-3 2	2-3 2	4-3 2
Zone-tailed Hawk	C	0-0 0	3-5 2	3-5 1	0-0 0	0-0 0	0-0 0	3-5 2	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Red-tailed Hawk	B	3-5 2	3-3 1	3-3 2	4-3 1	1-2 1	2-3 1	2-3 1	2-3 1	3-3 1	4-3 1	4-3 1	2-3 1
Ferruginous Hawk	B	0-0 0	3-5 2	3-5 1	2-3 3	3-4 2	2-3 3	3-4 2	3-4 2	4-3 2	4-3 3	3-4 2	4-3 3
Golden Eagle	B	3-5 2	3-4 2	3-3 2	3-3 2	3-4 2	2-2 2	3-4 2	3-4 2	1-1 2	4-3 2	3-5 2	4-3 2
American Kestrel	B	3-5 2	4-3 1	5-1 2	5-2 1	2-3 1	2-3 1	1-1 1	1-1 1	4-2 1	2-3 1	4-3 1	1-1 1
Merlin	A	3-5 3	0-0 0	3-5 1	0-0 0	3-5 1	3-4 2	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	3-4 2
Peregrine Falcon	A	3-5 3	3-5 2	3-4 2	1-2 2	3-5 2	3-4 2	3-5 2	3-5 1	3-5 2	3-5 1	3-5 1	3-5 2
Prairie Falcon	B	0-0 0	3-5 2	2-3 2	3-3 3	3-4 2	2-3 2	3-4 3	3-4 1	2-3 2	3-4 3	3-5 2	1-2 2
Killdeer	B	3-5 2	4-3 1	5-1 2	4-3 1	5-1 1	5-1 1	4-3 1	4-3 1	5-1 1	4-3 1	5-1 1	2-3 1
Mountain Plover	A	0-0 0	0-0 0	0-0 0	3-4 4	0-0 0	3-5 4	3-5 3	0-0 0	0-0 0	0-0 0	0-0 0	3-4 3
Upland Sandpiper	A	3-5 2	0-0 0	0-0 0	3-4 2	3-5 2	3-3 2	0-0 0	0-0 0	3-5 1	0-0 0	3-5 1	4-3 2
Long-billed Curlew	A	0-0 0	0-0 0	0-0 0	3-4 2	4-3 2	3-3 3	3-4 2	3-4 2	2-3 2	3-4 2	3-4 2	1-2 3
Band-tailed Pigeon	A	3-5 1	3-4 2	4-3 3	3-4 2	0-0 0	0-0 0	3-4 3	3-4 1	5-2 2	3-4 2	3-3 2	0-0 0
White-winged Dove	C	0-0 0	4-3 2	1-2 2	0-0 0	0-0 0	0-0 0	3-4 2	3-4 1	0-0 0	3-5 1	0-0 0	0-0 0
Mourning Dove	B	0-0 0	4-3 1	3-3 2	4-3 2	3-3 1	2-3 1	5-1 1	4-1 2	4-3 2	4-3 1	2-3 2	1-1 1
Black-billed Cuckoo	A	0-0 0	0-0 0	0-0 0	3-5 1	3-5 1	4-3 2	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	3-4 2
Yellow-billed Cuckoo	A	0-0 0	3-5 2	3-5 2	3-4 2	3-5 1	3-5 1	3-4 2	3-4 2	3-5 1	3-5 2	0-0 0	3-5 1
Flammulated Owl	A	0-0 0	3-5 2	3-4 2	3-5 2	3-5 2	3-5 1	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2	0-0 0
Elf Owl	C	0-0 0	3-5 2	3-5 1	0-0 0	0-0 0	0-0 0	3-5 1	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0
Burrowing Owl	A	0-0 0	3-4 2	2-2 2	4-3 2	3-4 2	4-3 2	4-3 2	4-3 2	3-4 2	3-4 2	3-4 2	3-4 2
Long-eared Owl	B	0-0 0	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2	3-5 2
Short-eared Owl	B	3-5 2	3-5 1	3-4 2	3-5 2	3-4 2	4-3 2	0-0 0	3-5 2	3-4 2	3-4 2	3-4 2	3-4 1
Lesser Nighthawk	A	0-0 0	1-1 2	2-3 2	0-0 0	0-0 0	0-0 0	3-4 2	3-4 2	0-0 0	3-5 1	0-0 0	0-0 0
Common Nighthawk	A	3-5 1	3-4 1	2-3 2	2-3 1	3-3 1	2-3 1	5-1 2	5-1 2	2-3 2	2-3 2	4-3 2	4-3 1
Common Poorwill	B	0-0 0	3-4 2	4-3 2	3-4 2	3-4 2	3-5 2	3-4 2	3-4 2	3-4 2	3-5 2	3-4 2	3-4 2
Buff-collared Nightjar	C	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Whip-poor-will	A	0-0 0	3-5 2	3-5 1	0-0 0	0-0 0	0-0 0	3-5 2	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0
Black Swift	A	3-5 1	0-0 0	3-4 3	3-5 4	3-4 1	3-4 2	3-5 2	0-0 0	3-5 1	3-5 1	3-4 2	0-0 0
Chimney Swift	A	0-0 0	0-0 0	3-5 1	3-5 2	0-0 0	3-4 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Vaux's Swift	A	3-5 1	0-0 0	4-3 2	0-0 0	3-4 2	3-4 2	0-0 0	0-0 0	5-1 2	0-0 0	4-3 2	0-0 0
White-throated Swift	A	0-0 0	3-4 2	4-3 2	3-4 2	3-4 2	3-5 2	3-4 2	5-1 2	3-5 1	3-4 2	3-4 1	2-2 2
Broad-billed Hummingbird	C	0-0 0	3-4 2	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Violet-crowned Hummingbird	C	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Blue-throated Hummingbird	C	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Magnificent Hummingbird	C	0-0 0	3-4 2	0-0 0	3-5 1	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Lucifer Hummingbird	C	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Ruby-throated Hummingbird	A	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Black-chinned Hummingbird	A	0-0 0	3-4 3	5-2 3	3-4 2	3-5 2	3-5 1	3-4 3	3-4 3	3-5 2	3-4 3	3-4 2	0-0 0
Anna's Hummingbird	B	0-0 0	3-5 2	4-3 5	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	3-4 3	0-0 0	3-5 2	0-0 0
Costa's Hummingbird	A	0-0 0	3-5 4	3-3 4	0-0 0	0-0 0	0-0 0	3-5 1	3-5 1	3-5 1	3-5 1	0-0 0	0-0 0
Calliope Hummingbird	A	0-0 0	0-0 0	2-3 3	0-0 0	4-3 3	3-4 2	0-0 0	3-5 3	3-4 3	3-5 2	4-3 2	3-4 1
Broad-tailed Hummingbird	A	0-0 0	3-4 3	3-4 2	3-3 2	3-4 2	0-0 0	3-4 3	3-4 2	3-5 1	4-2 2	0-0 0	3-4 2
Rufous Hummingbird	A	3-5 3	0-0 0	3-4 2	0-0 0	3-4 2	3-4 2	0-0 0	3-5 1	5-2 3	0-0 0	5-1 3	3-4 1
Allen's Hummingbird	A	0-0 0	0-0 0	5-1 5	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0
Elegant Trogon	C	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Belted Kingfisher	B	3-5 2	3-5 1	4-2 2	4-3 1	3-3 1	3-3 1	3-4 3	3-4 2	4-3 1	3-5 2	4-3 2	3-4 1
Green Kingfisher	C	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Lewis' Woodpecker	B	0-0 0	3-4 2	4-2 3	3-4 2	3-4 3	3-4 2	3-4 2	3-4 3	3-4 2	3-4 2	3-4 2	3-4 2
Yellow-bellied Sapsucker	B	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0
Red-naped Sapsucker	B	0-0 0	3-5 3	3-5 1	3-5 3	2-3 3	1-1 3	3-4 3	3-4 3	3-4 2	3-4 3	1-1 1	3-4 3
Red-breasted Sapsucker	B	3-5 3	0-0 0	2-3 3	0-0 0	0-0 0	0-0 0	0-0 0	3-5 2	2-3 3	0-0 0	2-3 3	0-0 0
Williamson's Sapsucker	B	0-0 0	3-5 2	3-4 3	3-4 3	3-4 3	3-4 2	3-4 2	3-4 3	5-1 3	3-4 3	3-4 2	3-4 3
Northern Flicker	B	3-5 2	3-4 1	3-3 2	2-3 1	5-1 1	4-3 1	5-1 1	5-1 1	2-2 1	5-1 1	2-2 1	4-3 1
No. Beardless-Tyrannulet	C	0-0 0	3-4 2	0-0 0	0-0 0	0-0 0	0-0 0	3-5 1	0-0 0	0-0 0	0-0 0	0-0 0	0-0 0
Olive-sided Flycatcher	A	3-5 2	3-4 2	4-2 2	3-4 2	4-3 2	3-4 2	3-4 2	3-4 1	5-2 2	3-4 2	4-3 2	3-4 2

Table 3. Continued.

Species	Type	AK		AZ		CA		CO		ID		MT		NM		NV		OR		UT		WA		WY	
Greater Pewee	C	0-0	0	3-4	2	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Western Wood-Pewee	A	3-5	2	3-4	2	5-1	2	1-2	2	4-3	2	1-2	2	2-3	2	2-3	2	3-3	2	3-4	2	2-3	2	2-3	2
Alder Flycatcher	A	3-5	3	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Willow Flycatcher	A	0-0	0	3-5	1	2-3	2	3-4	2	5-1	2	3-3	2	3-5	2	3-5	2	3-3	2	3-4	2	4-3	2	2-3	2
Least Flycatcher	A	3-5	1	0-0	0	0-0	0	3-5	1	0-0	0	3-3	2	0-0	0	0-0	0	3-5	1	0-0	0	3-4	1	3-4	2
Hammond's Flycatcher	A	3-5	3	3-5	1	4-3	2	3-4	2	2-3	3	3-4	2	3-5	2	3-5	1	4-3	2	3-5	2	2-3	2	3-4	2
Dusky Flycatcher	A	3-5	1	3-5	1	2-3	2	3-4	2	3-3	2	4-3	2	3-4	2	3-4	2	3-3	2	3-4	2	1-1	2	2-3	3
Gray Flycatcher	A	0-0	0	3-4	3	3-4	2	3-4	3	3-4	2	0-0	0	3-4	3	3-4	4	2-3	3	3-4	3	3-5	2	4-3	2
Pacific-slope Flycatcher	A	3-5	3	0-0	0	3-5	3	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	3-5	3	0-0	0	3-5	2	0-0	0
Cordilleran Flycatcher	A	0-0	0	3-5	2	3-5	1	3-5	2	3-5	1	3-4	3	3-5	2	3-5	1	3-5	2	3-5	2	0-0	0	3-5	3
Buff-breasted Flycatcher	C	0-0	0	3-5	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Eastern Phoebe	B	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1
Say's Phoebe	B	3-5	3	4-2	2	4-3	2	3-3	2	3-4	2	3-3	2	4-3	2	4-3	2	4-3	2	1-2	2	4-3	2	4-3	2
Vermilion Flycatcher	A	0-0	0	3-4	2	3-5	1	0-0	0	0-0	0	0-0	0	3-5	2	3-5	1	0-0	0	3-5	1	0-0	0	0-0	0
Dusky-capped Flycatcher	C	0-0	0	3-4	2	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Ash-throated Flycatcher	A	0-0	0	4-3	2	2-3	2	3-4	1	3-5	1	0-0	0	2-3	2	2-3	2	2-3	2	1-1	2	3-5	1	3-5	1
Great Crested Flycatcher	A	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Brown-crested Flycatcher	C	0-0	0	1-2	2	3-5	1	0-0	0	0-0	0	0-0	0	3-5	1	3-5	1	0-0	0	3-5	1	0-0	0	0-0	0
Sulphur-bellied Flycatcher	C	0-0	0	3-4	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Tropical Kingbird	C	0-0	0	3-5	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Cassin's Kingbird	A	0-0	0	5-2	3	5-1	2	3-4	2	0-0	0	3-4	1	2-3	3	2-3	1	0-0	0	3-4	2	0-0	0	3-4	2
Thick-billed Kingbird	C	0-0	0	3-4	1	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Western Kingbird	A	0-0	0	2-3	2	2-2	2	4-3	2	3-3	2	1-2	2	4-3	2	4-3	2	4-3	2	3-3	2	3-3	2	2-3	2
Eastern Kingbird	A	0-0	0	0-0	0	3-5	1	2-3	2	5-2	2	1-1	2	3-5	2	3-5	1	3-4	2	3-4	2	4-3	2	2-3	2
Scissor-tailed Flycatcher	A	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	3-5	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Rose-throated Becard	C	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Horned Lark	B	3-5	2	5-1	1	4-2	2	4-3	1	4-3	1	1-1	1	4-3	1	4-3	1	4-3	1	4-3	1	3-3	1	4-3	1
Purple Martin	A	0-0	0	3-4	2	3-3	2	3-5	1	0-0	0	3-5	2	3-4	2	0-0	0	3-4	2	3-4	1	3-5	1	0-0	0
Tree Swallow	B	3-5	2	3-5	2	4-3	2	2-3	1	2-3	2	3-3	2	3-5	2	3-5	2	4-3	2	3-4	2	2-3	2	2-3	2
Violet-green Swallow	A	3-5	3	5-2	2	4-3	2	2-3	2	2-3	2	1-2	2	1-2	2	1-2	2	2-3	2	4-3	2	2-3	2	2-2	2
No. Rough-winged Swallow	A	3-5	1	5-1	2	4-3	2	2-3	2	2-3	2	2-3	2	3-4	2	3-4	2	2-3	2	4-3	2	2-3	2	2-3	2
Bank Swallow	A	3-5	2	0-0	0	3-4	1	3-4	2	1-1	2	4-3	2	3-5	2	3-5	2	3-4	2	3-4	2	4-3	2	4-3	2
Cliff Swallow	A	3-5	2	3-3	1	4-2	2	2-3	1	4-3	1	2-3	1	2-3	1	2-3	1	2-3	1	2-3	1	2-3	1	2-3	1
Cave Swallow	C	0-0	0	3-5	1	3-5	1	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Barn Swallow	A	3-5	1	3-4	1	5-1	2	2-3	1	2-3	1	4-3	1	2-3	1	2-3	1	5-1	1	4-3	1	5-1	1	2-3	1
Brown Creeper	B	3-5	1	3-4	2	4-3	2	3-4	2	3-4	2	3-4	1	3-4	2	3-5	2	4-3	2	3-5	2	2-3	2	3-5	2
Rock Wren	B	0-0	0	5-1	2	4-3	2	4-3	2	4-3	2	5-1	2	5-1	2	5-1	2	5-1	2	4-3	2	1-2	2	4-3	2
House Wren	A	0-0	0	3-4	2	4-3	2	4-3	2	3-3	2	1-1	2	3-4	2	3-4	2	3-3	2	3-4	2	1-1	2	2-3	2
Sedge Wren	B	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Marsh Wren	B	0-0	0	3-5	1	2-3	2	3-5	1	3-4	2	3-4	2	3-5	1	3-5	1	3-4	2	3-5	1	4-3	2	3-4	2
Golden-cr. Kinglet (Supp.)	B	3-5	2	3-5	2	3-3	2	3-4	2	3-3	2	3-4	2	3-4	2	3-5	1	5-1	2	3-5	2	5-2	2	3-4	2
Ruby-crowned Kinglet	B	3-5	3	3-4	2	4-3	2	3-4	2	2-3	2	2-3	2	3-4	2	3-4	2	2-3	2	3-4	2	4-3	2	2-3	2
Blue-gray Gnatcatcher	A	0-0	0	3-4	2	4-3	2	3-4	1	3-4	1	0-0	0	3-4	2	3-4	2	3-5	1	2-3	2	0-0	0	3-5	1
Eastern Bluebird	B	0-0	0	3-4	1	0-0	0	3-5	1	0-0	0	3-5	1	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1
Western Bluebird	B	0-0	0	3-4	2	4-3	2	3-4	2	3-4	2	3-4	2	4-3	2	4-3	2	2-3	2	3-4	2	2-3	2	3-5	2
Mountain Bluebird	B	3-5	1	3-4	2	4-3	2	4-3	2	2-3	2	3-3	2	4-3	2	4-3	2	2-3	2	1-1	2	1-1	2	2-2	2
Townsend's Solitaire	B	3-5	3	3-4	2	4-3	2	3-4	2	3-4	2	3-4	2	3-4	2	3-4	2	3-3	2	3-4	2	2-3	2	2-3	2
Veery	A	0-0	0	3-5	1	3-5	1	3-4	2	2-3	2	2-3	2	0-0	0	0-0	0	3-4	2	3-5	2	2-3	2	3-4	2
Gray-cheeked Thrush	A	3-5	4	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Swainson's Thrush	A	3-5	2	3-5	1	3-3	2	3-4	2	4-3	2	4-3	2	3-5	2	3-5	2	5-1	2	3-4	2	3-3	2	3-4	2
Hermit Thrush	B	3-5	2	3-4	2	2-3	2	3-4	2	4-3	2	3-4	2	3-4	2	3-4	2	3-3	2	3-4	2	1-2	2	3-3	2
American Robin	B	3-5	2	3-4	1	4-2	2	3-3	1	2-3	1	2-2	1	2-3	1	2-3	1	5-1	1	4-3	1	2-2	1	4-3	1
Gray Catbird	A	0-0	0	3-5	1	0-0	0	3-4	2	2-3	2	3-3	2	3-5	1	0-0	0	3-5	1	3-4	2	3-4	2	3-3	2
Northern Mockingbird	B	0-0	0	3-3	2	3-3	2	2-3	2	3-5	1	3-5	1	2-3	2	2-3	2	3-5	1	4-3	2	0-0	0	3-5	1
Sage Thrasher	B	0-0	0	3-4	2	3-3	2	3-4	2	3-3	3	3-3	3	3-4	2	3-4	4	2-3	3	4-3	3	3-4	3	2-3	3
Bendire's Thrasher	B	0-0	0	3-4	5	3-4	2	3-5	1	0-0	0	0-0	0	3-4	3	3-4	2	0-0	0	3-5	3	0-0	0	0-0	0
American Pipit	B	3-5	3	3-5	2	0-0	0	3-4	2	3-5	1	3-5	2	3-5	2	3-5	1	3-5	2	3-5	2	3-5	2	3-4	2
Sprague's Pipit	B	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	4-3	3	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Cedar Waxwing	B	3-5	1	0-0	0	2-3	2	3-5	1	5-2	2	4-3	2	0-0	0	3-5	2	4-3	2	3-5	1	2-3	2	3-4	2
Phainopepla	A	0-0	0	4-3	3	1-1	2	0-0	0	0-0	0	0-0	0	3-4	2	3-4	2	0-0	0	3-5	1	0-0	0	0-0	0
Loggerhead Shrike	B	0-0	0	5-2	2	5-1	2	3-3	2	3-4	2	2-3	2	3-3	2	3-3	2	3-4	2	2-3	2	3-4	2	2-3	2
Bell's Vireo	A	0-0	0	3-3	2	3-5	2	3-5	1	0-0	0	0-0	0	3-4	2	3-4	1	0-0	0	3-5	1	0-0	0	0-0	0
Gray Vireo	A	0-0	0	3-4	4	3-5	2	3-4	3	0-0	0	0-0	0	3-5	4	3-5	2	0-0	0	3-4	3	0-0	0	0-0	0
Solitary Vireo	A	0-0	0	3-4	2	1-1	2	3-4	2	2-3	2	4-3	2	3-4	2	3-4	2	2-3	2	3-4	2	2-3	2	3-4	2
Warbling Vireo	A	3-5	2	3-4	2	4-2	2	2-3	2	2-3	2	2-3	1	3-4	2	3-4	2	3-3	2	3-4	2	1-1	2	2-3	2
Red-eyed Vireo	A	3-5	1	0-0	0	0-0	0	3-5	1	3-4	2	2-3	2	0-0	0	0-0	0	3-4	1	0-0	0	1-1	2	3-4	1
Tennessee Warbler	A	3-5	2	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0

Table 3. Continued.

Species	Type	AK		AZ		CA		CO		ID		MT		NM		NV		OR		UT		WA		WY	
Orange-crowned Warbler	A	3-5	2	3-5	2	2-3	2	3-4	2	2-3	2	3-4	2	3-4	2	3-4	2	5-2	2	3-4	2	2-3	2	3-4	2
Nashville Warbler	A	0-0	0	0-0	0	4-2	2	0-0	0	1-1	2	3-4	2	0-0	0	3-5	1	4-3	2	0-0	0	4-3	2	0-0	0
Virginia's Warbler	A	0-0	0	3-4	4	3-5	2	3-4	3	3-5	1	0-0	0	3-4	3	3-4	3	0-0	0	3-4	4	0-0	0	3-5	2
Lucy's Warbler	C	0-0	0	4-3	5	3-5	2	0-0	0	0-0	0	0-0	0	3-5	3	3-5	1	0-0	0	3-5	1	0-0	0	0-0	0
Yellow Warbler	A	3-5	2	3-4	2	4-3	2	3-3	1	4-3	1	2-3	1	3-4	1	3-4	2	2-3	2	5-1	2	2-3	2	2-3	1
Chestnut-sided Warbler	A	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Yellow-rumped Warbler	B	3-5	2	3-4	2	4-3	2	3-4	2	3-3	2	4-3	2	3-4	2	3-4	2	4-3	2	3-4	2	4-3	2	2-3	2
Black-throated Gray Warbler	A	0-0	0	3-4	2	4-3	3	3-4	2	3-4	1	0-0	0	3-4	3	3-4	3	4-3	2	3-4	3	3-3	2	3-5	2
Townsend's Warbler	A	3-5	3	0-0	0	3-5	1	0-0	0	3-4	2	3-4	3	0-0	0	0-0	0	4-3	2	0-0	0	2-3	2	0-0	0
Hermit Warbler	A	0-0	0	0-0	0	3-3	5	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1	3-3	4	0-0	0	3-4	2	0-0	0
Grace's Warbler	A	0-0	0	3-4	3	0-0	0	3-5	2	0-0	0	0-0	0	3-4	3	3-4	1	0-0	0	3-5	2	0-0	0	0-0	0
Blackpoll Warbler	A	3-5	3	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Black-and-white Warbler	A	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	3-5	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
American Redstart	A	3-5	1	3-5	1	0-0	0	3-5	1	3-4	2	2-3	2	0-0	0	0-0	0	3-5	1	3-5	1	3-4	2	3-4	2
Ovenbird	A	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	3-4	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	3-4	2
Northern Waterthrush	A	3-5	3	0-0	0	0-0	0	0-0	0	3-4	1	3-4	2	0-0	0	0-0	0	3-5	1	0-0	0	3-5	1	0-0	0
MacGillivray's Warbler	A	3-5	2	3-5	2	4-2	2	3-4	2	3-3	2	3-4	2	3-4	2	3-4	2	4-3	2	3-4	2	4-3	2	3-4	2
Common Yellowthroat	A	3-5	1	3-4	1	2-3	2	4-3	1	4-3	1	4-3	1	3-4	1	3-4	2	2-2	1	3-4	1	2-3	1	2-3	1
Wilson's Warbler	A	3-5	2	0-0	0	5-1	2	3-4	2	4-3	2	3-4	2	3-5	2	3-5	1	5-2	2	3-4	2	5-2	2	3-4	2
Canada Warbler	A	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Red-faced Warbler	C	0-0	0	3-4	4	0-0	0	0-0	0	0-0	0	0-0	0	3-5	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Painted Redstart	C	0-0	0	3-4	2	0-0	0	0-0	0	0-0	0	0-0	0	3-5	2	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0
Yellow-breasted Chat	A	0-0	0	3-4	2	3-3	2	3-4	2	2-3	2	1-2	2	3-4	2	3-4	2	2-3	2	3-4	2	4-3	2	2-3	2
Olive Warbler	C	0-0	0	3-4	2	0-0	0	0-0	0	0-0	0	0-0	0	3-5	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Hepatic Tanager	A	0-0	0	3-4	3	3-5	2	3-5	1	0-0	0	0-0	0	3-4	3	3-4	1	0-0	0	0-0	0	0-0	0	0-0	0
Summer Tanager	A	0-0	0	3-4	2	3-5	2	0-0	0	0-0	0	0-0	0	3-5	2	3-5	1	0-0	0	3-5	1	0-0	0	0-0	0
Western Tanager	A	3-5	2	3-4	2	3-3	2	4-3	2	4-3	2	2-3	2	3-4	2	3-4	2	5-1	2	3-4	2	1-1	2	2-3	2
Rose-breasted Grosbeak	A	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1
Black-headed Grosbeak	A	0-0	0	3-4	2	3-3	2	2-3	2	1-2	2	1-2	2	2-3	2	2-3	2	1-1	2	3-4	2	2-3	2	2-2	2
Blue Grosbeak	A	0-0	0	3-4	2	1-2	2	4-3	2	3-5	1	3-5	1	2-3	2	2-3	2	0-0	0	3-4	2	0-0	0	3-4	1
Lazuli Bunting	A	0-0	0	3-4	2	4-3	2	3-4	2	4-3	2	2-3	2	3-4	2	3-4	2	2-3	2	5-2	2	1-2	2	2-3	2
Indigo Bunting	A	0-0	0	3-4	2	3-5	1	3-5	2	0-0	0	0-0	0	3-4	2	0-0	0	0-0	0	3-5	2	0-0	0	3-5	1
Varied Bunting	C	0-0	0	3-4	2	3-5	1	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Painted Bunting	A	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Dickcissel	A	0-0	0	0-0	0	0-0	0	3-4	1	0-0	0	3-5	1	3-4	1	0-0	0	0-0	0	0-0	0	0-0	0	3-4	1
Green-tailed Towhee	A	0-0	0	3-5	2	3-3	2	4-3	3	3-4	3	3-4	2	3-4	3	3-4	3	2-2	2	2-3	3	3-5	1	3-3	3
Rufous-sided Towhee	B	0-0	0	3-4	2	3-3	2	4-3	2	5-2	2	4-3	2	4-3	2	4-3	2	2-3	2	3-3	2	2-3	2	2-3	2
Botteri's Sparrow	C	0-0	0	3-4	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Cassin's Sparrow	B	0-0	0	3-4	2	0-0	0	2-3	2	0-0	0	0-0	0	2-3	3	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Chipping Sparrow	A	3-5	2	3-4	2	5-1	2	5-2	1	2-3	2	5-1	2	4-3	2	4-3	2	4-3	2	5-1	2	5-2	2	4-2	2
Clay-colored Sparrow	A	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	1-2	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	2-3	2
Brewer's Sparrow	A	0-0	0	3-4	2	4-3	2	5-2	3	4-2	3	4-3	3	3-4	2	3-4	3	5-2	2	5-2	3	3-4	2	5-1	3
Black-chinned Sparrow	A	0-0	0	3-4	2	5-1	3	3-5	1	0-0	0	0-0	0	3-4	2	3-4	1	0-0	0	3-5	1	0-0	0	0-0	0
Vesper Sparrow	B	0-0	0	3-4	2	3-3	1	3-3	2	4-3	2	4-3	2	4-3	2	4-3	2	2-3	2	2-3	2	2-3	2	2-3	2
Lark Sparrow	A	0-0	0	3-4	2	4-2	2	4-3	2	4-3	2	1-2	2	4-2	2	4-2	2	4-3	2	2-3	2	3-4	2	2-3	2
Black-throated Sparrow	B	0-0	0	5-2	3	5-1	2	0-0	0	3-4	1	0-0	0	4-3	2	4-3	3	3-4	1	5-2	2	3-5	1	0-0	0
Sage Sparrow	B	0-0	0	3-4	2	4-3	3	3-4	2	3-4	2	3-5	1	3-4	2	3-4	3	4-3	3	1-2	3	3-4	1	2-3	3
Lark Bunting	A	0-0	0	3-4	1	0-0	0	4-3	3	3-5	1	3-3	3	3-4	2	0-0	0	0-0	0	3-5	1	0-0	0	2-3	3
Savannah Sparrow	B	3-5	2	3-5	1	2-3	2	3-4	2	4-3	2	5-2	2	3-5	2	3-5	2	2-3	2	3-4	2	3-3	2	2-3	2
Baird's Sparrow	A	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	2-3	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Grasshopper Sparrow	A	0-0	0	3-4	1	5-2	2	5-2	2	4-3	1	4-3	2	3-4	1	3-4	2	3-4	1	3-5	2	2-3	2	2-3	1
Fox Sparrow	B	3-5	3	0-0	0	4-3	2	3-4	2	3-4	2	3-4	2	0-0	0	3-5	2	3-4	2	3-4	2	3-4	2	3-4	2
Song Sparrow	B	3-5	2	3-4	2	4-3	2	2-3	2	5-1	2	5-1	1	3-5	1	3-5	2	4-3	2	4-3	2	5-1	2	2-3	2
Lincoln's Sparrow	A	3-5	2	3-5	1	3-4	2	3-4	2	3-4	2	3-4	2	3-4	1	3-4	2	3-4	2	3-4	2	3-4	2	2-3	2
White-throated Sparrow	B	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
White-crowned Sparrow	B	3-5	2	3-5	1	4-3	2	3-4	2	4-3	2	3-4	2	3-5	2	3-5	2	4-2	2	3-4	2	3-3	2	2-3	2
Dark-eyed Junco	B	3-5	2	3-4	2	4-3	2	3-4	2	5-2	2	3-4	2	3-4	2	3-4	2	4-3	2	3-4	2	4-3	2	2-3	2
McCown's Longspur	B	0-0	0	0-0	0	0-0	0	3-5	2	0-0	0	1-2	4	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	3-4	4
Chestnut-collared Longspur	B	0-0	0	0-0	0	0-0	0	3-4	2	0-0	0	2-3	4	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	3-4	3
Bobolink	A	0-0	0	3-5	1	3-5	1	3-4	2	3-4	2	4-3	2	0-0	0	3-5	1	3-4	2	3-5	1	3-5	2	3-4	2
Red-winged Blackbird	B	3-5	2	4-3	2	4-3	2	2-3	1	2-3	1	4-3	1	5-2	1	5-2	1	3-3	1	2-2	1	2-3	1	2-3	1
Eastern Meadowlark	B	0-0	0	3-4	1	0-0	0	0-0	0	0-0	0	0-0	0	4-3	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Western Meadowlark	B	0-0	0	3-4	2	5-1	2	3-3	2	4-3	2	2-3	2	4-3	2	4-3	2	5-1	2	5-1	2	3-3	2	4-3	2
Yellow-headed Blackbird	A	0-0	0	3-4	2	2-3	2	2-3	2	4-3	2	2-3	2	3-5	2	3-5	2	4-3	2	4-3	2	4-3	2	2-3	2
Brewer's Blackbird	B	0-0	0	3-4	1	5-1	2	3-3	2	5-2	2	4-3	2	3-4	2	3-4	2	4-3	2	5-1	2	4-3	2	3-3	2
Bronzed Cowbird	C	0-0	0	3-4	2	3-5	1	0-0	0	0-0	0	0-0	0	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
Brown-headed Cowbird	B	3-5	1	4-3	2	4-3	2	3-3	1	2-3	1	1-1	1	4-3	2	4-3	2	2-3	2	3-3	2	4-3	2	2-3	1

Table 3. Continued.

Species	Type	AK		AZ		CA		CO		ID		MT		NM		NV		OR		UT		WA		WY	
Orchard Oriole	A	0-0	0	0-0	0	0-0	0	3-4	2	0-0	0	3-4	2	3-5	1	0-0	0	0-0	0	0-0	0	0-0	0	3-4	1
Hooded Oriole	A	0-0	0	3-4	2	4-3	2	0-0	0	0-0	0	0-0	0	3-5	1	3-5	2	0-0	0	3-5	1	0-0	0	0-0	0
Northern Oriole	A	0-0	0	3-4	2	3-3	2	4-3	2	3-3	2	2-3	2	2-3	2	2-3	2	4-3	2	5-2	2	1-2	2	4-3	2
Scott's Oriole	A	0-0	0	4-3	3	5-2	2	4-5	1	3-5	1	0-0	0	4-3	2	4-3	2	0-0	0	3-4	2	0-0	0	3-5	1
Purple Finch (NTMB?)	B	0-0	0	0-0	0	3-3	2	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	4-3	2	0-0	0	2-3	2	0-0	0
Cassin's Finch	B	0-0	0	3-5	1	5-2	2	3-4	2	4-3	3	4-3	2	3-5	2	3-5	2	4-3	2	3-4	3	2-3	2	2-2	2
Pine Siskin	B	3-5	2	3-4	2	5-1	2	5-1	2	4-3	2	2-3	2	3-4	2	3-4	2	2-3	2	3-4	2	5-2	2	3-3	2
Lesser Goldfinch (NTMB?)	B	0-0	0	5-2	2	3-3	2	3-4	2	3-5	1	0-0	0	4-3	2	4-3	2	3-4	2	3-4	2	0-0	0	0-0	0
Lawrence's Goldfinch	B	0-0	0	3-5	1	5-1	5	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0
American Goldfinch	B	0-0	0	0-0	0	4-3	2	4-3	2	4-3	2	2-3	2	0-0	0	3-5	2	3-3	2	3-4	2	1-1	2	4-3	2

Table 4.—Overall ranking for species of the West Working Group using population trend information from last 10 years of the Breeding Bird Survey. Zeros indicate that the species does not breed in the state.

Species	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Turkey Vulture	0.00	1.43	1.43	1.57	1.57	1.57	1.57	1.86	1.86	1.71	1.57	1.43
Osprey (Supp.)	2.57	2.29	2.43	2.43	2.43	2.43	2.29	2.43	2.43	2.43	2.14	2.43
Mississippi Kite	0.00	2.86	0.00	2.71	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Northern Harrier	2.71	2.57	2.86	2.57	2.57	2.57	2.57	2.71	2.57	2.86	2.86	2.43
Sharp-shinned Hawk	2.57	2.29	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
Cooper's Hawk	0.00	2.57	2.86	2.43	2.57	2.57	2.57	2.57	2.57	2.57	2.57	2.57
Northern Goshawk	2.86	2.71	2.57	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71
Common Black-Hawk	0.00	3.14	0.00	0.00	0.00	0.00	3.00	0.00	0.00	3.00	0.00	0.00
Gray Hawk	0.00	2.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-shouldered Hawk	0.00	2.71	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Swainson's Hawk	2.43	2.57	2.57	2.71	2.43	2.29	2.29	2.29	2.57	2.43	2.43	2.71
Zone-tailed Hawk	0.00	2.57	2.43	0.00	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00
Red-tailed Hawk	1.57	1.43	1.57	1.57	1.14	1.29	1.29	1.29	1.43	1.57	1.57	1.29
Ferruginous Hawk	0.00	3.14	3.00	3.14	3.14	3.14	3.14	3.14	3.29	3.43	3.14	3.43
Golden Eagle	2.29	2.29	2.29	2.29	2.29	2.14	2.29	2.29	2.00	2.43	2.29	2.43
American Kestrel	1.57	1.57	1.86	1.71	1.29	1.29	1.14	1.14	1.57	1.29	1.57	1.14
Merlin	2.86	0.00	2.57	0.00	2.57	2.71	0.00	0.00	0.00	0.00	2.57	2.71
Peregrine Falcon	3.14	3.00	3.00	2.71	3.00	3.00	3.00	2.86	3.00	2.86	2.86	3.00
Prairie Falcon	0.00	2.86	2.71	3.00	2.86	2.71	3.00	2.71	2.71	3.00	2.86	2.57
Killdeer	1.43	1.43	1.71	1.43	1.57	1.57	1.43	1.43	1.57	1.43	1.57	1.14
Mountain Plover	0.00	0.00	0.00	4.00	0.00	4.00	3.86	0.00	0.00	0.00	0.00	3.86
Upland Sandpiper	2.86	0.00	0.00	2.86	2.86	2.86	0.00	0.00	2.71	0.00	2.71	3.00
Long-billed Curlew	0.00	0.00	0.00	3.29	3.43	3.43	3.29	3.29	3.14	3.29	3.29	3.14
Band-tailed Pigeon	2.86	3.00	3.29	3.00	0.00	0.00	3.14	2.86	3.29	3.00	3.00	0.00
White-winged Dove	0.00	2.14	1.71	0.00	0.00	0.00	2.00	1.86	0.00	1.86	0.00	0.00
Mourning Dove	0.00	1.43	1.43	1.57	1.29	1.14	1.57	1.57	1.57	1.43	1.29	1.00
Black-billed Cuckoo	0.00	0.00	0.00	2.86	2.86	3.14	0.00	0.00	0.00	0.00	0.00	3.00
Yellow-billed Cuckoo	0.00	3.00	3.00	3.00	2.86	2.86	3.00	3.00	2.86	3.00	0.00	2.86
Flammulated Owl	0.00	2.71	2.71	2.71	2.71	2.57	2.71	2.71	2.71	2.71	2.71	0.00
Elf Owl	0.00	3.29	3.14	0.00	0.00	0.00	3.14	3.14	0.00	0.00	0.00	0.00
Burrowing Owl	0.00	3.29	3.14	3.43	3.29	3.43	3.43	3.43	3.29	3.29	3.29	3.29
Long-eared Owl	0.00	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14
Short-eared Owl	2.71	2.57	2.71	2.71	2.71	2.86	0.00	2.71	2.71	2.71	2.71	2.57
Lesser Nighthawk	0.00	2.00	2.14	0.00	0.00	0.00	2.29	2.29	0.00	2.14	0.00	0.00
Common Nighthawk	1.86	1.86	1.86	1.71	1.86	1.71	2.29	2.29	1.86	1.86	2.14	2.00
Common Poorwill	0.00	2.71	2.86	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71
Buff-collared Nightjar	0.00	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whip-poor-will	0.00	3.43	3.29	0.00	0.00	0.00	3.43	3.29	0.00	0.00	0.00	0.00
Black Swift	3.43	0.00	3.71	3.86	3.43	3.57	3.57	0.00	3.43	3.43	3.57	0.00
Chimney Swift	0.00	0.00	1.86	2.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00	0.00
Vaux's Swift	3.00	0.00	3.29	0.00	3.14	3.14	0.00	0.00	3.43	0.00	3.29	0.00
White-throated Swift	0.00	2.57	2.71	2.57	2.57	2.57	2.57	2.86	2.43	2.57	2.43	2.43
Broad-billed Hummingbird	0.00	2.86	0.00	0.00	0.00	0.00	2.71	0.00	0.00	0.00	0.00	0.00
Violet-crowned Hummingbird	0.00	2.86	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00
Blue-throated Hummingbird	0.00	2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Magnificent Hummingbird	0.00	2.71	0.00	2.57	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00
Lucifer Hummingbird	0.00	2.86	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00
Ruby-throated Hummingbird	0.00	0.00	0.00	0.00	0.00	2.14	0.00	0.00	0.00	0.00	0.00	0.00
Black-chinned Hummingbird	0.00	2.71	3.00	2.57	2.57	2.43	2.71	2.71	2.57	2.71	2.57	0.00
Anna's Hummingbird	0.00	2.43	3.00	0.00	0.00	2.29	0.00	0.00	2.57	0.00	2.43	0.00
Costa's Hummingbird	0.00	3.29	3.29	0.00	0.00	0.00	2.86	2.86	2.86	2.86	0.00	0.00
Calliope Hummingbird	0.00	0.00	2.86	0.00	3.14	2.86	0.00	3.00	3.00	2.86	3.00	2.71
Broad-tailed Hummingbird	0.00	2.86	2.71	2.71	2.71	0.00	2.86	2.71	2.57	2.86	0.00	2.71
Rufous Hummingbird	3.00	0.00	2.86	0.00	2.86	2.86	0.00	2.71	3.29	0.00	3.29	2.71
Allen's Hummingbird	0.00	0.00	3.86	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00
Elegant Trogon	0.00	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Belted Kingfisher	1.86	1.71	2.00	1.86	1.71	1.71	2.00	1.86	1.86	1.86	2.00	1.71
Green Kingfisher	0.00	2.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lewis' Woodpecker	0.00	3.00	3.29	3.00	3.14	3.00	3.00	3.14	3.00	3.00	3.00	3.00
Yellow-bellied Sapsucker	2.29	0.00	0.00	0.00	0.00	0.00	0.00	2.29	0.00	0.00	0.00	0.00
Red-naped Sapsucker	0.00	3.14	2.86	3.14	3.00	2.86	3.14	3.14	3.00	3.14	2.57	3.14
Red-breasted Sapsucker	3.14	0.00	3.00	0.00	0.00	0.00	0.00	3.00	3.00	0.00	3.00	0.00
Williamson's Sapsucker	0.00	3.00	3.14	3.14	3.14	3.00	3.00	3.14	3.43	3.14	3.00	3.14
Northern Flicker	1.43	1.29	1.43	1.14	1.57	1.43	1.57	1.57	1.14	1.57	1.14	1.43
Northern Beardless-Tyrannulet	0.00	2.71	0.00	0.00	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00

Table 4. Continued.

Species	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Olive-sided Flycatcher	3.29	3.29	3.43	3.29	3.43	3.29	3.29	3.14	3.57	3.29	3.43	3.29
Greater Pewee	0.00	2.71	0.00	0.00	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00
Western Wood-Pewee	2.57	2.57	2.86	2.29	2.71	2.29	2.43	2.43	2.57	2.57	2.43	2.43
Alder Flycatcher	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Willow Flycatcher	0.00	3.00	3.00	3.14	3.43	3.14	3.14	3.14	3.14	3.14	3.29	3.00
Least Flycatcher	2.86	0.00	0.00	2.86	0.00	3.00	0.00	0.00	2.86	0.00	2.86	3.00
Hammond's Flycatcher	3.29	3.00	3.29	3.14	3.14	3.14	3.14	3.00	3.29	3.14	3.00	3.14
Dusky Flycatcher	2.86	2.86	2.86	3.00	3.00	3.14	3.00	3.00	3.00	3.00	2.71	3.00
Gray Flycatcher	0.00	3.57	3.43	3.57	3.43	0.00	3.57	3.71	3.43	3.57	3.43	3.57
Pacific-slope Flycatcher	3.14	0.00	3.14	0.00	0.00	0.00	0.00	0.00	3.14	0.00	3.00	0.00
Cordilleran Flycatcher	0.00	3.00	2.86	3.00	2.86	3.14	3.00	2.86	3.00	3.00	0.00	3.14
Buff-breasted Flycatcher	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Phoebe	0.00	0.00	0.00	2.29	0.00	0.00	2.29	0.00	0.00	0.00	0.00	2.29
Say's Phoebe	2.71	2.71	2.71	2.57	2.57	2.57	2.71	2.71	2.71	2.29	2.71	2.71
Vermilion Flycatcher	0.00	2.00	1.86	0.00	0.00	0.00	2.00	1.86	0.00	1.86	0.00	0.00
Dusky-capped Flycatcher	0.00	2.57	0.00	0.00	0.00	0.00	2.43	0.00	0.00	0.00	0.00	0.00
Ash-throated Flycatcher	0.00	2.57	2.29	2.29	2.29	0.00	2.29	2.29	2.29	2.14	2.29	2.29
Great Crested Flycatcher	0.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brown-crested Flycatcher	0.00	2.29	2.43	0.00	0.00	0.00	2.43	2.43	0.00	2.43	0.00	0.00
Sulphur-bellied Flycatcher	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tropical Kingbird	0.00	2.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cassin's Kingbird	0.00	3.29	3.14	2.86	0.00	2.71	2.86	2.57	0.00	2.86	0.00	2.86
Thick-billed Kingbird	0.00	3.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Western Kingbird	0.00	2.29	2.29	2.57	2.43	2.14	2.57	2.57	2.57	2.43	2.43	2.29
Eastern Kingbird	0.00	0.00	2.29	2.29	2.71	2.14	2.43	2.29	2.43	2.43	2.57	2.29
Scissor-tailed Flycatcher	0.00	0.00	0.00	2.71	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00
Rose-throated Becard	0.00	2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horned Lark	1.43	1.57	1.57	1.43	1.43	1.00	1.43	1.43	1.43	1.43	1.29	1.43
Purple Martin	0.00	2.57	2.57	2.43	0.00	2.57	2.57	0.00	2.57	2.43	2.43	0.00
Tree Swallow	2.29	2.29	2.43	2.00	2.14	2.29	2.29	2.29	2.43	2.29	2.14	2.14
Violet-green Swallow	2.71	2.86	2.71	2.43	2.43	2.29	2.29	2.29	2.43	2.71	2.43	2.43
Northern Rough-winged Swallow	2.29	2.71	2.57	2.29	2.29	2.29	2.43	2.43	2.29	2.57	2.29	2.29
Bank Swallow	2.43	0.00	2.29	2.43	2.14	2.57	2.43	2.43	2.43	2.43	2.57	2.57
Cliff Swallow	2.29	2.14	2.43	2.00	2.29	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Cave Swallow	0.00	3.14	3.14	0.00	0.00	0.00	3.14	0.00	0.00	0.00	0.00	0.00
Barn Swallow	1.43	1.43	1.86	1.29	1.29	1.57	1.29	1.29	1.71	1.57	1.71	1.29
Brown Creeper	1.71	1.86	2.00	1.86	1.86	1.71	1.86	1.86	2.00	1.86	1.71	1.86
Rock Wren	0.00	2.71	2.57	2.57	2.57	2.71	2.71	2.71	2.71	2.57	2.14	2.57
House Wren	0.00	1.43	1.57	1.57	1.43	1.14	1.43	1.43	1.43	1.43	1.14	1.29
Sedge Wren	0.00	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00	0.00
Marsh Wren	0.00	2.57	2.57	2.57	2.71	2.71	2.57	2.57	2.71	2.57	2.86	2.71
Golden-crowned Kinglet (Supp.)	2.57	2.57	2.57	2.57	2.57	2.57	2.57	2.43	2.86	2.57	2.86	2.57
Ruby-crowned Kinglet	2.43	2.29	2.43	2.29	2.14	2.14	2.29	2.29	2.14	2.29	2.43	2.14
Blue-gray Gnatcatcher	0.00	2.43	2.57	2.29	2.29	0.00	2.43	2.43	2.29	2.29	0.00	2.29
Eastern Bluebird	0.00	2.43	0.00	2.43	0.00	2.43	2.43	0.00	0.00	0.00	0.00	2.43
Western Bluebird	0.00	2.71	2.86	2.71	2.71	2.71	2.86	2.86	2.57	2.71	2.57	2.71
Mountain Bluebird	2.43	2.57	2.71	2.71	2.43	2.57	2.71	2.71	2.43	2.29	2.29	2.43
Townsend's Solitaire	3.00	2.86	3.00	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.71	2.71
Veery	0.00	2.57	2.57	2.71	2.57	2.57	0.00	0.00	2.71	2.71	2.57	2.71
Gray-cheeked Thrush	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Swainson's Thrush	2.71	2.57	2.71	2.71	2.86	2.86	2.71	2.71	3.00	2.71	2.71	2.71
Hermit Thrush	2.57	2.57	2.43	2.57	2.71	2.57	2.57	2.57	2.57	2.57	2.29	2.57
American Robin	1.43	1.29	1.57	1.29	1.14	1.14	1.14	1.14	1.57	1.43	1.14	1.43
Gray Catbird	0.00	2.14	0.00	2.29	2.14	2.29	2.14	0.00	2.14	2.29	2.29	2.29
Northern Mockingbird	0.00	1.71	1.71	1.57	1.57	1.57	1.57	1.57	1.57	1.86	0.00	1.57
Sage Thrasher	0.00	2.57	2.57	2.57	2.71	2.71	2.57	2.86	2.57	2.86	2.71	2.57
Bendire's Thrasher	0.00	3.71	3.29	3.14	0.00	0.00	3.43	3.29	0.00	3.43	0.00	0.00
American Pipit	2.57	2.43	0.00	2.43	2.29	2.43	2.43	2.29	2.43	2.43	2.43	2.43
Sprague's Pipit	0.00	0.00	0.00	0.00	0.00	3.29	0.00	0.00	0.00	0.00	0.00	0.00
Cedar Waxwing	2.00	0.00	2.00	2.00	2.43	2.29	0.00	2.14	2.29	2.00	2.00	2.14
Phainopepla	0.00	3.00	2.43	0.00	0.00	0.00	2.71	2.71	0.00	2.57	0.00	0.00
Loggerhead Shrike	0.00	3.43	3.43	3.14	3.14	3.00	3.14	3.14	3.14	3.00	3.14	3.00
Bell's Vireo	0.00	3.43	3.43	3.29	0.00	0.00	3.43	3.29	0.00	3.29	0.00	0.00
Gray Vireo	0.00	4.00	3.71	3.86	0.00	0.00	4.00	3.71	0.00	3.86	0.00	0.00
Solitary Vireo	0.00	2.86	2.57	2.86	2.71	3.00	2.86	2.86	2.71	2.86	2.71	2.86
Warbling Vireo	2.57	2.57	2.71	2.43	2.43	2.29	2.57	2.57	2.57	2.57	2.29	2.43
Red-eyed Vireo	2.14	0.00	0.00	2.14	2.29	2.14	0.00	0.00	2.14	0.00	2.00	2.14

Table 4. Continued.

Species	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Tennessee Warbler	3.00	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00	0.00
Orange-crowned Warbler	2.57	2.57	2.43	2.57	2.43	2.57	2.57	2.57	2.86	2.57	2.43	2.57
Nashville Warbler	0.00	0.00	3.00	0.00	2.57	2.86	0.00	2.71	3.00	0.00	3.00	0.00
Virginia's Warbler	0.00	3.57	3.29	3.43	3.14	0.00	3.43	3.43	0.00	3.57	0.00	3.29
Lucy's Warbler	0.00	4.00	3.43	0.00	0.00	0.00	3.57	3.29	0.00	3.29	0.00	0.00
Yellow Warbler	2.00	2.00	2.14	1.86	2.00	1.71	1.86	2.00	1.86	2.29	1.86	1.71
Chestnut-sided Warbler	0.00	0.00	0.00	2.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yellow-rumped Warbler	1.71	1.71	1.86	1.71	1.71	1.86	1.71	1.71	1.86	1.71	1.86	1.57
Black-throated Gray Warbler	0.00	3.14	3.43	3.14	3.00	0.00	3.29	3.29	3.29	3.29	3.14	3.14
Townsend's Warbler	3.29	0.00	3.00	0.00	3.14	3.29	0.00	0.00	3.29	0.00	3.00	0.00
Hermit Warbler	0.00	0.00	4.00	0.00	0.00	0.00	0.00	3.43	3.86	0.00	3.57	0.00
Grace's Warbler	0.00	3.29	0.00	3.14	0.00	0.00	3.29	3.00	0.00	3.14	0.00	0.00
Blackpoll Warbler	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black-and-white Warbler	0.00	2.29	0.00	0.00	0.00	2.43	0.00	0.00	0.00	0.00	0.00	0.00
American Redstart	2.29	2.29	0.00	2.29	2.43	2.29	0.00	0.00	2.29	2.29	2.43	2.43
Ovenbird	0.00	0.00	0.00	2.86	0.00	3.00	0.00	0.00	0.00	0.00	0.00	3.00
Northern Waterthrush	2.71	0.00	0.00	0.00	2.43	2.57	0.00	0.00	2.43	0.00	2.43	0.00
MacGillivray's Warbler	3.14	3.14	3.29	3.14	3.14	3.14	3.14	3.14	3.29	3.14	3.29	3.14
Common Yellowthroat	2.00	2.00	2.00	2.14	2.14	2.14	2.00	2.14	1.86	2.00	1.86	1.86
Wilson's Warbler	2.71	0.00	3.00	2.71	2.86	2.71	2.71	2.57	3.00	2.71	3.00	2.71
Canada Warbler	2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-faced Warbler	0.00	3.57	0.00	0.00	0.00	0.00	3.29	0.00	0.00	0.00	0.00	0.00
Painted Redstart	0.00	3.00	0.00	0.00	0.00	0.00	3.00	2.86	0.00	0.00	0.00	0.00
Yellow-breasted Chat	0.00	2.57	2.57	2.57	2.43	2.29	2.57	2.57	2.43	2.57	2.71	2.43
Olive Warbler	0.00	3.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Hepatic Tanager	0.00	3.00	2.86	2.71	0.00	0.00	3.00	2.71	0.00	0.00	0.00	0.00
Summer Tanager	0.00	2.86	2.86	0.00	0.00	0.00	2.86	2.71	0.00	2.71	0.00	0.00
Western Tanager	2.57	2.57	2.57	2.71	2.71	2.43	2.57	2.57	2.86	2.57	2.29	2.43
Rose-breasted Grosbeak	0.00	0.00	0.00	2.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.43
Black-headed Grosbeak	0.00	2.71	2.71	2.57	2.43	2.43	2.57	2.57	2.43	2.71	2.57	2.57
Blue Grosbeak	0.00	2.57	2.29	2.71	2.43	2.43	2.43	2.43	0.00	2.57	0.00	2.43
Lazuli Bunting	0.00	2.71	2.86	2.71	2.86	2.57	2.71	2.71	2.57	3.00	2.43	2.57
Indigo Bunting	0.00	2.29	2.14	2.29	0.00	0.00	2.29	0.00	0.00	2.29	0.00	2.14
Varied Bunting	0.00	2.86	2.71	0.00	0.00	0.00	2.71	0.00	0.00	0.00	0.00	0.00
Painted Bunting	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00
Dickcissel	0.00	0.00	0.00	2.71	0.00	2.71	2.71	0.00	0.00	0.00	0.00	2.71
Green-tailed Towhee	0.00	2.71	2.71	3.00	2.86	2.71	2.86	2.86	2.57	2.71	2.57	2.86
Rufous-sided Towhee	0.00	2.14	2.14	2.29	2.43	2.29	2.29	2.29	2.00	2.14	2.00	2.00
Botteri's Sparrow	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cassin's Sparrow	0.00	3.43	0.00	3.29	0.00	0.00	3.43	0.00	0.00	0.00	0.00	0.00
Chipping Sparrow	2.00	2.00	2.29	2.14	1.86	2.29	2.14	2.14	2.14	2.29	2.29	2.14
Clay-colored Sparrow	0.00	0.00	0.00	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00	2.71
Brewer's Sparrow	0.00	2.86	3.00	3.29	3.14	3.14	2.86	3.00	3.14	3.29	2.86	3.29
Black-chinned Sparrow	0.00	3.00	3.43	2.86	0.00	0.00	3.00	2.86	0.00	2.86	0.00	0.00
Vesper Sparrow	0.00	2.29	2.14	2.29	2.43	2.43	2.43	2.43	2.14	2.14	2.14	2.14
Lark Sparrow	0.00	2.43	2.57	2.57	2.57	2.14	2.57	2.57	2.57	2.29	2.43	2.29
Black-throated Sparrow	0.00	3.14	3.00	0.00	2.57	0.00	2.86	3.00	2.57	3.00	2.57	0.00
Sage Sparrow	0.00	3.14	3.43	3.14	3.14	3.00	3.14	3.29	3.43	3.00	3.00	3.14
Lark Bunting	0.00	2.86	0.00	3.29	2.86	3.14	3.00	0.00	0.00	2.86	0.00	3.00
Savannah Sparrow	2.43	2.29	2.29	2.43	2.57	2.71	2.43	2.43	2.29	2.43	2.43	2.29
Baird's Sparrow	0.00	0.00	0.00	0.00	0.00	3.71	0.00	0.00	0.00	0.00	0.00	0.00
Grasshopper Sparrow	0.00	2.57	3.00	3.00	2.71	2.86	2.57	2.71	2.57	2.71	2.57	2.43
Fox Sparrow	2.43	0.00	2.43	2.29	2.29	2.29	0.00	2.29	2.29	2.29	2.29	2.29
Song Sparrow	1.71	1.71	1.86	1.57	2.00	1.86	1.57	1.71	1.86	1.86	2.00	1.57
Lincoln's Sparrow	2.29	2.14	2.29	2.29	2.29	2.29	2.14	2.29	2.29	2.29	2.29	2.14
White-throated Sparrow	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White-crowned Sparrow	2.00	1.86	2.14	2.00	2.14	2.00	2.00	2.00	2.14	2.00	2.00	1.86
Dark-eyed Junco	1.57	1.57	1.71	1.57	1.86	1.57	1.57	1.57	1.71	1.57	1.71	1.43
McCown's Longspur	0.00	0.00	0.00	3.71	0.00	3.71	0.00	0.00	0.00	0.00	0.00	4.00
Chestnut-collared Longspur	0.00	0.00	0.00	3.57	0.00	3.71	0.00	0.00	0.00	0.00	0.00	3.71
Bobolink	0.00	2.86	2.86	3.00	3.00	3.14	0.00	2.86	3.00	2.86	3.00	3.00
Red-winged Blackbird	1.57	1.71	1.71	1.29	1.29	1.57	1.71	1.71	1.43	1.29	1.29	1.29
Eastern Meadowlark	0.00	1.86	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
Western Meadowlark	0.00	2.14	2.43	2.14	2.29	2.00	2.29	2.29	2.43	2.43	2.14	2.29
Yellow-headed Blackbird	0.00	3.00	2.86	2.86	3.14	2.86	3.00	3.00	3.14	3.14	3.14	2.86
Brewer's Blackbird	0.00	2.14	2.57	2.29	2.57	2.43	2.29	2.29	2.43	2.57	2.43	2.29
Bronzed Cowbird	0.00	2.43	2.29	0.00	0.00	0.00	2.29	0.00	0.00	0.00	0.00	0.00

Table 4. Continued.

Species	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Brown-headed Cowbird	1.43	1.71	1.71	1.43	1.29	1.14	1.71	1.71	1.43	1.57	1.71	1.29
Orchard Oriole	0.00	0.00	0.00	2.86	0.00	2.86	2.71	0.00	0.00	0.00	0.00	2.71
Hooded Oriole	0.00	2.43	2.57	0.00	0.00	0.00	2.29	2.43	0.00	2.29	0.00	0.00
Northern Oriole	0.00	2.57	2.57	2.71	2.57	2.43	2.43	2.43	2.71	2.86	2.29	2.71
Scott's Oriole	0.00	3.29	3.29	3.00	2.86	0.00	3.14	3.14	0.00	3.00	0.00	2.86
Purple Finch (NTMB?)	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00	2.71	0.00	2.43	0.00
Cassin's Finch	0.00	2.29	2.71	2.43	2.71	2.57	2.43	2.43	2.57	2.57	2.29	2.29
Pine Siskin	1.57	1.57	1.86	1.86	1.71	1.43	1.57	1.57	1.43	1.57	1.86	1.57
Lesser Goldfinch (NTMB?)	0.00	2.71	2.43	2.43	2.29	0.00	2.57	2.57	2.43	2.43	0.00	0.00
Lawrence's Goldfinch	0.00	3.14	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Goldfinch	0.00	0.00	1.71	1.71	1.71	1.43	0.00	1.57	1.57	1.57	1.29	1.71

Table 5.—Means and sums by habitat for overall rankings and uncertainties (TBU+TWU+PTU)/3 using ten year period BBS trends for the state of Colorado.

Habitat	No. of Species	Uncertainty Mean	Uncertainty Sum	Species Ranks Mean	Species Ranks Sum
Cottonwood Riparian	29	4.21	122	2.64	78
Shortgrass Prairie	22	3.41	75	2.93	64
High-elevation Riparian	12	3.75	45	2.69	32
Gambel's Oak	11	3.91	43	2.86	31
Pinyon/juniper	6	4.17	25	3.00	18
Wetlands	7	3.43	24	2.18	15
Lodgepole Pine	7	3.29	23	2.10	15
Ponderosa Pine	4	3.50	14	2.93	11
Sage/scrub	4	3.50	14	2.93	11
Alpine tundra	1	4.00	4	2.43	2
Habitat Generalists	23	3.13	72	1.96	45

Status of Neotropical Migrant Landbirds in the Midwest: Identifying Species of Management Concern

Frank R. Thompson[1], Stephen J. Lewis[2], Janet Green[3], and David Ewert[4]

Abstract — We ranked species of neotropical migrant landbirds by decreasing management concern for their viability in the Midwest. This was part of a coordinated effort by regional working groups of the *Partners In Flight* Program, an interagency program for the conservation of neotropical migratory birds (NTMBs). Species were ranked by seven criteria, developed by working group co-chairs and participants in the *Partners In Flight* Program. The first four criteria were global and do not change with the region being considered; they were global abundance, extent of winter distribution, threats on wintering grounds, and extent of breeding distribution. The last three criteria pertained specifically to the Midwest region, and included threats on the breeding grounds, the importance of the Midwest to the species, and population trends. Breeding Bird Survey (BBS) data were used to score population trends, range maps and BBS density maps were used to estimate the importance of Midwest breeding habitat, and expert opinion to score breeding threats. We identified 110 NTMB species in the Midwest. The species with the highest ranks had previously been identified as federally threatened or endangered, candidates for federal listing as threatened or endangered, or species of special concern by the U.S. Fish and Wildlife Service. The closeness of the scores and the diversity of habitats within which highly ranked species occurred suggest that broad scale problems may be affecting these species on their breeding areas or that common non-breeding threats are affecting them. Alternatively, the results could reflect insensitivity of, or uncertainties in, the ranking system. The large number of highly ranked species in mature forest habitats, grasslands, and shrub-sapling habitats, and the high mean score of species in lowland deciduous and young conifer habitats, suggest these habitats deserve special management attention.

INTRODUCTION

The Midwest Working Group on Neotropical Migrant Birds (Working Group) was formed in 1991 as a regional component of the *Partners In Flight* program. The geographic area encompassed by the Working Group includes 14 States and 3 provinces (Figure 1). The Working Group to fosters communication, coordination, and cooperation among public agencies, tribal entities, private conservation organizations, academic institutions, and others interested in conserving

[1] *North Central Forest Experiment Station, University of Missouri, 1-26 Agriculture Bldg., Columbia, Missouri 65211, USA.*

[2] *USFWS/Migratory Bird Office, Federal Bldg-Ft. Snelling, Twin Cities, Minnesota 55111, USA.*

[3] *National Audubon Society, 1754 Old North Shore Dr., Duluth, Minnesota 55804, USA.*

[4] *The Nature Conservancy, 2840 East Grand River Ave., Suite 5, East Lansing, Michigan 48823, USA.*

Figure 1.—States and provinces included in the Midwest region of the *Partners In Flight* program.

NTMBs in the Midwest. Committees within the Working Group address issues and activities related to population and habitat monitoring, research, habitat management, and education.

Of the 143 species of landbirds that the *Partners In Flight* program has identified as breeding in North America and wintering south of the United States, 110 (77%) breed in the Midwest region. The Working Group collects and evaluates information related to these species and the habitats upon which they depend. The relative importance of the region to the well-being of these birds varies considerably among species; some occur at the center of their range in the Midwest, others make only minor or transitory use of the region. The abundance, population trends, and limiting factors of these species also differ greatly, with some very common and secure, others common but susceptible to threats, and others rare or declining.

The regional Working Groups developed a standardized procedure to determine the status of NTMBs within each region and to identify those species most in need of management attention (Hunter et al. this proceedings). The primary objective of this effort is to focus monitoring, research, and management activities. We report the initial results of that analysis for the Midwest. We hope that the approach and information presented in this paper ultimately will allow the Working Group to establish more specific objectives and to make appropriate recommendations about how personnel, funds, and other limited resources should be allocated to best conserve neotropical migrant birds in the Midwest. In this paper, we: (1) present a preliminary list of neotropical migrant landbirds in the Midwest prioritized by degree of management concern; (2) present BBS trend data for NTMBs in the Midwest; and (3) identify habitats that are important to those neotropical migrant landbirds most in need of management attention in the Midwest.

METHODS

We identified all neotropical migrant landbirds that breed in the Midwest region and ranked species by decreasing management concern based on the mean score of seven criteria (Table 1; see Hunter et al. this proceedings for a thorough description). The first four criteria were global and did not change with the region being considered. These criteria were scored initially by Hunter et al. (this proceedings). The last three criteria - breeding ground threats, importance of region, and population trends - pertained specifically to the Midwest region. Breeding ground threats were scored based on expert opinion and included habitat loss or degradation, cowbird parasitism, predation, contaminants, human disturbance, etc. We used field guide range maps (National Geographic Society 1983, Peterson 1980, Peterson 1990) and contour maps of species abundance developed from BBS data (J. Price, Northern Prairie Wildlife Research Center, U. S. Fish and Wildlife Service, unpublished data) to determine the importance of the Midwest region to each species. The population trend score was primarily based on BBS trend data (Appendix 1; B. Peterjohn, Office of Migratory Bird Management, and J. Sauer, Branch Of Migratory Bird Research, Patuxent Wildlife Research Center, U. S. Fish and Wildlife Service). BBS trends were calculated for the periods 1966-1991 and 1982-1991 by the route regression method (Geissler and Sauer 1990). BBS trends should be interpreted with caution because of possible biases associated with roadside point counts and because the results may not be reliable when the degrees of freedom of the analysis are < 14 or when the average number of detections per route are less than 1.0. The population trend criterion was scored 1-5 based on the direction and significance of long- and short-term declines (Table 1). When BBS data were nonexistent or unreliable, participants' opinions were used to score the population trend criteria. If there were no opinions on a species population trend the species received a score of 3.

We then sent our initial scores to 48 people in the region affiliated with federal or state agencies, universities, and conservation organizations who had some expertise in NTMBs. Twenty-one of these people provided comments (see acknowledgements). We reviewed these comments and came to a consensus on species scores. We then listed species in order of decreasing management concern by ranking them by the mean of the seven criteria.

We identified general habitat associations of all species based on literature review (Griscom and Sprunt 1957, Pettingill and Whitney 1965, Erskine 1977, Harrison 1975, Johnsgard 1979, Clawson 1982, American Ornithologist's Union 1983, Godfrey 1986, Benyus et al. 1992, DeGraaf and Rudis 1988, DeGraaf et al. 1991, Peterjohn and Rice 1991) and personal observations. Habitats were described as: primary (ledges, cliffs, caves, banks, etc.); wetland (sedge meadow, fen, cattail marsh); agricultural-woodland edge (woody fence-rows, shelterbelts, and forest edge in agricultural landscape); grassland (prairie, hayfield, pasture, cultivated grasses); shrub-sapling (shrub swamp, upland old field, seedling-sapling forest <12-years-old); lowland coniferous forest (semi-open to closed canopy lowland coniferous forest); lowland deciduous forest (bottomland deciduous forest); young deciduous forest (upland deciduous forest 12- to 30-years-old); mature deciduous forest (upland deciduous forest > 30-years-old); young coniferous forest (upland coniferous forest 12- to 30-years-old); mature coniferous forest(upland coniferous forest > 30-years-old); and developed (urban, suburban, rural development). We listed 1 or 2 habitats for each species in decreasing order of importance. We tabulated the number of species per habitat based on the first habitat listed for each species.

RESULTS AND DISCUSSION

We ranked 110 neotropical migrant landbird species that breed in the Midwest by decreasing management concern (Table 2). Mean species scores ranged from 4.71 to 1.57 (scores of 1-5 were possible). Only 4 species scored >4.00, and 3 species scored <2.00. Of the remaining species, about half scored between 3.00 and 4.00, and half between 2.00 and 3.00 (Table 2). Several of the highest-ranked species on our list, including the Kirtland's, Cerulean, and Golden-winged Warblers, Baird's Sparrow, and Bell's Vireo, have previously been designated as endangered, candidate, or special concern species by the U.S. Fish and Wildlife Service (Office of Migratory Bird Management 1987), giving credence to our ranking system. The Peregrine Falcon, although a Federally-endangered species, was not ranked high in our list because the Midwest is relatively unimportant to the species and its population is doing well.

Species rank based on mean score of the 7 criteria differed from ranks based on magnitude of BBS trends alone. For instance, the ten species showing the largest significant declines (1982-1991)in the Midwest are the Yellow-billed Cuckoo, Bank Swallow, Bobolink, Whip-poor-will, Bell's Vireo, Mississippi Kite, Scissor-tail Flycatcher, Blue-winged Warbler, Nashville Warbler, and Wood Thrush (Appendix 1). Only 5 of these species ranked in the top 20 of our management concern list (Table 2). The differences indicate the importance of the additional criteria in determining management concern.

Species richness of NTMBs in the Midwest is highest in shrub-sapling habitats, mature upland deciduous forests, mature upland coniferous forests, and grasslands (Table 3). These same habitats also had the most highly ranked species (mean score >3.0). While mature forests and grasslands are widely distributed in the Midwest, there is concern regarding fragmentation of these habitats (Robinson et al. this proceedings, Faaborg et al. this proceedings) and for the impacts of forestry (Thompson et al. this proceedings) and agricultural practices (Rodenhouse et al. this proceedings). Birds in shrub-sapling habitats were of high management concern probably because their habitat is more spatially and temporally limited than older forest habitats.

On average, species scores were greatest in lowland deciduous forest, young conifer forest, mature deciduous forest, and grassland; indicating the importance of these habitats to high-priority species (Table 3). Fourteen of the top 25-ranked species occur in these four habitats. Lowland deciduous forest and lowland coniferous forest had low species richness, but on average, the species occurring there were of high management concern (Table 3).

This analysis was performed at a regional level and should be regarded as the first step in a hierarchial approach to conservation of NTMBs (Freemark et al. this proceedings, Hunter et al. this proceedings, Thompson et al. this proceedings). NTMBs' regional status should serve as a context for local management decisions. The approach used in this exercise also should be applied at the state/province or physiographic stratum level (Hunter et al. this proceedings). While many management and monitoring activities are carried out at the State/provincial level, physiographic strata are probably the most meaningful level of analysis because they are ecologically based. Local management decisions should be based on priorities determined at local scales but should complement regional priorities. Clearly, all levels need to be examined, and doing so will be an ongoing task of the Midwest Working Group.

Our analysis was based primarily on BBS for information on population trends. The BBS, however, inadequately sampled 44% of the NTMB species in the Midwest due to small sample sizes or low abundances (Appendix 1). Also, roadside point counts, such as the BBS, are inappropriate for sampling the abundance of some species (see Butcher and Droege 1992). As a result some of our scoring was subjective, and introduced uncertainty into the ranking system. Likewise, assessing threats to species on the breeding grounds was very subjective. These problems point to the need for additional monitoring and research that will allow a better assessment of the status of NTMBs in the Midwest. Until these information gaps are filled, management activities should be implemented cautiously.

Our habitat analysis was based on broad categories assigned by reviewing existing literature on habitat use by NTMBs. Additional analyses are needed to identify finer habitat classifications and habitat components that will allow resource managers to implement appropriate land protection and management strategies.

CONCLUSIONS

The large number of species (53) with management concern scores > 3.0, the closeness of the scores, and the diversity of habitats used by highly-scored species suggest that broad-scale problems are affecting these species on their breeding areas or that common non-breeding threats are affecting them. Alternatively, the results could reflect insensitivity of, or uncertainties in, the ranking system. We do not encourage the use of this ranking to focus species specific management on a limited number of highly ranked species. Rather, we encourage ecosystem level management that addresses the needs of the many species of high management concern in the Midwest. The large number of highly ranked species in mature forest habitats, grasslands, and shrub-sapling habitats, and high mean score of NTMBs in lowland deciduous and young coniferous forests, suggest these habitats deserve special management attention. That some of these habitats are relatively abundant in the Midwest (mature deciduous and coniferous forest) implies a need for additional research to identify limiting factors. Factors limiting species in these habitats may be related to habitat degradation (such as edge effects or fragmentation) as opposed to habitat loss. The high percentage of species (44%) inadequately monitored by the BBS also suggests the need for more intensive monitoring to better assess the status of these species in the Midwest.

ACKNOWLEDGEMENTS

We especially thank B. Peterjohn and J. Sauer for supplying BBS data, J. Price for BBS density contour maps, and J. Probst, L. Pfannmuller, and A. W. Weisbrod for helping us reach a consensus on species scores based on solicited comments. W. D. Dijak, R. Clawson, L. Pfannmuller, M. Ryan, S. R. Shifley, and D. Whitehead provided helpful comments on the manuscript. We thank the following individuals for their comments on the species scoring: W. H. Busby, R. Dettmers, J. J. Dinsmore, J. Faaborg, J. M. Hanowski, J. Herkert, G. Holland, R. W. Howe, W. C. Hunter, B. Jacobs, R. Janssen, P. M. McKenzie, M. Mossman, G. J. Niemi, B. Peterjohn, S. K. Robinson, M.R. Ryan, D. Sample, D. R. Whitehead, and J. L. Zimmerman.

LITERATURE CITED

American Ornithologist's Union. 1983. Check-list of North American birds. Allen Press, Lawrence, KS. 877 pp.

Benyus, J. M., R. R. Buech, and M. D. Nelson. 1992. Wildlife in the Upper Great Lakes region: a community profile. U. S. Forest Service, North Central Forest Experiment Station Research Paper NC-301. 27 pp.

Butcher, G. and S. Droege. 1992. Needs assessment: monitoring neotropical migratory birds. Partners In Flight Program. 58pp.

Clawson, R. L. 1982. The status, distribution, and habitat preferences of the birds of Missouri. Terrestrial Series 11. Missouri Dept. of Conservation, Jefferson City, MO. 80 pp.

DeGraaf, R. M. & D. D. Rudis. 1988. New England wildlife: habitat, natural history and distribution. USDA Forest Service Northeast Forest Experiment Station Gen. Tech. Rpt. NE-108.

DeGraaf, R. M., V. E. Scott, R. H. Hamre, L. Ernst, and S. H. Anderson. 1991. Forest and rangeland birds of the United States: natural history and habitat use. USDA Agriculture Handbook 688. 625 pp.

Erskine, A. J. 1977. Birds in boreal Canada. Report Series 41. Canadian Wildlife Service, Ottawa, Canada.

Faaborg, J., M. Brittingham, T. Donovan, J. Blake. Habitat fragmentation in the temperate zone. Pp. _____ *in* D. Finch and P. Stangel (editors), Proceedings of the workshop on management of neotropical migratory birds, September 21-25, 1992, Estes Park CO.

Freemark, K., J. Probst, S. Hejl, B. Dunning. Landscape ecology of neotropical migrant birds. Pp. _____ *in* D. Finch and P. Stangel (editors), Proceedings of the workshop on management of neotropical migratory birds, September 21-25, 1992, Estes Park CO.

Geisler, P. H. and J. R. Sauer. 1990. Topics in route regression analysis. Pages 54-57 *in* J.R. Sauer and S. D. Droege, eds. Survey designs and statistical methods for estimation of avian population trends. U.S. Fish and Wildlife Service Biological Report 90(1).

Godfrey, W. E. 1986. The birds of Canada. National Museum of Canada, Ottawa, Canada. 595 pp.

Griscom, L. & A. Sprunt, Jr. 1957. The warblers of America. The Devin-Adair Co., New York. 302 pp.

Harrison, H. H. 1975. A field guide to birds' nests. Houghton Mifflin Co., Boston, MA. 257 pp.

Hunter, W. C., D. N. Pashley, and M. Carter. 1993. Partners in Flight species prioritization scheme, why do we need a prioritization scheme and how is one implemented for neotropical migrant birds. Pp. _____ *in* D. Finch and P. Stangel (editors), Proceedings of the workshop on management of neotropical migratory birds, September 21-25, 1992, Estes Park CO.

Johnsgard, P. A. 1979. Birds of the Great Plains. Univ. of Nebraska Press, Lincoln, NE. 539 pp.

National Geographic Society. 1983. Field guide to the birds of North America. National Geographic Society, Washington, DC. 464 pp.

Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern in the United States:1987 list. U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Washington DC. 62pp.

Peterjohn, B. G. & D. L. Rice. 1991. The Ohio breeding bird atlas. The Ohio Dept. of Nat. Resources, Columbus, Ohio.

Peterson, R. T. 1980. A field guide to the birds. Houghton Mifflin Company, Boston, MA. 384 pp.

Peterson R. T. 1990. A field guide to western birds. Houghton Mifflin Company, Boston, MA. 366 pp.

Pettingill, O. S. & N. R. Whitney. 1965. Birds of the Black Hills. Special Publ. No. 1. Cornell Lab. of Ornithology, Ithaca, N.Y. 139pp.

Robinson, S. K., J. A. Grzybowski, S. I. Rothstein, M. C. Brittingham, L. J. Petit, and F. R. Thompson, III. 199_. Management implications of cowbird parasitism for neotropical migrant songbirds. Pp. _____ *in* D. Finch and P. Stangel (editors), Proceedings of the workshop on management of neotropical migratory birds, September 21-25, 1992, Estes Park CO.

Rodenhouse, N., L. Best, E. Bollinger, and R. O'Connor. Effects of agricultural practices on Neotropical migratory birds. Pp. _____ *in* D. Finch and P. Stangel (editors), Proceedings of the workshop on management of neotropical migratory birds, September 21-25, 1992, Estes Park CO.

Thompson, F. R., III, J. Probst, and M. Raphael. Silvicultural options for neotropical migratory birds. Pp. _____ *in* D. Finch and P. Stangel (editors), Proceedings of the workshop on management of neotropical migratory birds, September 21-25, 1992, Estes Park CO.

Table 1. — Criteria used to rank the level of management concern for neotropical migrant birds in the Midwest region. Each species was assigned a score for each of the 7 criteria listed below and ranked based on the mean of the seven scores. For more details on these criteria see Hunter et al. (This proceedings).

Score	Criteria
	Global Abundance
1	Abundant or demonstrably secure
2	Common or apparently secure
3	Uncommon to fairly common, including locally common
4	Rare to uncommon
5	Very rare to rare
	Winter Distribution
1	Southern latitudes of the U.S. through Central America (C.A.) into South America (S.A.), or all S.A.
2	Southern U.S. through C.A., or C.A. into S.A.
3	Mexico or Caribbean and C.A. or Middle American highlands or Amazon Basin
4	Caribbean Basin or Caribbean Slope of Middle America or Pacific Slope of Middle America or Mexican Highlands or Andean Ridge of S.A.
5	Bahamas or Guatemala, Honduras, and Nicaragua highlands or Mexican States of Jalisco, Michoacan, and Guerrero or southern Sinoloa and southern Baja California in Mexico.
	Severity of Threats on Wintering Grounds and Migration Routes (habitat loss, contaminants, human disturbance, predation, etc.)
1	No known threats.
2	Minor threats.
3	Moderate threats.
4	Severe threats.
5	Extirpation or extinction likely.
	Breeding Distribution--area of breeding range
1	≥ 76% of temperate North America
2	51-75% of temperate North America
3	26-50% of temperate North America
4	11-25% of temperate North America
5	≤ 10% of temperate North America
	Severity of Threats on Breeding Grounds in Midwest Region (habitat loss and fragmentation, low nesting success, contaminants, human disturbance, etc.)
1	No known threats.
2	Minor threats.
3	Moderate threats.
4	Severe threats.
5	Extirpation or extinction likely.
	Importance of Midwest Region to Species
1	< 1% of population in region.
2	1-10% of population in region.
3	11-25% of population in region.
4	26-50% of population in region.
5	> 50% of population in region.
	Population Trend in Midwest Region (based on Breeding Bird Survey[1])

Long term trend (1966-91)

		+*	+	-	-*
short-	+*	1	1	3	3
term	+	1	2	3	4
trend	-	3	3	4	5
(1982-91)	-*	4	4	5	5

[1] +* = significant positive trend, + = non-significant positive trend, - = non-significant negative trend, -* = significant negative trend.

Table 2. — Criteria scores used to rank management concern for Midwest neotropical migrant landbirds. A score of 5 indicates the most concern and 1 the least. Species are listed in order of decreasing management concern based on the mean of the seven criteria. Species with the same mean score are in taxonomic order.

Species	Global abund-ance	Winter distri-bution	Winter threats	Breed. distri-bution	Breed. threats	Area import-ance	Popn. trend	Mean score	Primary habitat[1]
Kirtland's Warbler	5	5	5	5	5	5	3	4.71	YngCon, Shrub
Bachman's Warbler	5	5	5	5	5	2	5	4.57	LowDec
Cerulean Warbler	4	4	4	4	4	5	5	4.29	MatDec
Golden-winged Warbler	4	4	4	4	4	5	5	4.14	Shrub
Baird's Sparrow	4	4	4	4	4	5	3	3.86	Grass
Swainson's Warbler	4	5	4	4	4	2	4	3.86	LowDec
Mississippi Kite	3	4	4	5	4	4	5	3.71	LowDec, Grass
Wood Thrush	2	4	4	4	4	4	5	3.57	MatDec
Chestnut-sided Warbler	4	5	4	4	2	4	4	3.57	Shrub
Bay-breasted Warbler	2	5	4	4	3	4	4	3.57	MatCon
Dickcissel	2	4	4	4	3	5	4	3.57	Grass
Connecticut Warbler	4	4	3	4	2	5	3	3.57	LowCon
Prothonotary Warbler	3	4	4	3	3	3	5	3.57	LowDec
Blue-winged Warbler	3	4	4	4	2	4	4	3.57	Shrub
Bell's Vireo	3	4	3	3	3	3	5	3.43	Shrub
Acadian Flycatcher	2	4	4	3	3	4	4	3.43	MatDec
Mountain Plover	4	4	3	4	4	1	4	3.43	Grass
Bobolink	2	4	3	3	3	4	5	3.43	Grass
Prairie Warbler	2	4	4	3	3	3	5	3.43	Shrub
Long-billed Curlew	3	4	3	4	4	2	4	3.43	Grass
Nashville Warbler	3	4	3	3	2	5	4	3.43	LowCon, YngDec
Philadelphia Vireo	4	5	4	3	2	4	2	3.43	YngDec
Canada Warbler	2	4	4	3	3	4	4	3.43	MatCon, YngCon
Grasshopper Sparrow	3	3	3	2	4	5	4	3.43	Grass
Clay-colored Sparrow	3	4	2	4	2	5	4	3.43	Shrub
Lark Bunting	2	3	3	4	4	4	3	3.29	Grass
Eastern Wood-Pewee	2	4	3	3	2	4	5	3.29	MatDec
Black-throated Blue Warbler	3	4	4	3	3	3	3	3.29	MatDec
Whip-poor-will	2	3	3	3	3	4	5	3.29	YngDec, MatDec
Yellow-billed Cuckoo	3	3	4	2	2	4	5	3.29	MatDec
Veery	2	3	3	3	3	4	5	3.29	MatDec, YngDec
Cape May Warbler	3	4	4	3	3	4	2	3.29	MatCon
Mourning Warbler	3	4	3	3	2	5	3	3.29	Shrub
Great Crested Flycatcher	2	4	4	3	2	4	4	3.29	MatDec

Table 2. Continued.

Species	Global abund-ance	Winter distri-bution	Winter threats	Breed. distri-bution	Breed. threats	Area import-ance	Popn. trend	Mean score	Primary habitat[1]
Hooded Warbler	3	4	4	3	3	3	3	3.29	MatDec
Worm-eating Warbler	3	4	4	3	3	3	3	3.29	MatDec, YngDec
Olive-sided Flycatcher	3	3	4	2	3	2	5	3.14	MatCon, LowCon
Ovenbird	2	3	3	3	3	5	3	3.14	MatDec
Blackburnian Warbler	3	4	4	3	3	4	1	3.14	MatCon
White-eyed Vireo	2	3	3	3	3	3	5	3.14	Shrub
Upland Sandpiper	3	3	3	3	4	5	1	3.14	Grass
Burrowing Owl	4	3	3	3	3	2	4	3.14	Grass
Kentucky Warbler	2	4	3	3	3	4	3	3.14	Shrub, MatDec
Black-billed Cuckoo	3	4	4	3	2	5	1	3.14	YngDec, MatDec
Rose-breasted Grosbeak	2	3	3	3	2	4	5	3.14	YngDec
Scissor-tailed Flycatcher	2	4	2	4	3	2	5	3.14	Grass
Summer Tanager	2	3	3	3	3	3	4	3.00	MatDec, YngDec
Swainson's Hawk	3	3	3	2	4	2	4	3.00	Grass
Scarlet Tanager	2	4	4	3	3	4	1	3.00	MatDec
Tennessee Warbler	3	4	3	3	2	3	3	3.00	Shrub
Yellow-throated Vireo	3	3	4	3	3	4	1	3.00	MatDec
Louisiana Waterthrush	4	3	3	3	3	3	2	3.00	LowDec
Magnolia Warbler	3	3	4	3	3	4	1	3.00	YngCon
Yellow-breasted Chat	2	3	3	2	3	3	5	3.00	Shrub
Yellow-bellied Flycatcher	2	4	4	3	2	4	2	3.00	LowCon
Black-throated Green Warbler	3	3	3	3	3	4	2	3.00	MatCon
Purple Martin	2	3	3	2	3	4	4	3.00	Develop
Chimney Swift	1	3	3	2	2	4	5	2.86	Develop
Broad-winged Hawk	3	2	3	2	3	4	3	2.86	MatDec
American Redstart	2	2	3	2	3	3	5	2.86	YngDec
Northern Oriole	2	3	3	3	2	4	3	2.86	AgEdge, Develop
Lark Sparrow	3	3	3	2	3	2	3	2.86	Grass
Indigo Bunting	1	3	2	3	2	3	5	2.86	Shrub, AgEdge
Willow Flycatcher	3	3	3	2	3	3	3	2.86	Shrub
Yellow-throated Warbler	3	3	3	3	3	3	2	2.86	MatDec
Blackpoll Warbler	2	4	3	3	3	2	3	2.86	MatCon
Alder Flycatcher	2	4	3	3	2	3	3	2.86	Shrub

Table 2. Continued.

Species	Global abund-ance	Winter distri-bution	Winter threats	Breed. distri-bution	Breed. threats	Area import-ance	Popn. trend	Mean score	Primary habitat[1]
Gray Catbird	2	3	4	2	2	4	3	2.86	AgEdge, Shrub
Orchard Oriole	2	3	3	3	3	3	3	2.86	AgEdge, Develop
Wilson's Warbler	3	3	2	3	3	3	3	2.86	Shrub
Painted Bunting	3	3	3	4	2	1	3	2.71	Shrub
Grey-cheeked Thrush	3	4	3	3	2	1	3	2.71	MatCon
Orange-crowned Warbler	3	3	2	3	2	3	3	2.71	Shrub
Least Flycatcher	3	3	2	2	2	4	3	2.71	MatDec, YngDec
Yellow-headed Blackbird	2	3	3	3	3	4	1	2.71	Wetl
Black-headed Grosbeak	2	4	3	3	3	2	2	2.71	YngDec
Warbling Vireo	2	3	3	1	2	4	3	2.57	MatDec, Develop
Blue Grosbeak	3	3	2	2	2	3	3	2.57	Shrub
Bank Swallow	3	3	2	1	2	3	4	2.57	Develop, Primary
Cordilleran Flycatcher	2	4	3	3	2	1	3	2.57	MatCon, MatDec
Swainson's Thrush	3	2	3	2	3	3	2	2.57	MatCon
Ruby-throated Hummingbird	2	3	2	2	2	4	3	2.57	MatDec, YngDec
Dusky Flycatcher	2	4	3	3	2	1	3	2.57	Shrub
Western Tanager	2	3	3	3	3	1	3	2.57	MatCon
Northern Waterthrush	2	2	4	2	2	3	3	2.57	LowCon, LowDec
Northern Parula	2	3	3	3	3	3	1	2.57	MatCon, MatDec
Solitary Vireo	3	3	3	3	3	2	1	2.57	MatCon
Merlin	4	2	3	2	2	3	2	2.57	MatCon
Palm Warbler	3	3	2	3	2	4	1	2.57	LowCon
Eastern Kingbird	2	3	3	2	2	3	2	2.43	AgEdge
Peregrine Falcon	4	1	4	2	3	1	2	2.43	Primary, Develop
Lazuli Bunting	2	4	2	3	3	2	1	2.43	Shrub
Chuck-will's-widow	2	3	3	3	2	3	1	2.43	YngDec
Western Kingbird	2	4	3	3	2	2	1	2.43	AgEdge
Blue-gray Gnatcatcher	2	3	2	2	2	3	3	2.43	MatDec, YngDec
White-throated Swift	1	3	2	1	2	1	3	2.43	Primary
Black-and-white Warbler	2	2	3	2	3	1	1	2.43	MatDec, YngDec
MacGillivray's Warbler	3	3	2	3	2	1	3	2.43	Shrub
Western Wood-Pewee	2	4	3	2	2	2	1	2.29	MatCon, MatDec

Table 2. Continued.

Species	Global abund-ance	Winter distri-bution	Winter threats	Breed. distri-bution	Breed. threats	Area import-ance	Popn. trend	Mean score	Primary habitat[1]
Common Nighthawk	2	2	2	1	2	3	4	2.29	Primary, Develop
Common Yellowthroat	1	2	2	1	2	3	5	2.29	Shrub, AgEdge
Cliff Swallow	2	3	2	1	2	3	3	2.29	Develop, Primary
Lincoln's Sparrow	2	2	2	2	2	3	2	2.14	LowCon, Shrub
Northern Rough-winged Swallow	3	3	2	1	2	3	1	2.14	Primary, Develop
Barn Swallow	1	1	2	1	2	4	4	2.14	Primary, Develop
Violet-green Swallow	2	3	3	2	2	1	2	2.14	MatCon, Develop
Red-eyed Vireo	1	3	2	2	2	4	1	2.14	MatDec
Chipping Sparrow	1	2	2	1	2	4	1	1.86	YngCon, YngDec
House Wren	1	1	1	1	2	4	1	1.57	Shrub
Yellow Warbler	1	1	2	1	2	3	1	1.57	Shrub

[1]Habitats defined as: Primary = ledges, cliffs, caves, banks, etc.; Wetl (wetland) = sedge meadow, fen, cattail marsh; AgEdge (agricultural-woody edge) = woody fencerows, windbreaks, and forest edges in agricultural landscape; Grass (grassland) = prairie, hayfield, pasture, cultivated grassland; Shrub (shrub-sapling) = shrub swamp, upland oldfield, seedling-sapling forest; LowCon (lowland coniferous forest) = semi open to closed canopy lowland conifers; LowDec (lowland deciduous forest) = lowland-bottomland deciduous forest; YngDec (young deciduous forest) = poletimber-size upland deciduous forest 12-30 years old; MatDec (mature deciduous forest) = mature, upland deciduous forest > 30 years old; YngCon (young coniferous forest) = poletimber-size upland conifer forest 12-30 years old; MatCon (mature coniferous forest) = mature upland conifer forest > 30 years old; Develop (developed) = urban, suburban, rural devlopement.

Table 3.—Number of Midwest neotropical migrant landbird species and mean management concern score by species' primary habitat association. The management concern score is the mean score of seven criteria used to rank management concern. A score of 5 indicates the most concern and 1 the least. Habitats are listed in order of decreasing mean concern score. See text for habitat descriptions.

Habitat	Management concern score				Total	Mean concern
	1-1.9	2-2.9	3-3.9	4-5	spp.	score
Lowland deciduous forest	0	0	4	1	5	3.57
Young coniferous forest	1	0	1	1	3	3.19
Mature deciduous forest	0	8	13	1	22	3.18
Grassland	0	5	7	0	12	3.07
Shrub-sapling	2	11	10	1	24	3.02
Mature coniferous forest	0	10	6	0	16	3.00
Young deciduous forest	0	3	4	0	7	3.00
Lowland coniferous forest	0	3	3	0	6	2.88
Developed	0	3	1	0	4	2.75
Wetland	0	1	0	0	1	2.71
Agricultural-woodland edge	0	5	0	0	5	2.69
Primary	0	5	0	0	5	2.29
TOTAL	3	54	49	4	110	

Appendix 1.—Trends in neotropical migrant landbird populations in the Midwest determined from the Breeding Bird Survey. Mean percent annual change was estimated by the route regression method[1]. Blanks indicate no data were available.

Species	Mean % annual change 1966-91	No. of rts.[2]	Mean % annual change 1982-91	No. of rts.[2]	Mean birds/rt. 1982-91	Trend reliable[3]
Mississippi Kite	-1.34	10	-4.11*[4]	7	0.4	no
Broad-winged Hawk	-0.94	41	-2.70	32	0.2	no
Swainson's Hawk	-0.95	33	-0.60	31	1.0	yes
Merlin	1.72	16	0.83	14	0.1	no
Peregrine Falcon	-1.58***	4				no
Mountain Plover						no
Upland Sandpiper	3.40***	59	4.11***	52	4.2	yes
Long-billed Curlew	-3.26	11	-6.21	9	1.5	yes
Black-billed Cuckoo	0.64	69	4.78**	65	0.8	no
Yellow-billed Cuckoo	-1.22**	69	-5.62***	61	2.8	yes
Burrowing owl	-0.33	14	-3.37	12	0.8	no
Common Nighthawk	1.49*	67	-3.17*	64	0.8	no
Chuck-will's-widow	0.55	18	3.40*	17	1.1	yes
Whip-poor-will	-0.62	48	-4.23***	42	0.8	no
Chimney Swift	-0.62	62	-2.98***	61	5.8	yes
White-throated Swift	2.48	2	0.63	2	0.9	no
Ruby-throated Hummingbird	-0.15	56	0.60	53	0.3	no
Scissor-tailed Flycatcher	-2.87***	13	-3.58**	12	1.0	yes
Great-crested Flycatcher	-0.01	67	-0.95	67	2.7	yes
Olive-sided Flycatcher	-2.96**	18	-1.73	14	0.8	no
Eastern wood-pewee	-1.35**	65	-0.94	63	2.6	yes
Western wood-pewee	1.06*	14	4.45**	14	0.4	no
Yellow-bellied Flycatcher	3.09	9	6.24	8	0.5	no
Cordilleran Flycatcher	3.14**	1	1.74	1	10.4	no

Appendix 1. Continued.

Acadian Flycatcher	-0.76	41	-0.85	31	0.9	no
Alder Flycatcher	8.24***	33	-1.65	28	5.6	yes
Willow Flycatcher	3.60***	59	-0.40	52	0.8	no
Least Flycatcher	-1.16	54	0.76	43	4.7	yes
Dusky Flycatcher						no
Western Kingbird	1.46**	37	1.58	34	8.3	yes
Eastern Kingbird	0.45	72	0.62	72	7.8	yes
Purple Martin	-0.41	65	-1.06	64	3.0	yes
Violet-green Swallow	2.39	5	4.59	3	0.5	no
Northern Rough-winged Swallow	2.85***	72	3.25	67	1.7	yes
Bank Swallow	0.30	65	-5.15**	62	3.0	yes
Cliff Swallow	0.93	65	-2.47	64	14.9	yes
Barn Swallow	0.75	72	-2.69***	72	21.6	yes
House Wren	1.74***	71	2.43***	69	7.5	yes
Blue-gray Gnatcatcher	-1.19	44	1.32	44	1.8	yes
Veery	-1.39**	40	-2.31***	32	4.6	yes
Gray-cheeked Thrush						no
Swainson's Thrush	2.06	16	2.29	12	11.6	yes
Wood Thrush	-1.87*	53	-2.14**	48	1.9	yes
Gray Catbird	-0.40	71	0.01	68	2.7	yes
White-eyed Vireo	-1.26**	35	0.00	32	1.6	yes
Bell's Vireo	-1.30	32	-4.15**	25	0.3	no
Solitary Vireo	1.74	20	7.14*	17	0.6	no
Yellow-throated Vireo	1.05	57	3.69***	50	0.5	no
Warbling Vireo	0.64	69	-0.75	68	2.3	yes
Philadelphia Vireo	1.35	14	3.05	9	0.5	no
Red-eyed Vireo	1.21**	71	1.85***	69	12.1	yes
Bachman's Warbler						no
Blue-winged Warbler	0.63	32	-3.26**	29	0.3	no
Golden-winged Warbler	-1.68**	19	-0.91	15	0.3	no

Appendix 1. Continued.

Tennessee Warbler	2.56	16	-3.41	12	6.0	yes
Orange-crowned Warbler	3.83	3	-3.24	3	0.2	no
Nashville Warbler	0.52	19	-3.24**	15	8.1	yes
Northern Parula	1.11	42	3.07*	36	0.4	no
Yellow Warbler	1.10**	71	0.96	69	3.5	yes
Chestnut-sided Warbler	-0.56	27	-0.31	24	5.9	yes
Magnolia Warbler	3.13*	12	4.01	11	4.8	yes
Cape-May Warbler	5.94*	11	2.09	10	0.9	no
Black-throated blue Warbler	1.01	8	1.60	8	0.4	no
Black-throated Green Warbler	1.00	21	0.57	16	3.1	yes
Blackburnian Warbler	0.11	13	7.68***	12	2.5	yes
Yellow-throated Warbler	1.03	24	3.71	22	0.3	no
Kirtlands Warbler						no
Prairie Warbler	-2.85***	26	-2.62	19	1.1	yes
Palm Warbler	6.74***	7	1.04	5	0.1	no
Bay-breasted Warbler	-0.24	8	-0.30	6	1.3	yes
Blackpoll Warbler	-2.46**	5				no
Cerulean Warbler	-2.32***	30	-0.61	28	0.2	no
Black-&-white Warbler	2.61*	45	2.53**	40	1.6	yes
American Redstart	-2.82**	60	-2.79	49	2.4	yes
Prothonotary Warbler	-0.79	21	-2.27*	18	0.3	no
Worm-eating Warbler	-2.36	20	5.76	15	0.2	no
Swainson's Warbler	-0.39	4	-0.61	2	0.0	no
Ovenbird	0.24	60	-0.19	56	7.6	yes
Northern Waterthrush	-0.60	18	0.60	18	0.8	no
Louisiana Waterthrush	0.77	31	0.45	27	0.1	no
Kentucky Warbler	-0.88	30	0.69	26	1.2	yes
Connecticut Warbler	1.64	14	-2.76	14	0.5	no
Mourning Warbler	0.13	23	-1.63	22	6.2	yes
MacGillivray's Warbler						

Appendix 1. Continued.

Common Yellowthroat	-0.45	71	-2.96***	71	10.6	yes
Hooded Warbler	-2.02	21	0.03	16	0.1	no
Wilson's Warbler	0.76	6	-6.51	6	0.5	no
Canada Warbler	-1.22	13	-0.73	13	1.0	yes
Yellow-breasted Chat	-2.18***	53	-1.68*	46	2.6	yes
Summer Tanager	-0.41	28	-1.34	25	2.0	yes
Scarlet Tanager	0.55	54	1.98*	48	0.8	no
Western Tanager	-1.69	2	-2.99***	1	7.4	no
Rose-breasted Grosbeak	-0.67	61	-1.82*	55	2.4	yes
Black-headed Grosbeak	1.18	11	3.09	6	0.3	no
Blue Grosbeak	1.69*	36	-1.19	35	1.6	yes
Lazuli Bunting	5.44**	10	14.36**	5	0.8	no
Indigo Bunting	-0.53	68	-2.44***	62	10.7	yes
Painted Bunting	-6.52***	9	15.07**	7	0.4	no
Dickcissel	-2.15***	60	1.00	57	17.4	yes
Chipping Sparrow	1.03*	71	1.67**	69	9.0	yes
Clay-colored Sparrow	-1.21*	36	0.63	30	7.8	yes
Lark Sparrow	-2.09**	51	0.81	44	1.2	yes
Lark Bunting	-4.70**	24	6.29*	17	38.3	yes
Baird's Sparrow	-1.37	14	1.26	13	1.9	yes
Grasshopper Sparrow	-6.10***	71	0.03	67	6.4	yes
Lincoln's Sparrow	4.39	14	5.07	12	1.8	yes
Bobolink	-1.33**	60	-4.70***	59	6.8	yes
Yellow-headed Blackbird	3.77**	41	1.51	36	18.6	yes
Brown-headed Cowbird[5]	-0.22	72	1.75**	72	24.0	yes
Orchard Oriole	-0.66	63	0.34	61	2.1	yes
Northern Oriole	0.49	70	-0.28	69	4.3	yes

[1] *Provided by B. Peterjohn and J. Sauer, Office of Migratory Bird Management and the Branch Of Migratory Bird Research, Patuxent Wildlife Research Center, U. S. Fish and Wildlife Service.*
[2] *Number of BBS routes species was present on.*
[3] *Trend not reliable if d.f. in analysis were <14 or mean abundance was <1.0 birds/rt.*
[4] *Statistical significance of the trend (*= p <0.1, **= p <0.05, ***= p <0.01).*
[5] *Not a neotropical migrant, but included because of its impact as a brood parasite of neotropical migrants.*

Neotropical Migratory Landbird Species and Their Habitats of Special Concern Within the Southeast Region

William C. Hunter[1], David N. Pashley[2], and
Ronald E. F. Escano[3]

Abstract — The Southeast Management Working Group for Partners in Flight initiated a prioritization scheme in April 1991 to help guide regional and local conservation efforts for Neotropical migratory landbirds. Preliminary breeding season priorities have been established in each of 24 physiographic areas for species and habitats, with some non-breeding season priorities set as well. Interested parties have met in most physiographic areas in the Southeast to review preliminary priorities and organize for future action. Species of regional concern, habitats of regional and physiographic area concern, and examples of priorities at a local land management level are discussed. Ongoing and future actions are listed.

Priorities within the Southeast Region are based on two principles. First, a habitat/ecosystem (hereafter, habitat) approach is the goal of the Partners in Flight conservation effort. Identifying species most at risk and grouping them by habitats assists in targeting habitats that require special consideration (Hunter et al. these proceedings). A multi-species/habitat approach is more efficient and provides for better coordination of ongoing conservation efforts at higher spatial scales (regional, national, etc.).

Second, the physiographic area (ecologically classified land units used in the Breeding Bird Survey, Robbins et al. 1986) is the appropriate spatial scale for establishment of initial conservation priorities. Twenty-four physiographic areas covering 16 states are encompassed within the Southeast Region (Figure 1, Table 1). Physiographic area working groups set priorities without regard for state boundaries, but implementation of priority actions can be tailored to the needs of individual states as state working groups are formed (see Tables 1 and 2 in Hunter et al. these proceedings). The approach outlined here encourages (1) identification of ecological issues for states sharing bird and habitat resources, (2) coordination of conservation efforts by habitats within and across state boundaries, and (3) consolidation of limited financial and logistical resources to address shared conservation needs.

[1]*US Fish and Wildlife Service, 75 Spring Street, SW, Atlanta, Georgia 30303.*

[2]*The Nature Conservancy, P.O. Box 4125, Baton Rouge, Louisiana 70821.*

[3]*USDA Forest Service Box 2750, Asheville, North Carolina 28802.*

SPECIES OF REGIONAL CONCERN

Forty-six species (including subspecies and isolated populations of conservation concern) of Neotropical migratory landbirds (not including those described as temperate migrants in Gauthreaux 1992) receive ranks indicating a need for increased conservation attention in the Southeast on the basis of the regional prioritization scheme described in Hunter et al. (these proceedings; Table 2). Of these, the Black-capped Vireo (*Vireo atricapillus*) and Golden-cheeked Warbler (*Dendroica chrysoparia*) already receive intensive management and monitoring attention. Bachman's Warbler (*Vermivora bachmanii*; possibly extinct), Southwestern Willow Flycatcher (*Empidonax traillii extimus*), and Sonoran Yellow Warbler (*Dendroica petechia sonorana*) formally occurred but are not presently known to breed in the Southeast Region. Many of the remaining 41 species in need of increased conservation attention are still relatively common and may not be declining everywhere they occur. However, all suffer from one or more of the following problems: (1) limited distribution and a high degree of threat

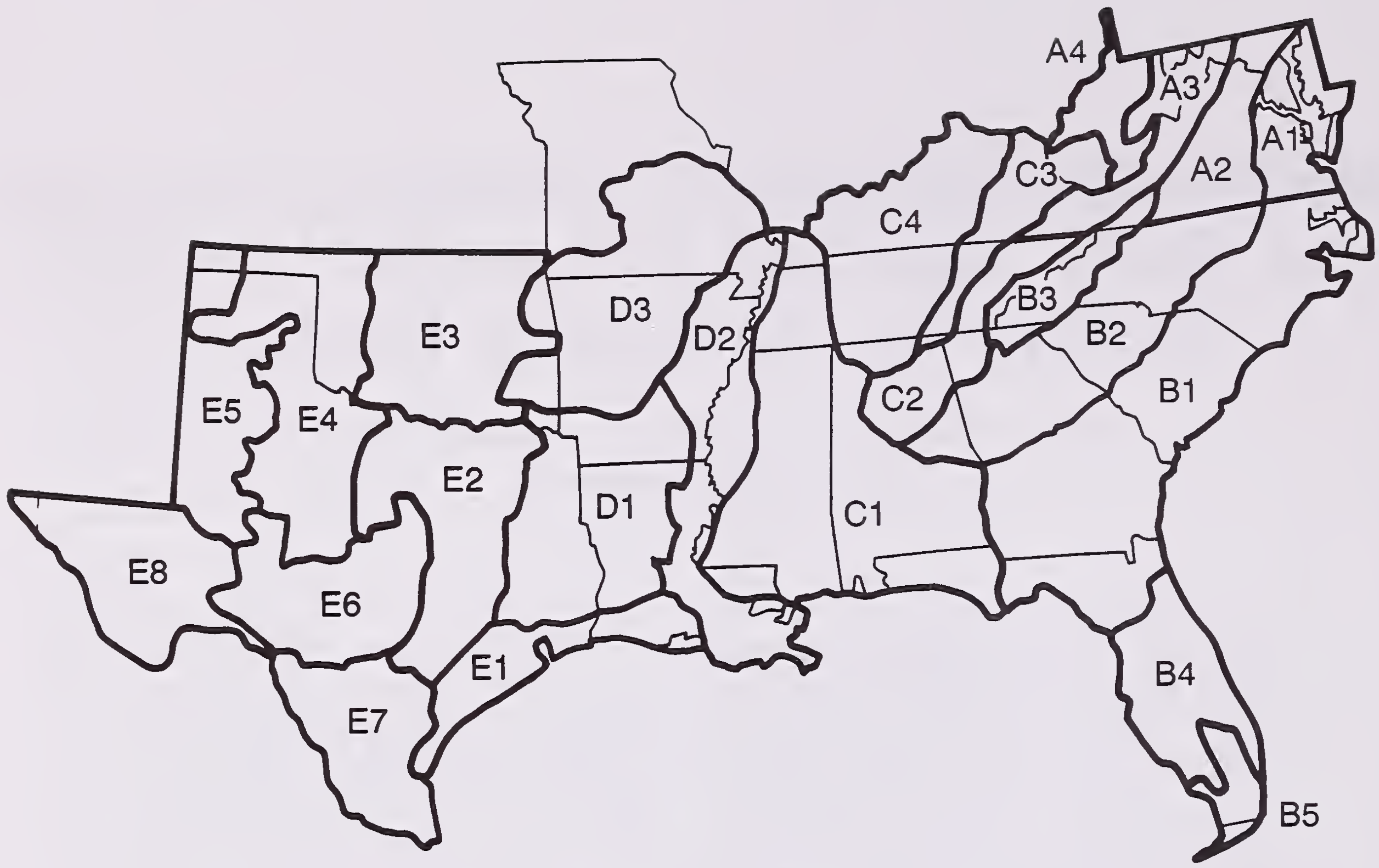


Figure 1. — Map of states and physiographic areas in the Southeast Region. Refer to Table 1 for names and component states for each physiographic area.

during breeding and/or non-breeding seasons, (2) widespread signs of recent or long-term decline, and/or (3) use of habitats within the Southeast Region that are essential for conservation of the full variation inherent within the species.

The regional ranking scheme differs from the physiographic area/state scheme in the specific information used to derive CONCERN SCORES (measures of each species' degree of vulnerability; Hunter et al. these proceedings). The regional scheme is a tracking tool to assess progress on priorities set by physiographic area/state working groups, which cumulatively fulfill the goals and objectives identified at the regional level. Specific conservation action for the regionally identified species (including increased survey, management, land protection, monitoring, and/or research) is best determined at the local land management level based on priorities set and coordinated at the physiographic area/state scale.

Along this line of organization, regionally identified species of concern are not necessarily the highest priority species in every physiographic area in which they occur. Where regionally identified species of highest concern are (1) on the periphery of their distribution, (2) are stable or increasing, and/or (3) incur a relatively low degree of local threat, they may be eclipsed by other species requiring more local attention. Locally vulnerable species that are more common outside of the Southeast are especially relevant in physiographic areas on the peripheries of the region. High priority species on the edge of their range in West Texas and Oklahoma include the Mountain Plover (*Charadrius montanus*), Gray Vireo (*Vireo vicinior*), and Lucy's Warbler (*Vermivora luciae*). The many primarily Mexican species that warrant attention in West and South Texas include the Red-billed Pigeon (*Columba flavirostris*), Buff-bellied Hummingbird (*Amazilia yucatanensis*), Lucifer Hummingbird (*Calothorax lucifer*), and Colima Warbler (*Vermivora crissalis*). South Florida is occupied by West Indies species that may require some actions, including the White-crowned Pigeon (*Columba leucocephala*), Mangrove Cuckoo (*Coccyzus minor*), Black-whiskered Vireo (*Vireo altiloquus*), and Cuban Yellow Warbler (*Dendroica petechia gundlachi*).

HABITATS OF REGIONAL AND PHYSIOGRAPHIC AREA CONCERN

Habitats identified for conservation of Neotropical migratory landbirds vary widely among physiographic areas across the Southeast Region. However, some broadly defined habitat types are frequently recognized. The MATURE BOTTOMLAND HARDWOOD-BALDCYPRESS FOREST and/or RIPARIAN (STREAMSIDE) WOODLANDS that provide optimal breeding habitat for many of the highest priority species are consistently identified as needing the highest attention. In addition, these habitats serve as corridors, providing important stop-over habitats during migration, particularly among the western physiographic areas within the Southeast Region.

MARITIME (COASTAL) SHRUB-SCRUB AND WOODLANDS (UPLANDS) on both the Atlantic and Gulf coasts (including the cheniers of Louisiana and oak mottes of the Upper Texas Coast) are critically important for many transient Neotropical migrants. The Atlantic and Florida

Table 1. — Physiographic areas defined for the Southeast Region.

Alpha-numeric identification	Physiographic Area	States
A1	Mid Atlantic Coastal Plain	Maryland, Virginia
A2	Mid Atlantic Piedmont	Maryland, Virginia
A3	Mid Atlantic Ridge and Valley	West Virginia, Maryland, Virginia
A4	Ohio Hills	West Virginia
B1	South Atlantic Coastal Plain	North Carolina, South Carolina, Georgia, Florida
B2	Southern Piedmont	North Carolina, South Carolina, Georgia, Alabama
B3	Blue Ridge	Virginia, Tennessee, North Carolina, South Carolina, Georgia
B4	Peninsular Florida	Florida
B5	Subtropical Florida	Florida
C1	East Gulf Coastal Plain	Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Florida
C2	Southern Ridge and Valley	Tennessee, Alabama, Georgia
C3	Cumberland Plateau	West Virginia, Kentucky, Tennessee, Georgia, Alabama
C4	Highland Rim and Lexington Plain	Kentucky, Tennessee, Alabama
D1	West Gulf Coastal Plain	Louisiana, Arkansas, Oklahoma, Texas
D2	Mississippi Alluvial Plain	Louisiana, Mississippi, Arkansas, Tennessee, Kentucky, Missouri
D3	Ozark-Ouachita Highlands	Missouri, Arkansas, Oklahoma
E1	Texas Coastal Prairies	Louisiana, Texas
E2	Oaks and Prairies	Texas
E3	Osage Plains	Oklahoma
E4	Colorado and Unita Basins	Oklahoma, Texas
E5	Staked and Pecos Plains	Oklahoma, Texas
E6	Edwards Plateau	Texas
E7	South Texas Brushlands	Texas
E8	Trans-Pecos Texas	Texas

Table 2. — Highly ranked species identified for the Southeast Region in need of management and/or monitoring attention (see Hunter et al. these proceedings) and the physiographic areas where they occur.

Species	Regional score*	Physiographic areas**
Southwestern Willow Flycatcher *Empidonax traillil extimus*	35	E8 (extirpated)
Bachman's Warbler *Vermivora bachmanii*	35	A1,B1,C1,D1,D2 (extinct?)
Golden-cheeked Warbler *Dendroica chrysoparia*	*35*	*E6,E2 (peripheral E7)*
Black-capped Vireo *Vireo atricapillus*	33	E6,E2,E3 (peripheral E8,E7)
Brownsville Common Yellowthroat *Geothlypis trichas insperata*	31	E7
Texas Botteri's Sparrow *Aimophila botterii texana*	31	E7
Florida Short-tailed Hawk *Buteo brachyurus fuliginosus*	30	B4,B5 (peripheral B1)
Colima Warbler *Vermivora crissalis*	30	E8
Cerulean Warbler *Dendroica cerulea*	*30*	*see Appendix 1*
"South Atlantic" Painted Bunting *Passerina ciris "ciris"****	30	B1 (peripheral B4)
Sennett's Hooded Oriole *Icterus cucullatus sennetti*	30	E7
American Swallow-tailed Kite *Elanoides forficatus forficatus*	29	B4,B5,B1,C1,D2,D1,E1
Golden-winged Warbler *Vermivora chrysoptera*	29	B3,A3,C3,A4
Cuban Yellow Warbler *Dendroica petechia gundlachi*	29	B5
Florida Prairie Warbler *Dendroica discolor paludicola*	29	B5,B4
Swainson's Warbler *Limnothlypis swainsonii*	29	see Appendix 1
Wayne's Black-throated Green Warbler South Atlantic coastal population *Dendroica virens waynei*	28	B1,A1
Prothonotary Warbler *Protonotaria citrea*	28	see Appendix 1
Wood Thrush *Hylocichla mustelina*	27	see Appendix 1
Sonoran Yellow Warbler *Dendroica petechia sonorana*	*27*	*E8 (extirpated)*
Northern Prairie Warbler *Dendroica discolor discolor*	27	see Appendix 1
"Western" Painted Bunting *Passerina ciris "pallidor"****	27	see Table 4, Appendix 1
White-crowned Pigeon *Columba leucocephala*	26	B5
Texas Elf Owl *Micrathene whitneyi idonea*	26	E7
Bell's Vireo *Vireo bellii*peripheral	26	see Table 4 (also E6,D3,D2,C4,D1,E2,E1)
Blue-winged Warbler *Vermivora pinus*	*26*	see Appendix 1
Chestnut-sided Warbler *Dendroica pensylvanica*	*26*	*B3,A3,C3,A4*
Blackburnian Warbler *Dendroica fusca*	*26*	*B3,A3 (peripheral* C3,A4)
Worm-eating Warbler *Helmitheros vermivorous*	26	see Appendix 1
Louisiana Waterthrush *Seiurus motacilla*	26	see Appendix 1
Hooded Warbler *Wilsonia citrina*	26	see Appendix 1
Mississippi Kite *Ictinia mississippiensis*	25	E4,D2,E3,B1,C1,D1 (peripheral E8,B4,E1,E5,A1,C4)
Acadian Flycatcher *Empidonax virescens*	25	see Appendix 1
Gray Vireo *Vireo vicinior*	25	E8
Yellow-throated Vireo *Vireo flavifrons*	25	see Appendix 1
Lucy's Warbler *Vermivora luciae*	*25*	*E8*
Mountain Plover *Charadrius montanus*	24	E5 (peripheral E4,E8)
Black-billed Cuckoo *Coccyzus erythropthalmus*	*24*	*A4,A3,E3 (peripheral* C3,A2,B3,A1,D3,C2,B2,B1.C1)
Yellow-billed Cuckoo *Coccyzus americanus*	24	see Table 4, Appendix 1
Eastern Wood-Pewee *Contopus virens*	24	see Appendix 1
Great Crested Flycatcher *Myiarchus crinitus*	24	see Appendix 1
White-eyed Vireo *Vireo griseus*	24	see Appendix 1
Black-throated Blue Warbler *Dendroica caerulescens*	24	B3,A3,C3 (peripheral A4,B2)
Kentucky Warbler *Oporornis formosus*	24	see Appendix 1
Canada Warbler *Wilsonia canadensis*	24	B3,A3,C3 (peripheral A4)
Orchard Oriole *Icterus spurius*	24	see Table 4, Appendix 1

_*See Hunter et al. (these proceedings).
**See Table 1; physiographic areas are ordered by decreasing relative abundance.
***See Thompson (1991)

coastlines are particularly important during migration for the Cape May Warbler (*Dendroica tigrina*), Black-throated Blue Warbler (*Dendroica caerulescens*), Kirtland's Warbler (*Dendroica kirtlandii*), and Connecticut Warbler (*Oporornis agilis*). In addition, some breeding species are dependent upon MARITIME UPLANDS along the South Atlantic Coast (especially, Painted Bunting [*Passerina ciris "ciris"*]; see Thompson 1991). Finally, many Neotropical migrant species that reach the northern edge of their winter ranges along Gulf coastlines typically concentrate in MARITIME UPLAND habitats.

A third frequently recognized habitat type needing conservation attention is growing-season fire-maintained LONGLEAF PINE. Properly managed LONGLEAF PINE habitats are not only important for providing habitat for a number of endangered species (most notably the Red-cockaded Woodpecker [*Picoides borealis*]), but also should support many shrub-scrub Neotropical migrant species. These open pine habitats when managed on a large scale (1000's of hectares) should provide a more natural habitat for many species presently dependent upon oldfields and clearcuts and undergoing widespread declines (e.g., Prairie Warbler [*Dendroica discolor*]; see Nolan 1978).

An unprioritized list of locally identified important habitats includes: (1) POCOSINS and CAROLINA BAYS; (2) MANGROVE WOODLANDS and (3) TROPICAL HARDWOODS (both important for breeding, migrant, and northerly wintering populations); (4) MIXED SPRUCE-FIR/NORTHERN HARDWOODS; (5) various types of MATURE UPLAND HARDWOOD FORESTS in all interior physiographic areas; (6) HIGH ELEVATION HEATH BALDS, OLDFIELDS, and SHRUB-SCRUB; (7) UPLAND HARDWOOD-PINE MIX of the West Gulf Coastal Plain; (8) COASTAL PRAIRIES of Texas and Louisiana; (9) POST OAK WOODLANDS of the Oaks and Prairies and Osage Plains; (10) SAVANNA-PRAIRIES-GRASSLANDS of central Oklahoma and Texas; (11) JUNIPER-OAK WOODLANDS of the Edwards Plateau; (12) TAMAULIPAN THORN FOREST AND SCRUB of the Lower Rio Grande Valley (important for breeding as well as northerly wintering populations); and (13) all MONTANE WOODLAND HABITATS, CHAPARRAL, and SEMI-DESERT GRASSLAND within the Trans-Pecos.

INTERPRETING MULTI-SPECIES PATTERNS AT THE REGIONAL LEVEL

Priorities set for species and habitats within a physiographic area can be used to some extent for comparisons among physiographic areas. Examples from (1) southern forests and (2) western riparian areas follow.

Southern Forests

Population trends for species using forested landscapes (including those that occupy shrub-scrub habitats) can provide insight into habitat trends among physiographic areas within the Southeast Region. Breeding Bird Survey (hereafter BBS) population trend data for the last 26 years (1966-1991) were used to copare trends among 19 southweastern geographic areas for 22 species that are widespread in their use of mature forest, 6 predominately forest edge species, and 6 declining shrub/scrub species, all at elevations below 1000 m (appendix 1). Population trends were considered reasonably definite with a significance level of P0.10, using the linear route-regression method of Geissler and Noon (1981); otherwise population trends were considered possible increases or decreases. Many mature forest species are declining in physiographic areas where they are most commonly detected on BBS routes, as reflected by high average IMPORTANCE OF AREA SCORES in those areas where there are higher numbers of declining species (Table 3). Detection rate is a measure of a species' relative abundance, which in turn is a measure of how important an area is to a species (see Hunter et al. these proceedings). Declining trends combined with high relative detection rates for many mature forest species also result in high average CONCERN SCORES for physiographic areas. In essence, many mature forest species have declined over the last 26 years in physiographic areas where they are most common. These are the areas that may serve as sources of excess young dispersing to other areas.

Despite the declining trends, mature forest species are not imminently threatened in areas where they remain common, nor are they undergoing declines in all land management units (i.e., Great Smoky Mountains National Park in the Blue Ridge; Wilcove 1988). Further, short-term (e.g., last 10 years) population trends may or may not correspond with long-term trends for each species in each physiographic area. A review of land use patterns within physiographic areas with many declining mature forest species can determine whether management adjustments are needed to stall ongoing regional declines.

Three physiographic areas (Mississippi Alluvial Plain, Southern Ridge and Valley, and Osage Plains) with many declining mature forest species did not have high average IMPORTANCE OF AREA SCORES (Table 3). However, local management units (e.g., state wildlife management areas, national wildlife refuges, national forests) in those areas are locally important population centers for mature forest species, but do not cover enough of the landscape to influence overall BBS species detection rates. There are also declining population trends for many forest edge and shrub-scrub species in the Mississippi Alluvial Plain and Southern Ridge and Valley. Conservation actions in these physiographic areas must consider not only mature forest species, but also inhabitants of shrub-scrub and forest edge habitats.

Table 3. — A comparison of Neotropical migrant population trends among physiographic areas with Southeastern forested landscapes based on 26 years of Breeding Bird Survey data. Species are grouped into three categories: (1) mature forest, (2) forest edge, and (3) shrub-scrub (see Appendix 1).

Species/ Physiographic area	Species declining*	Species possibly declining	Species with unclear trends	High area importance and concern scores**
Mature forest (n=species; total=22)				
Blue Ridge (n=22)	12	5	1	Yes, Yes
Southern Ridge and Valley (n=22)	11	3	2	No, No
Mississippi Alluvial Plain (n=22)	7	3	5	No, Yes
Osage Plains (n=18)	7	3	5	No, No
Ohio Hills (n=21)	7	1	1	Yes, Yes
Mid Atlantic Ridge and Valley (n=22)	6	4	2	Yes, Yes
West Gulf Coastal Plain (n=22)	5	8	3	Yes, Yes
Cumberland Plateau (n=22)	5	5	2	Yes, Yes
Ozark-Ouachita Highlands (n=22)	4	7	1	Yes, Yes
Oaks and Prairies (n=15)	4	3	9	No, No
Southern Piedmont (n=22)	4	0	3	No, No
East Gulf Coastal Plain (n=22)	4	0	3	No, No
Highland Rim (n=22)	3	3	1	No, No
Mid Atlantic Coastal Plain (n=22)	2	3	2	Yes, No
South Atlantic Coastal Plain (n=22)	2	2	1	No, No
Peninsular Florida (n=11)	2	2	2	No, No
Mid Atlantic Piedmont (n=21)	1	2	1	No, No
Texas Coastal Prairies (n=14)	1	1	8	No, No
Edwards Plateau (n=12)	1	0	5	No, No
Forest edge (n=species; total=6)				
Mississippi Alluvial Plain (n=6)	6	0	0	Yes, Yes
Southern Ridge and Valley (n=5)	4	0	1	No, No
Ozark-Ouachita Highlands (n=6)	3	1	0	No, Yes
Cumberland Plateau (n=5)	3	1	0	Yes, Yes
Osage Plains (n=6)	3	1	0	No, Yes
West Gulf Coastal Plain (n=6)	3	0	0	No, Yes
East Gulf Coastal Plain (n=6)	2	2	0	No, Yes
Oaks and Prairies (n=6)	2	1	0	No, No
Edwards Plateau (n=6)	2	1	2	No, No
Highland Rim (n=5)	2	1	0	Yes, Yes
South Atlantic Coastal Plain (n=6)	1	3	0	Yes, Yes
Blue Ridge (n=5)	1	3	0	No, No
Mid Atlantic Ridge and Valley (n=5)	1	1	0	Yes, No
Mid Atlantic Coastal Plain (n=5)	1	0	0	No, No
Ohio Hills (n=5)	1	0	0	Yes, No
Southern Piedmont (n=6)	1	0	2	No, No
Mid Atlantic Piedmont (n=5)	0	2	0	Yes, No
Texas Coastal Prairies (n=6)	0	1	2	No, No
Peninsular Florida (n=5)	0	0	3	No, No

Table 3. Continued.

Species/ Physiographic area	Species declining*	Species possibly declining	Species with unclear trends	High area importance and concern scores**
Shrub-scrub (n=species; total=6)				
Southern Ridge and Valley (n=6)	5	0	0	No, Yes
Blue Ridge (n=6)	4	1	0	No, Yes
Mid Atlantic Ridge and Valley (n=6)	4	0	0	No, No
Mississippi Alluvial Plain (n=5)	4	0	0	No, No
Mid Atlantic Coastal Plain (n=5)	3	1	0	Yes, No
Osage Plains (n=5)	3	1	0	No, No
East Gulf Coastal Plain (n=6)	3	0	1	Yes, Yes
Cumberland Plateau (n=6)	3	0	0	No, Yes
Southern Piedmont (n=6)	2	2	0	Yes, Yes
Ohio Hills (n=6)	2	0	0	Yes, Yes
Mid Atlantic Piedmont (n=6)	2	0	0	Yes, No
West Gulf Coastal Plain (n=5)	2	0	0	Yes, No
Oaks and Prairies (n=4)	1	1	0	No, No
Highland Rim (n=6)	1	1	0	Yes, Yes
Peninsular Florida (n=4)	1	1	0	No, No
Ozark-Ouachita Highlands (n=6)	1	0	0	No, No
South Atlantic Coastal Plain (n=5)	1	0	0	Yes, No
Texas Coastal Prairies (n=4)	0	0	0	No, No
Edwards Plateau (n=4)	0	0	2	No, No

*Significance at P0.10

**For detailed discussions on "Importance of Area" scores and "Concern" scores, see Hunter et al. (these proceedings). In summary, the Importance of Area criterion reflects the distribution and abundance levels of a species within an area under consideration relative to the total distribution of the species, with higher scores given to species that are either relatively common compared with other areas or occur only within this and a few other areas. Concern Score is the culmination of all criteria used to judge relative vulnerability of each species within each physiographic area. "High" refers to the 7 to 9 (depending on ties) highest scores among physiographic areas for species' Importance of Area and Concern scores (Appendix 1).

Differences or similarities in trends among physiographic areas that share many land cover and land use patterns can raise broader questions concerning the relationship among these birds and their habitats. For example, why are more mature forest species declining in the West Gulf Coastal Plain than in the physiographically similar East Gulf Coastal Plain, South Atlantic Coastal Plain, and Mid Atlantic Coastal Plain (Table 3)? An analysis of long-term trends among these physiographic areas in forest cover, average patch size of contiguous mature forest, and geographic relationships among patches may address this question. However, a relationship between forest trends and the number of declining mature forest species among physiographic areas does not necessarily imply a cause and effect relationship in that species are affected by factors (or combinations of factors) independent of co-occurring species (see James et al. 1984). Forest trend data can, nonetheless, provide clues to direct investigations into specific details of habitat-bird relationships.

Southwestern Riparian

Although it may seem inappropriate, Texas and Oklahoma and thus many habitats and birds generally associated with the West are included in the Partners in Flight Southeastern region. Frequently cited literature (particularly MacArthur 1959) has lead to the misconception that there are relatively few Neotropical migratory landbirds in the West. In fact, there are often more Neotropical migrant species and individuals than residents and short-distance migrants in western forested habitats, especially within southwestern riparian zones (i.e., Rosenberg et al. 1991). Although BBS data show few major population declines for most Neotropical migrants in the West (Sauer and Droege 1992), there have been more local extirpations and severe population declines during recent years for Neotropical migratory species in southwestern riparian habitats than in most other North American habitats (Hunter et al. 1987, Rosenberg et al. 1991). In the Southeastern region, two riparian habitat subspecies, the Southwestern Willow Flycatcher and the Sonoran Yellow Warbler, are thought to be extirpated from west Texas. A closer look at western species in general, and southwestern riparian species in particular, is required for effective conservation of Neotropical migrants.

Population trends were reviewed for 15 species using riparian habitats in central and western Oklahoma and in western and southern Texas (Table 4). Whereas consistent declines were found in the Colorado and Unita Basins and in the South Texas Brushlands physiographic areas, increasing trends were found for most species in the Staked and Pecos Plains and Trans-Pecos physiographic areas. Some riparian species may be increasing in these latter two physiographic areas, due in part to population expansions accompanying the spread of exotic saltcedar (*Tamarix chinensis*) (Hunter et al. 1988). However, interpretation of population trends in the Staked and Pecos Plains and Trans-Pecos is tenuous due to the small number of BBS routes upon which they are based. The lack of any data for Lucy's Warbler and inadequate data for Yellow-billed Cuckoo, Bell's Vireo (*Vireo bellii*), Yellow-breasted Chat (*Icteria virens*), and Summer Tanager (*Piranga rubra*) are notable as these species are at least locally fairly common along the Rio Grande system (Engel-Wilson and Ohmart 1978).

Increased conservation attention, to include surveys and monitoring, should be focused on western riparian birds and their habitats. The BBS is presently an ineffective technique for assessing population changes of western riparian birds because roadways tend to run perpendicular to streams and rivers. Thus, very few BBS stops sample the riparian habitats in which most Neotropical migrant species are concentrated. The general need for other monitoring and survey techniques to complement BBS routes throughout the Southeast Region is clearly greatest in southwestern riparian habitats.

USING THE HABITAT APPROACH AT THE LOCAL LEVEL

Land managers can be provided with lists of species that occur in each identified habitat in each physiographic area (e.g., bottomland hardwoods/riparian in the Ozark-Ouachita

Table 4.— A comparison of Neotropical migrant population trends based on 26 years of Breeding Bird Survey data for selected western riparian landbirds in four physiographic areas where sample sizes for all species are low. N=number of Breeding Bird Survey routes species was detected from; -*=decline (≤P0.10), -=possible decline, O=no trend, +=possible increase, +*=increase (≤P0.10), ?=present but trends unclear or no available data.

Species	Colorado and Unita Basins		Staked and Pecos Plains		South Texas Brushlands		Trans-Pecos	
	N	Trend	N	Trend	N	Trend	N	Trend
White-winged Dove *Zenaida asiatica*					16	-	9	0
Yellow-billed Cuckoo	18	-	7	0	18	0	8	-*
Southwestern Willow Flycatcher							extirpated	
Vermilion Flycatcher *Pyrocephalus rubinus*					15	0	6	+
Bell's Vireo	5	-*			10	-*	8	+*
Lucy's Warbler							?	?
Yellow Warbler (various subsp.)	extirpated				extirpated			
Sonoran Yellow Warbler							extirpated	
Yellow-breasted Chat *Icteria virens*	?	?	2	+	5	-	10	+*
Summer Tanager	4	-	?	?	7	-	10	-
Blue Grosbeak *Guiraca caerulea*	17	1	11	+*	16	-*	14	+
"Western" Painted Bunting	15	+	2	+	18	-*	11	+
Orchard Oriole	16	-			15	-*	9	+
Northern Baltimore Oriolem *Icterus galbula galbula*	11	0			3	0		
Northern Bullock's Oriole *Icterus galbula bullockii*	18	-*	12	+	17	0	9	+*

Highlands; Appendix 2). If some species are absent or rare, as determined by local surveys, managers can consult with local experts and appropriate works on bird-habitat relationships (i.e., Hamel 1992) to draft appropriate management strategies. Once surveys are satisfactorily complete, management strategies implemented, and appropriate questions framed, populations can be monitored to determine the response of target species or whether other species are suffering because of actions taken. Research may become necessary to investigate alternate management approaches or to identify causal factors of decline.

Persistent patterns in the rarity of species or species groups among land management units should be evaluated at the physiographic area or state level to devise an overall management strategy. Management emphasis differs among landowners and an understanding of who is doing what will allow better coordination of efforts. Similarly, persistent and widespread problems within any particular habitat among physiographic areas or states can be coordinated at the regional level to develop corrective strategies.

ONGOING AND FUTURE ACTIONS

Meetings to review preliminary species and habitat priorities and identify action needs have occurred in almost all of the 24 Southeastern physiographic areas. A variety of habitat acquisition and enhancement actions should be recognized as important for the conservation of Neotropical migrants. Ongoing land acquisition and reforestation efforts in bottomlands, especially within the Mississippi Alluvial Plain and the coastal plain physiographic areas, often are associated with implementation of the North American Waterfowl Management Plan and related wetland protection and enhancement programs. Elsewhere, efforts along the lower Rio Grande Valley (South Texas Brushlands Physiographic Area), intended to conserve overall biological diversity, are providing critical benefits for breeding and wintering Neotropical migrant populations as well as for stable migration habitat to and from the Neotropics. Current research, such as the efforts to understand migrant bird ecology along the Gulf Coast (i.e., Moore and Simons 1992), will be instrumental in development of strategies to improve the amount and condition of stopover habitat for trans-Gulf and circum-Gulf migrants.

Although recent initiatives undertaken by many federal, state and private landowners involve reviews of various activities to improve habitat conditions for Neotropical migrants, there remain many questions before major shifts in management direction will be undertaken. The great variety of habitat needs for all the species involved and the general lack of population trend data available at local levels require that land managers remain cautious before redirecting limited logistical and financial resources towards new and untested management approaches. The most important management need is identification of those habitat factors that allow relative stability of species and species groups in order to suggest management practices that may reverse declines where they are occurring.

It is difficult to differentiate breeding season effects from those during migration or on the wintering grounds. An indirect approach would be to determine whether or not improvement of habitat conditions on land management units or within a physiographic area are reflected in population trends among species of concern (as tracked by BBS). If so, breeding season effects are at least partially responsible for population changes and local efforts toward habitat restoration or improvement could be effective. If not, conservation efforts for these species may need to concentrate on migration and winter habitat.

The temptation may arise to identify and monitor indicator species from which the response of many species to management change can be inferred. Although there is a valid logistical justification for this approach, there is little evidence that indicator Neotropical migrants reflect trends for the guilds they are purported to represent. In general, each species has different microhabitat needs and, specifically, Neotropical migrants sharing breeding habitats often have differing needs during migration and winter.

Nevertheless, managers throughout the Southeast are beginning to develop sound management practices along with their neighbors (private and public, within states and across state boundaries) that are consistent with other established management objectives using the information that is presently applicable. Initiatives involving (1) educating the public on what they can do to conserve these species, (2) implementing surveys to determine local bird-habitat associations, (3) monitoring populations at the local level, and (4) addressing specific issues through research, are all under development to complement developing management plans within most physiographic areas in the Southeast Region.

One of the more important future needs for the Southeast Region is greater attention to monitoring technique and subsequent data analysis. Monitoring standards need to be set and implemented to judge the success of management activities and to identify the threshold of population change at which management prescriptions would be reevaluated. Development of a consistent monitoring approach for all land managers is desirable for comparative reasons, but uniformity in implementation will be difficult to achieve. Enthusiasm among land managers in the Southeast to initiate surveys is very high, but we risk losing the initiative because there is as yet no consensus at the national level on a number of important issues. These issues include but are not limited to: (1) habitat definitions and how samples should be stratified among habitat types, (2) sample sizes necessary to provide valid information at the local land management level and for each habitat sampled, and (3) decision rules for when a management approach should be reevaluated.

In particular, disagreements over the most appropriate probability level (e.g., $P \leq 0.05$, $P \leq 0.10$, or even $P \leq 0.25$) to identify significant declines must be resolved as this influences the probability of wrongly ignoring a possible decline when a decline has in fact occurred. The probability level chosen has obvious ramifications for conservation priorities as detection of a serious population decline may not be assured until it is too late to effectively stabilize the population (e.g., $P \leq 0.05$) while at the other extreme conservation attention may be directed toward a species not undergoing a severe decline ($P \leq 0.25$). Also, the selection of a probability level influences sample size needs for monitoring efforts, with greater assurance in the population trend requiring a larger sample size. Sample size considerations are critical for judging the logistical and financial commitment land managers must make for implementation of a monitoring program that will tell them what they need to know.

Another important action to be undertaken within the Southeast Region is an increased effort to link breeding, migrating, and wintering factors together to understand the conservation needs of each Neotropical migratory landbird species. The Southeast Region is critically important during migration as Neotropical migrants breeding east of the Rocky Mountains must pass through the Southeast en-route to their wintering grounds. The Southeast also includes important wintering areas, especially in south Texas and peninsular Florida. Along these lines, an important objective is to gain a better understanding about where specific breeding populations spend the winter and what migration routes they use. Member agencies and organizations within the Southeast Regional Working Group are actively involved in joint projects with the West Indies Neotropical Migratory Bird Conservation Committee and with Latin American nations that may eventually lead to a better understanding of the annual cycle for at least some species (i.e., the National Audubon Society's Birds in the Balance Campaign, The Sister Forest Program of the U.S.D.A. Forest Service, The Migratory Birdwatch Program of the National Park Service).

CONCLUSION

The Southeast Management Working Group has made substantial progress in identifying specific priority actions for conservation of Neotropical migratory landbirds in the 24 physiographic areas comprising the region. However, actual conservation action still requires frequent discussion and constant refinement within each physiographic area and at state and regional levels. The establishment of effective feedback mechanisms at local, physiographic area, state, regional, national, and international organizational levels (as we are attempting to establish in the Southeast) will be critical for effective sharing of information and ultimately the measure by which the Partners in Flight program will be judged as a conservation success story.

ACKNOWLEDGMENTS

Many individuals have contributed to the development of the prioritization scheme used in this paper and in the actual establishment of priorities at the physiographic area scale within the Southeast and beyond. To all we extend our sincerest appreciation for sharing with us their expertise. We would especially like to thank the following individuals for their help on this and other efforts undertaken by the Southeast Management Working Group: Fred Alsop, Ray Aycock, Carol Beardmore, Dana Bradshaw, Kelly Bryan, Dawn Carrie, Mike Carter, John Cely, Fred Collins, Jerry Davis, Ted Eubanks, Bob Ford, Sid Gauthreaux, Gary Graham, Bryan Hale, Paul Hamel, Steve Helfert, Brad Jacobs, Scott Klinger, Harry LeGrand, Madge Lindsey, Jane Lyons, Tony Melchoirs, Laura Mitchell, Frank Moore, Eddie Morris, Allan Mueller, Chuck Nicholson, Lance Peacock, Rick Reynolds, Steve Rickerson, Ted Simons, Jan Self, Winston Smith, Ted Stevens, Frank Thompson, Bill Vermillion, Gary Waggerman, E.G. White-Swift, and Karen Yaich. The BBS data presented here are the result of a collaborative effort by many volunteers in the field and researchers and data managers with the U.S. Fish and Wildlife Service at Patuxent, Maryland. Specifically, we wish to thank John Sauer and Bruce Peterjohn for adapting their analysis of BBS data to the physiographic area structure of the Southeast Management Working Group. Richard Coon, John Dunning, Daniel Petit, and Peter Stangel kindly provided comments that improved the content of this manuscript.

LITERATURE CITED

Engel-Wilson, R.W., and R.D. Ohmart. 1978. Floral and attendant faunal changes on the lower Rio Grande between Fort Quitman and Presidio, Texas. U.S.D.A. For. Serv. Gen. Tech. Rep. WO-12:139-147.

Gauthreaux, S. 1992. Preliminary lists of migrants for *Partners in Flight* Neotropical Migratory Bird Conservation Program. National Fish and Wildlife Foundations's Partners in Flight Newsletter 2:30.

Geissler, P.H., and B.R. Noon. 1981. Estimates of avian population trends from the North American Breeding Bird Survey. Pp. 42-51 *in* Estimating numbers of terrestrial birds (C.J. Ralph and M.J. Scott, eds). Studies in Avian Biology 6.

Hamel, P.B. 1992. Land manager's guide to the birds of the South. The Nature Conservancy, Chapel Hill, North Carolina.

Hunter, W.C., M.F. Carter, D.N. Pashley, and K. Barker. 1993. The Partnersin Flight species prioritization scheme. These proceedings.

Hunter, W.C., R.D. Ohmart, and B.W. Anderson. 1987. Status of breeding riparian-obligate birds in southwestern riverine systems. Western Birds 18:10-18.

Hunter, W.C., R.D. Ohmart, and B.W. Anderson. 1988. Use of exotic saltcedar (*Tamarix chinensis*) by birds in arid riparian systems. Condor 90:113-123.

James, F.C., R.F. Johnston, N.O. Wamer, G.J. Niemi, and W.J. Boecklin. 1984. The Grinnellian niche of the Wood Thrush. Am. Naturalist 124:17-30.

MacArthur, R.H. 1959. On the breeding distribution pattern of North American birds. Auk 76:318-325.

Moore, F.R., and T.R. Simons. 1992. Habitat suitability and stopover ecology of Neotropical landbird migrants. Pp. 345-355 *in* Ecology and conservation of Neotropical migratory landbirds (J.M. Hagan III and D.W. Johnston, eds.). Smithsonian Institution Press, Washington, D.C.

Nolan, V., Jr. 1978. The ecology and behavior of the Prairie Warbler *Dendroica discolor*. Ornith. Monogr. No. 26.

Robbins, C.S., D. Bystrak, P.H. Geissler. 1986. The Breeding Bird Survey: Its First Fifteen Years, 1965-1979. U.S. Fish and Wildlife Serv. Resource Publ. 157.

Rosenberg, K.V., R.D. Ohmart, W.C. Hunter, and B.W. Anderson. 1991. Birds of the lower Colorado River Valley. University of Arizona Press, Tucson.

Sauer, J.R., and S. Droege. 1992. Geographic patterns in population trends of Neotropical migrants in North America. Pp. 26-42 *in* Ecology and conservation of Neotropical migratory landbirds (J.M. Hagan III and D.W. Johnston, eds.). Smithsonian Institution Press, Washington, D.C.

Thompson, C.W. 1991. Is the Painted Bunting actually two species? Problems in determining species limits between allopatric populations. Condor 93:987-1000.

Wilcove, D.S. 1988. Changes in the avifauna of the Great Smoky Mountains: 1947-1983. Wilson Bull. 100:256-271.

Appendix 1. — Population trends (26-year) for selected species grouped by their use of mature forest, forest edge, or shrub-scrub habitats below 1000 meters in elevation. Physiographic areas are as listed in Table 1. The raw importance of area rank scores and mean concern scores for each species are on file with the Southeast Management Working Group and these are averaged for all species in each group, within each physiographic area. The physiographic areas with the highest average scores are underlined (see Table 3). NP=species not known to be present in the physiographic area; ?=present but trends unclear or no available data; trends in parentheses refer to a species occurring peripherally in the physiographic area; -*=decline ($P \leq 0.10$), -=possible decline, O=no trend, +=possible increase, +*=increase ($P \leq 0.10$).

	Physiographic Area																		
Species Group/Species	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**E6**
Mature Forest																			
Yellow-billed Cuckoo	0	0	-	-*	0	-*	+*	-*	-*	-*	0	-*	-*	-*	0	0	-*	0	-*
Eastern Wood-Pewee	-	0	-*	-*	0	0	-*	(?)	-*	-*	-*	0	-*	-*	-	(+*)	-	-*	+*
Acadian Flycatcher	0	-	+*	0	+*	-*	-*	?	+*	-*	-	+*	-	-	-*	(?)	(?)	(-*)	(?)
Great Crested Flycatcher	0	0	0	-*	0	+	0	0	0	0	0	0	+	-	-	(+)	-	-*	(+)
Blue-gray Gnatcatcher *Polioptila melanura*	0	0	-	0	+*	+*	-	-	+*	0	-	-	-*	-*	0	(?)	(-)	0	+
Wood Thrush	-*	0	-*	+*	-*	-*	-*	NP	-*	-*	0	-*	-	-*	-*	(?)	(?)	(-*)	NP
Yellow-throated Vireo	-	0	-	+	+*	+*	-	+	0	-*	-	+*	-	0	0	NP	(?)	(-)	0
Red-eyed Vireo *Vireo olivaceus*	0	+*	0	0	-*	+*	0	+	+*	-	0	0	-	-*	0	(-*)	(-*)	(-*)	0
Northern Parula *Parula americana*	0	+*	-*	0	-	+	-*	+	+*	+*	0	+*	-	-*	0	(?)	(-*)	-*	(?)
Yellow-throated Warbler *Dendroica dominica*	0	0	(0)	+	-	+	0	-	0	-*	+	+*	0	+	0	(?)	(?)	(?)	(?)
Cerulean Warbler	(?)	(+)	-*	-*	(?)	(?)	-	NP	(?)	(?)	-*	-*	(?)	(?)	-*	NP	(?)	NP	NP
Black-and-white Warbler *Mniotilta varia*	-	+	-*	-*	(+*)	+	-*	NP	0	-*	-	-	-	+*	0	NP	(?)	(0)	(?)
American Redstart *Setophaga ruticilla*	+*	-*	-*	-	(+)	+	-*	NP	0	-*	-*	-	-	+*	-	NP	NP	(?)	NP
Prothonotary Warbler	0	(?)	(?)	NP	+*	-*	(?)	-*	-*	-	(?)	+*	-*	-*	0	-	(?)	(+)	NP
Worm-eating Warbler	0	+*	+	-*	+	(?)	-	NP	(+*)	0	0	+	0	(?)	-	NP	NP	NP	NP
Swainson's Warbler	(?)	NP	(?)	(?)	+*	?	-*	NP	0	(?)	?	(?)	+	-	?	(?)	NP	NP	NP
Ovenbird *Seiurus aurocapillus*	0	+*	0	+	+*	0	-*	NP	(?)	+	-*	+*	(?)	(?)	-*	NP	NP	NP	NP
Louisiana Waterthrush	0	0	0	-*	+*	+*	-*	NP	+*	-*	-	0	+	(?)	-	NP	(?)	(+)	NP
Kentucky Warbler	0	-	0	+	+*	0	-*	NP	+	-*	0	0	-*	+*	0	(?)	(?)	-	(?)
Hooded Warbler	0	+*	0	0	0	+	-*	NP	+*	-	0	0	-	+	-	(?)	NP	(?)	NP
Summer Tanager *Piranga rubra*	0	0	-	0	0	0	-*	+	0	-*	-*	0	0	0	0	0	-*	-*	0
Scarlet Tanager *Piranga olivacea*	-*	+	+*	+	(+*)	0	-	NP	(?)	+*	+*	+*	(?)	(?)	-	NP	NP	(0)	NP
Average Importance of Area	3.9	3.6	3.9	4.0	3.6	3.4	4.4	3.2	3.6	3.3	4.6	3.5	4.1	3.2	3.9	2.2	2.4	2.6	2.7
Average Concern Score	3.2	3.0	3.3	3.3	3.1	3.1	3.5	3.0	3.1	3.2	3.4	3.1	3.3	3.3	3.3	2.9	3.0	3.0	2.8
Forest Edge																			
Gray Catbird *Dumetella carolinensis*	-*	-	-	0	-	-*	-*	(?)	-*	-*	-*	-*	0	-*	-*	(?)	(-)	0	(?)
White-eyed Vireo	0	+*	-*	+*	0	+	-	+	0	-*	-	-	-*	-*	-	0	+*	(0)	+*
Indigo Bunting *Passerina cyanea*	0	0	0	0	-	+	-	(+)	0	-*	-*	-*	-*	-*	0	0	0	-	-
"Western" Painted Bunting	NP	NP	NP	NP	NP	NP	NP	NP	(-)	NP	NP	NP	0	-*	-*	-	-*	-*	-*
"South Atlantic" Painted Bunting	NP	NP	NP	NP	-*	(?)	NP	(?)	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
Orchard Oriole	+*	+*	0	+	+*	+	-	(?)	-	-*	+	0	-*	-*	-*	+	-*	-*	-*
Northern Baltimore Oriole	+*	-	0	-*	-	(?)	+	NP	-*	(?)	(-*)	+*	0	-*	0	(?)	(0)	-*	(?)
Average Importance of Area	3.8	4.2	4.2	4.2	4.0	3.6	3.8	2.8	3.5	3.6	4.2	4.6	3.7	4.3	3.7	3.0	3.0	3.5	3.2
Average Concern Score	2.9	2.8	3.0	3.0	3.1	3.0	3.0	2.9	3.1	3.1	3.1	3.1	3.1	3.4	3.1	2.9	2.9	3.0	3.0
Shrub-scrub																			
Eastern Kingbird *Tyrannus tyrannus*	-	-*	-*	0	0	-	-*	-*	-*	0	+	0	0	-*	0	+	0	-*	(?)
Blue-winged Warbler	NP	(0)	(0)	+	NP	(-)	0	NP	(?)	-*	+*	-	NP	NP	+	NP	NP	NP	NP
Northern Prairie Warbler	-*	+	-*	-*	0	-*	(-*)	NP	-*	-*	-*	-*	-*	(-*)	-*	NP	NP	(-*)	NP
Common Yellowthroat *Geothlypis trichas*	-*	-*	-*	0	-*	-*	-*	-	-*	-*	-*	0	-*	-*	0	0	(0)	-	(?)
Yellow-breasted Chat	-*	+	-*	-*	+*	0	-*	NP	+	-*	-*	+*	+*	-*	0	0	(-)	-*	+*
Blue Grosbeak	+*	+*	0	(0)	+*	+*	-	+	+*	-*	0	+*	+	0	0	(+*)	-*	0	+
Average Importance of Area	4.2	5.0	2.8	4.2	4.6	4.2	2.8	3.7	4.2	4.0	4.0	4.3	4.2	3.6	3.7	3.3	2.5	2.8	2.5
Average Concern Score	2.9	2.8	2.9	3.0	2.8	3.0	3.0	2.6	3.0	3.1	3.0	3.1	2.8	2.9	2.9	2.4	2.5	2.9	2.3

Appendix 2. — Information on priority habitats and their associated species developed by the Ozark-Ouachita Highlands physiographic area working group using the procedure developed by the Southeast Management Working Group. This appendix provides an example of a list from one habitat type to be given to managers for determining which habitats are present on lands under their jurisdiction, and to encourage them to survey these habitats to determine if species expected to occur are absent or occur in lower than expected numbers. This is the first step towards identifying whether shifts in management emphasis may be needed locally for conservation of Neotropical migrants. ?=species present, but no available data; -*=decline ($P \leq 0.10$), -=possible decline, O=no trend, +=possible increase, +*=increase ($P \leq 0.10$).

Habitat/ecosystem	Guild	Species (physiographic area concern score, 26-year population trend)
Bottomland hardwoods/riparian	Canopy	Cerulean Warbler (27, -*), Yellow-throated Vireo (24, -), Northern Parula (23, -), Summer Tanager (23, -), Yellow-throated Warbler (22, -), Red-eyed Vireo (17, +)
	Midstory	Prothonotary Warbler (25, -), Great Crested Flycatcher (24, -), Eastern Wood-Pewee (23, -), Yellow-billed Cuckoo (21, +), Blue-gray Gnatcatcher (21, -), American Redstart (19, -), Ruby-throated Hummingbird (*Archilochus colubris*; 18, -)
	Understory	Swainson's Warbler (26, ?), Wood Thrush (25, -*), Worm-eating Warbler (25, -), Acadian Flycatcher (24, -*), Hooded Warbler (24, -)
	Ground	Kentucky Warbler (24, -), Louisiana Waterthrush (23, -), Chuck-will's-widow (21, +)
	Edge	Painted Bunting (26, -*), Orchard Oriole (24, -*), Gray Catbird (22, -*), White-eyed Vireo (21, -), Northern Oriole (20, -), Indigo Bunting (18, O), Warbling Vireo (*Vireo gilvus*; 17, +), Yellow Warbler (16, +*),

Status of Neotropical Migratory Birds in the Northeast: A Preliminary Assessment

Charles R. Smith[1], Diane M. Pence[2], and Raymond J. O'Connor[3]

Abstract—The Northeast Region encompasses a diversity of habitats, from the coastal plain of Virginia to the boreal spruce-fir forests of northern Maine, with a varied group of neotropical migratory bird species occupying these habitats. The geographic area of concern in this analysis includes the states of Maine, Vermont, New Hampshire, New York, Massachusetts, Connecticut, Rhode Island, New Jersey, Pennsylvania, Delaware, West Virginia, Maryland, Virginia, and the District of Columbia, corresponding to Administrative Region 5 of the U.S. Fish and Wildlife Service (USFWS). These states represent Administrative Regions 1, 2, and 3 of the U.S. Environmental Protection Agency, and parts of the Eastern and Southern Regions of the U.S. Forest Service. Portions of 16 physiographic strata, as defined by the USFWS Breeding Bird Survey (BBS), are included in the Northeast Region. A total of 132 species of neotropical migratory birds from Lists "A" and "B" (as defined by the "Preliminary Lists of Migrants for Partners in Flight," published in the Partners in Flight Newsletter, vol. 2, no. 1, p. 30), occur regularly in the Northeast Region. Of that species complement, 88 (66.7%) are List A species and 44 (33.3%) are List B species. There are no List C or D species in the Northeast Region. Of the species that regularly occur in the Northeast Region, 77 occur only as breeding species, 49 breed and winter in the region, 5 only winter in the region (Merlin, American Pipit, Orange-crowned Warbler, White-crowned Sparrow, and Fox Sparrow), and one species (Connecticut Warbler) occurs in the region only as a migrant. In addition, all 132 species are represented as migrants through the region.

Taken as a whole, the Northeast Region presents a somewhat different picture of the status of neotropical migrants than appears to be the case for other regions of the United States. We evaluated BBS data from 1966 through 1990, looking at sample size and trend significance and consistency (Table 1). We also used supplemental information for species not adequately sampled by the BBS (e.g. Peregrine Falcon and Upland Sandpiper). We find that 60 breeding species are showing declining population trends over the 25-year period, but only 29 species (22.0%) are showing declining population trends that are significant at the 0.05 level or better. Thirty species are showing increasing population trends, with 16 of those trends significant at the 0.05 level or better. Of those remaining, data available for 32 species indicate no significant population changes over the 25-year period, and data do not exist for four species (Long-eared Owl, Willow and Alder Flycatchers, and Gray-cheeked Thrush). In effect, a majority of the 126 species (81 species, 64.3%) of neotropical migrants breeding in the Northeast Region have populations for which no significant increasing or decreasing trend can be discerned from BBS data (Table 1). The appearance of no population change could result either from no real change in population trend or from inadequacy of the sampling procedure.

[1]*Department of Natural Resources, Cornell University, Ithaca, NY 14853-3001*

[2]*USFWS, Region 5, 300 Westgate Center Drive, Hadley, MA 01035-9589*

[3]*Department of Wildlife, University of Maine, Orono, ME 04469-0125*

In the absence of a generally agreed upon scheme or vocabulary within the Partners in Flight initiative for identifying and classifying habitat types, we define two general types of habitat for the Northeast Region: relatively mature (arbitrarily defined as stands older than 50 years), forested habitats and disturbed or successional habitats (e.g. clear-cuts, beaver meadows, blow-downs, shrublands, pastures). If we examine the habitat affinities for those species in the Northeast Region that have significantly declining population trends, using our very coarse habitat classification scheme, some interesting patterns emerge (Tables 2 through 5). Among the 126 species of neotropical migrants breeding in the Northeast Region, we find that 74 species (58.7%) are species of disturbed or successional habitat types, while 52 species (41.3%) are species of mature, forested habitats, as we have defined them (Table 2). A majority of species of declining neotropical migrants in the Northeast Region (22 species, 75.9%) are species of disturbed or successional habitats (Tables 2 and 4).

For our region, considerable refinement of our interpretations of bird/habitat relationships will result from the Gap Analysis Project of the USFWS (Scott et al. 1991), now underway throughout the northern half of the Northeast Region (New York and New England), and scheduled to be completed for the entire region within five to eight years (possibly sooner). Conclusion of a regional gap analysis will give us a consistent, regionwide scheme of habitat classification, based on remotely sensed landscape imagery, as well as a better idea of the areas of different habitats, their spatial arrangements, and field-validated associations of migratory bird species within those habitats, at a resolution of approximately 30 x 30 meters on the ground. A preliminary scheme of community classification applicable to the Northeast Region will be available from the Eastern Heritage Task Force of The Nature Conservancy by the end of 1993, as part of the Gap Analysis Project. Any application of results from ranking schemes designed to assess status and set management priorities for neotropical migrants and their habitats would be premature for our region before TNC's community classification scheme has been fully tested and implemented.

A provisional, preliminary ranking of neotropical migrants for the Northeast Region, based upon perceptions of their status, is presented in Table 6, using the methods of Hunter et al. (in press). This system uses seven biological and habitat variables to rank and prioritize conservation needs of neotropical migrant species for a defined geographic area. Each of seven variables (global abundance, extent of winter distribution, threats on wintering grounds, extent of breeding distribution, threats on breeding grounds in area of consideration, importance of area of consideration to the species, and population trend in area of consideration) are ranked from one to five for each species, with five representing the highest level of concern. The values then are totalled for a possible high score of 35, and the species are subsequently ordered to identify those of highest concern (Table 6).

We believe that it is especially important to note that this is the first effort to apply the ranking scheme of Hunter et al. over large geographic areas different in character from the southeastern United States. Since the proposed ranking sceme has not been fully peer-reviewed at this time and has had very limited field testing, we offer its application here in a very tentative way, subject to further review and future modification. One difficulty we perceive with the current ranking scheme is that real numerical data, such as that provided by the BBS, are included in the ranking scheme with the same weight as very qualitative judgments that amount to little more than best guesses, given the primitive state of our knowledge of the biology of many of these species, especially their winter distributions and habitat requirements. Another difficulty is that the proposed ranking scheme does not provide for including an absence of information in its process, as currently is being applied in a ranking of migratory bird species of management concern by USFWS, applying a Delphi technique (J. Trapp, pers. comm.). Any ranking scheme should be carefully reviewed and thoroughly tested before it is adopted. In that context, this application of the scheme proposed by Hunter et al. is merely a first test of the approach in the Northeast and will be subject to ongoing modification, evaluation, and refinement. In a preliminary test of the ranking scheme at the Annual Meeting of the Northeast Working Group in November 1992, ten experienced observers were asked to rank five species (Broad-winged hawk, Whip-poor-will, House Wren, Yellow-throated Vireo, and Bobolink). The observers were given trend information from USFWS BBS data analysis and provided with range maps from Rappole et. al. (1983). There was little or no agreement among our observers in the final sums of ranks (column T of Table 6) assigned to these five species. The ranges for sums of ranks assigned to the five species were as follows (ranges in parenthesis): Broad-winged Hawk (14-22), Whip-poor-will (21-27), House Wren (8-16), Yellow-throated Vireo (18-25), Bobolink (13-24). Unfortunately, the scheme proposed by Hunter et al. provides no guidance for reconciling differences among ranks or for assessing the significance of differences among different ranks assigned to the same species by different observers, all of which are experienced observers, familiar with the birds of their region.

In general, we feel that continued scrutiny of the assumptions, strengths, and weaknesses of the route-regression procedure applied to BBS data by the USFWS (Geissler and Sauer 1990) and others is prudent. Confirmation of trends suggested by the route regression method by use of alternative analytical procedures, such as the Mountford method (Mountford 1985) or nonparametric, nonlinear route regression (James et al. 1992), can strengthen our conclusions and lend to their credibility among fellow researchers. Those species with clearly declining population trends, identified by agreement among different analytical procedures, become high priority species for further study. Where they are available and applicable, other databases should be used to cross-check BBS trends. We intend to follow this approach as outlined in our "Research Considerations" document of 30 September 1991 (Appendix A), for the Northeast Region.

We also believe it is important to point out that caution still should be applied in evaluating the population status of neotropical migrants, relying solely upon the BBS database. One of our group (R. O'Connor) is concluding an extensive analysis and evaluation of the BBS database for the Northeast Region and is satisfied that there are inconsistencies in the BBS database that can affect analytical results, thereby affecting management recommendations based on those results. For example, there is some evidence that "poorer" routes (i.e. those with fewer species or individuals) were abandoned by observers during the early years of the survey at a greater rate than "better" routes. Other researchers, using different analytical procedures (Wiedenfeld et al. 1992), also have found regional patterns of population change different from those previously reported. There is a clear need for further discussion and deliberation, with the objective of reaching a clearer consensus among professionals on the statistical procedures and interpretations that can be applied appropriately to the BBS database, or subsets of that database.

At this stage in the Partners in Flight initiative, a challenge before us is to evaluate thoroughly and objectively the nature of the BBS database and analytical procedures that can be applied to it. We should use the same care and precision employed by Chandler Robbins and his associates when the sampling design for the BBS originally was proposed, painstakingly field tested, and carefully peer reviewed. In the "Partners in Flight" initiative, as with other conservation efforts, it is important to be sure that the conservation cart is not in front of the research horse. Otherwise, we risk exaggerating the severity of declines that exist for neotropical migrants and making management recommendations that could be premature or, unfortunately, wrong, causing the credibility of our conservation efforts to be undermined.

Acknowledgments

We would like to thank Réné Borgella, Richard DeGraaf, Carol Foss, and Gary Goff for carefully reviewing various drafts of this manuscript and making numerous suggestions for its improvement. Financial support for parts of this work was provided by Hatch Project No. NYC-147406 , U.S. Department of Agriculture, to C.R. Smith.

Literature Cited

Geissler, P.H. and J.R. Sauer. 1990. Topics in route-regression analysis. Pp. 54-57, in: J.R. Sauer and S. Droege (eds.). Survey Designs and Statistical Methods for the Estimation of Avian Population Trends. U.S. Fish and Wildlife Service, Biological Report 90(1). 166 pp.

Hunter, W.C., M.F. Carter, D.N. Pashley, and K. Barker. In press. Partners in Flight species prioritization scheme--Why do we need a priority scheme and how is one implemented for neotropical migrants?

James, F.C., D.A. Wiedenfeld, and C.E. McCulloch. 1992. Trends in breeding populations of warblers: declines in the southern highlands and increases in the lowlands. Pp. 43-56 in J.M. Hagan, III and D.W. Johnston (eds.), Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, DC. 609 pp.

Mountford, M.D. 1985. An index of population change with application to the Common Birds Census. Pp. 121-132 in: B.J.T. Morgan, and P.M. North (eds.), Statistics in Ornithology. Springer-Verlag, Berlin. 418 pp.

Rappole, J.H., E.S. Morton, T.E. Lovejoy, III, and J.L. Ruos. 1983. Nearctic Avian Migrants in the Neotropics. U.S. Fish and Wildlife Service, Washington, DC. 646 pp.

Scott, J.M., B. Csuti, and F. Davis. 1991. Gap analysis: an application of geographic information systems for wildlife species. Pp. 167-180 in: D.J. Decker, M.E. Krasny, G.R. Goff, C.R. Smith, and D.W. Gross (eds.), Challenges in the Conservation of Biological Resources. Westview Press, Boulder, CO. 402 pp.

Wiedenfeld, D.A., L.R. Messick, and F.C. James. 1992. Population Trends in 65 Species of North American Birds Including Neotropical Migrants, Temperate-zone Migrants, and Resident Species 1966-1990. Final Report to National Fish and Wildlife Foundation, U.S. Fish and Wildlife Service, and U.S. Forest Service. Coastal Plains Institute, 1313 North Duvall Street, Tallahassee, FL 32303. 200 pp.

Table 1. — Northeastern neotropical migrants grouped by population trend from "A" and "B" Lists combined (132 species). AOU = American Ornithologists' Union species number. Oc = Occurrence: B = Breeds and migrates regularly; M = Migrates regularly; W = Winters and migrates regularly. PT = Population Trend in the Northeast Region (breeding species only): 1 = statistically significant increase; 2 = non-significant increase; 3 = no consistent trend; 4 = non-significant decline; 5 = statistically significant decline; NA = Not Applicable; U = Unknown. MS = Migrant Status: L = Long distance; S = Short distance. BH = Breeding Habitat: S = Successional; MF = Mature Forest. Trends are based on route regression analysis of Breeding Bird Survey data (1966-90), or inferred from other available information for species not well represented in the BBS database.

AOU	Species	Oc	PT	MS	BH
6240	Red-eyed Vireo	B	1	L	MF
6270	Warbling Vireo	B	1	L	MF
6290	Solitary Vireo	B	1	L	MF
6550	Yellow-rumped Warbler	B/W	1	S	MF
6570	Magnolia Warbler	B	1	L	MF
6630	Yellow-throated Warbler	B	1	L	MF
6740	Ovenbird	B	1	L	MF
3160	Mourning Dove	B/W	1	S	S
3250	Turkey Vulture	B/W	1	S	S
3370	Red-tailed Hawk	B/W	1	S	S
3560	Peregrine Falcon	B/W	1	L	S
5060	Orchard Oriole	B	1	L	S
5970	Blue Grosbeak	B	1	L	S
6190	Cedar Waxwing	B/W	1	S	S
6520	Yellow Warbler	B	1	L	S
7660	Eastern Bluebird	B/W	1	S	S
4650	Acadian Flycatcher	B	2	L	MF
5950	Rose-breasted Grosbeak	B	2	L	MF
6080	Scarlet Tanager	B	2	L	MF
5970	Prothonotary Warbler	B	2	L	MF
6500	Cape May Warbler	B	2	L	MF
6620	Blackburnian Warbler	B	2	L	MF
6750	Northern Waterthrush	B	2	L	MF
6840	Hooded Warbler	B	2	L	MF
7260	Brown Creeper	B/W	2	S	MF
7590	Hermit Thrush	B/W	2	S	MF

Table 1. — Continued.

AOU	Species	Oc	PT	MS	BH
5980	Indigo Bunting	B	2	L	S
6140	Tree Swallow	B/W	2	S	S
6410	Blue-winged Warbler	B	2	L	S
6790	Mourning Warbler	B	2	L	S
3330	Cooper's Hawk	B/W	3	S	MF
3390	Red-shouldered Hawk	B/W	3	S	MF
3490	Golden Eagle	B/W	3	S	MF
4520	Great Crested Flycatcher	B	3	L	MF
4630	Yellow-bellied Flycatcher	B	3	L	MF
5330	Pine Siskin	B/W	3	S	MF
6100	Summer Tanager	B	3	L	MF
6260	Philadelphia Vireo	B	3	L	MF
6280	Yellow-throated Vireo	B	3	L	MF
6470	Tennessee Warbler	B	3	L	MF
6480	Northern Parula	B	3	L	MF
6610	Blackpoll Warbler	B	3	L	MF
6670	Black-throated Green Warbler	B	3	L	MF
6720	Palm Warbler	B/W	3	L	MF
6850	Wilson's Warbler	B	3	L	MF
7510	Blue-gray Gnatcatcher	B	3	L	MF
2730	Killdeer	B/W	3	S	S
3600	American Kestrel	B/W	3	S	S
4020	Yellow-bellied Sapsucker	B/W	3	S	S
4160	Chuck-will's-widow	B	3	L	S
4280	Ruby-throated Hummingbird	B	3	L	S
5600	Chipping Sparrow	B/W	3	L	S
5610	Clay-colored Sparrow	B	3	L	S
5670	Dark-eyed Junco	B/W	3	S	S
5840	Swamp Sparrow	B/W	3	S	S
6110	Purple Martin	B	3	L	S
6310	White-eyed Vireo	B	3	L	S
6450	Nashville Warbler	B	3	L	S
6810	Common Yellowthroat	B/W	3	L	S

Table 1. — Continued.

AOU	Species	Oc	PT	MS	BH
7030	Northern Mockingbird	B/W	3	S	S
7040	Gray Catbird	B/W	3	L	S
7210	House Wren	B/W	3	L	S
3320	Sharp-shinned Hawk	B/W	4	S	MF
3340	Northern Goshawk	B/W	4	S	MF
3430	Broad-winged Hawk	B	4	L	MF
6390	Worm-eating Warbler	B	4	L	MF
6540	Black-throated Blue Warbler	B	4	L	MF
6580	Cerulean Warbler	B	4	L	MF
6600	Bay-breasted Warbler	B	4	L	MF
6770	Kentucky Warbler	B	4	L	MF
6870	American Redstart	B	4	L	MF
7490	Ruby-crowned Kinglet	B/W	4	S	MF
7560	Veery	B	4	L	MF
2610	Upland Sandpiper	B	4	L	S
3310	Northern Harrier	B/W	4	S	S
3670	Short-eared Owl	B/W	4	S	S
3870	Yellow-billed Cuckoo	B	4	L	S
3900	Belted Kingfisher	B/W	4	S	S
4560	Eastern Phoebe	B/W	4	S	S
4940	Bobolink	B	4	L	S
5070	Northern Oriole	B	4	L	S
5460	Grasshopper Sparrow	B	4	L	S
5830	Lincoln's Sparrow	B	4	L	S
6040	Dickcissel	B	4	L	S
6120	Cliff Swallow	B	4	L	S
6130	Barn Swallow	B	4	L	S
6160	Bank Swallow	B	4	L	S
6170	N. Rough-winged Swallow	B	4	L	S
6380	Swainson's Warbler	B	4	L	S
6590	Chestnut-sided Warbler	B	4	L	S
6730	Prairie Warbler	B	4	L	S
6760	Louisiana Waterthrush	B	4	L	S

Table 1. — Continued.

AOU	Species	Oc	PT	MS	BH
7610	American Robin	B/W	4	S	S
4610	Eastern Wood-Pewee	B	5	L	MF
4670	Least Flycatcher	B	5	L	MF
5170	Purple Finch	B/W	5	S	MF
6[illegible]60	Black-and-white Warbler	B	5	L	MF
6860	Canada Warbler	B	5	L	MF
7550	Wood Thrush	B	5	L	MF
7580	Swainson's Thrush	B	5	L	MF
3880	Black-billed Cuckoo	B	5	L	S
4120	Northern Flicker	B/W	5	S	S
4170	Whip-poor-will	B	5	L	S
4200	Common Nighthawk	B	5	L	S
4230	Chimney Swift	B	5	L	S
4440	Eastern Kingbird	B	5	L	S
4590	Olive-sided Flycatcher	B	5	L	S
4740	Horned Lark	B/W	5	S	S
4950	Brown-headed Cowbird	B/W	5	S	S
4980	Red-winged Blackbird	B/W	5	S	S
5070	Eastern Meadowlark	B/W	5	S	S
5290	American Goldfinch	B/W	5	S	S
5400	Vesper Sparrow	B/W	5	S	S
54[illegible]0	Savannah Sparrow	B/W	5	S	S
5580	White-throated Sparrow	B/W	5	S	S
5810	Song Sparrow	B/W	5	S	S
5870	Rufous-sided Towhee	B/W	5	S	S
6220	Loggerhead Shrike	B/W	5	S	S
6420	Golden-winged Warbler	B	5	L	S
6830	Yellow-breasted Chat	B	5	L	S
7240	Sedge Wren	B/W	5	S	S
7250	Marsh Wren	B/W	5	S	S
6780	Connecticut Warbler	M	NA	L	MF
3570	Merlin	W	NA	L	S
5540	White-crowned Sparrow	W	NA	S	S

Table 1. — Continued.

AOU	Species	Oc	PT	MS	BH
5850	Fox Sparrow	W	NA	S	S
6460	Orange-crowned Warbler	M	NA	L	S
6970	American Pipit	W	NA	S	S
7570	Gray-cheeked Thrush	B	U	L	MF
3660	Long-eared Owl	B/W	U	S	S
4660	Willow Flycatcher	B	U	L	S
4661	Alder Flycatcher	B	U	L	S

Table 2. — Comparison of neotropical migratory bird population trends for 126 species according to two very general habitat types in the Northeast Region. In this context, mature forest is arbitrarily defined as stands 50 or more years old. *-Trend based on a significance level of 0.05, or better.

	Mature Forest	Successional Habitats
Increasing Species*	7 (43.8%)	9 (56.2%)
Decreasing Species*	7 (24.1%)	22 (75.9%)
No detectable change*	38 (46.9%)	43 (53.1%)

Table 3. — Population trends for species associated with mature forests (stands 50 years of age or older) in the Northeast Region. Based on significance level of 0.05, or better.

Increasing Species	Decreasing Species
Solitary Vireo	Eastern Wood-Pewee
Warbling Vireo	Least Flycatcher
Red-eyed Vireo	Swainson's Thrush
Magnolia Warbler	Wood Thrush
Yellow-rumped Warbler	Black-and-white Warbler
Yellow-throated Warbler	Canada Warbler
Ovenbird	Purple Finch

Table 4. — Population trends for species associated with successional habitats in the Northeast Region. Based on significance level of 0.05, or better.

Increasing Species	Decreasing Species
Turkey Vulture	Black-billed Cuckoo
Red-tailed Hawk	Common Nighthawk
Mourning Dove	Whip-poor-will
Eastern Bluebird	Chimney Swift
Cedar Waxwing	Northern Flicker
Yellow Warbler	Olive-sided Flycatcher
Blue Grosbeak	Eastern Kingbird
Orchard Oriole	Horned Lark
	Sedge Wren
	Marsh Wren
	Loggerhead Shrike
	Golden-winged Warbler
	Yellow-breasted Chat
	Rufous-sided Towhee
	Vesper Sparrow
	Savannah Sparrow
	Song Sparrow
	White-throated Sparrow
	Red-winged Blackbird
	Eastern Meadowlark
	Brown-headed Cowbird
	American Goldfinch

Table 5. — Population trends of neotropical breeding birds in the Northeast Region, partitioned by habitat and migratory behavior. Trends are from Table 1.

Number of Species

Wintering Habitat	Increasing		Decreasing		Other		Total
	No. Trends	No. Significant	No. Trends	No. Significant	No Trend	Not known	
Short-distance	9	6	23	15	10	1	43
Long-distance	21	10	37	14	22	3	83
Total	30	16	60	31	32	4	126

Number of Species

Breeding Habitat	Increasing		Decreasing		Other		Total
	No. Trends	No. Significant	No. Trends	No. Significant	No Trend	Not known	
Mature Forest	17	7	18	7	16	1	52
Successional	13	9	42	22	16	3	74
Total	30	16	60	29	32	4	126

Number of Species

Breeding Habitat	Short-distance Migrant	Long-distance Migrant	Total
Mature Forest	11	41	52
Successional	32	42	74
Total	43	83	126

Table 6. — Summary of ranking scores for species of neotropical migrants in the Northeast Region (same as USFWS Region 5). Oc = Occurrence: B = Breeds and migrates regularly; M = Migrates regularly; W = Winters and migrates regularly. GA = Global abundance of species; WD = Winter distribution; TW = Threats on wintering grounds; BD = Breeding distribution; TB = Threats on breeding grounds in area of consideration; IA = Importance of area of consideration; PT = Population trend in area of consideration; T = Total score. BH = Breeding habitat; S = Successional; MF = mature forest. All rankings are on a scale of 1 to 5, with a score of 5 indicating a maximum level of concern for the species. Higher total values indicate a greater level of perceived threat to the species, with 35 the maximum possible score. Only 82 species from the Partners in Flight List "A" are included and species with a score less than 10 are not listed.

Species	Oc	GA	WD	TW	BD	TB	IA	PT	T	BH
Cerulean Warbler	B	4	4	4	4	4	4	4	28	MF
Golden-winged Warbler	B	4	4	4	4	3	4	5	23	S
Swainson's Warbler	B	4	5	4	4	5	1	4	27	S
Wood Thrush	B	2	4	4	3	3	4	5	25	MF
Black-throated Blue Warbler	B	4	4	4	4	3	3	4	28	MF
Blue-winged Warbler	B	3	4	4	4	3	4	2	28	S
Worm-eating Warbler	B	3	4	4	3	2	3	4	23	MF
Chestnut-sided Warbler	B	3	5	4	3	2	2	4	23	S
Black-billed Cuckoo	B	3	4	4	3	2	2	5	23	S
Philadelphia Vireo	B	4	5	4	3	3	1	3	23	MF
Canada Warbler	B	2	4	4	3	3	2	5	28	MF
Louisiana Waterthrush	B	4	3	3	3	2	3	4	22	S
Eastern Wood-Pewee	B	2	4	4	3	2	3	5	22	MF
Bobolink	B	2	4	3	3	4	2	4	22	S
Yellow-throated Vireo	B	3	3	4	3	3	3	3	22	MF
Scarlet Tanager	B	2	4	4	3	3	4	2	22	MF
Blackburnian Warbler	B	3	4	4	4	4	3	2	27	MF
Veery	B	2	3	3	3	3	3	4	21	MF
Prairie Warbler	B	2	4	4	3	2	2	4	21	S
Kentucky Warbler	B	2	4	3	3	3	2	4	21	MF
Bay-breasted Warbler	B	2	5	4	3	2	1	4	21	MF
Whip-poor-will	B	2	3	3	3	3	2	5	21	S
Olive-sided Flycatcher	B	3	3	4	2	3	1	5	21	S
Hooded Warbler	B	3	4	4	3	3	2	2	21	MF
Upland Sandpiper	B	3	3	3	3	4	1	4	21	S
Black-throated Green Warbler	B	3	3	3	3	3	3	3	21	MF
Great Crested Flycatcher	B	2	4	4	3	2	2	3	20	MF

Table 6. — Continued.

Species	Oc	GA	WD	TW	BD	TB	IA	PT	T	BH
Gray-cheeked Thrush	B	3	4	3	3	3	1	3	20	MF
Yellow-bellied Flycatcher	B	3	4	4	3	2	1	3	20	MF
Clay-colored Sparrow	B	3	4	3	4	2	1	3	20	S
Yellow-breasted Chat	B	2	3	3	2	3	2	5	20	S
Acadian Flycatcher	B	2	4	4	3	2	3	2	20	MF
Tennessee Warbler	B	3	4	3	3	3	1	3	20	MF
Northern Parula	B	2	3	3	3	3	3	3	20	MF
Nashville Warbler	B	3	4	3	3	3	1	3	20	S
Yellow-billed Cuckoo	B	3	3	4	2	2	2	3	19	S
Mourning Warbler	B	3	4	3	3	3	1	2	19	S
Prothonotary Warbler	B	3	4	4	3	2	1	2	19	MF
Cape May Warbler	B	3	4	4	3	2	1	2	18	MF
Magnolia Warbler	B	3	3	4	3	3	2	1	19	MF
Swainson's Thrush	B	3	2	3	2	4	1	5	19	MF
Eastern Kingbird	B	2	3	3	2	2	2	5	19	S
Northern Oriole	B	2	3	3	3	3	1	4	18	S
Broad-winged Hawk	B	3	2	3	2	2	2	4	18	MF
Chuck-will's-widow	B	2	3	3	3	2	2	3	19	S
Blackpoll Warbler	B	2	4	3	3	2	1	3	18	MF
Alder Flycatcher	B	2	4	3	3	2	1	3	18	S
Least Flycatcher	B	3	3	2	2	2	1	5	18	MF
American Redstart	B	2	2	3	2	2	3	4	19	MF
Black-and-white Warbler	B	2	2	3	2	2	2	5	19	MF
Ovenbird	B	2	3	3	3	3	3	1	18	MF
Rose-breasted Grosbeak	B	2	3	3	3	3	2	2	18	MF
Willow Flycatcher	B	3	3	3	2	2	2	3	18	S
Grasshopper Sparrow	B	3	3	3	2	2	1	4	18	S
Gray Catbird	B/W	2	3	4	2	4	3	3	18	S
Indigo Bunting	B	1	3	2	3	3	3	2	17	S
Yellow-throated Warbler	B	3	3	3	3	3	1	1	17	MF
Chimney Swift	B	1	3	3	2	1	2	5	17	S
Bank Swallow	B	3	3	2	1	2	2	4	17	S
White-eyed Vireo	B	2	3	3	3	2	1	3	17	S
Solitary Vireo	B	3	3	3	3	2	2	1	17	MF

Table 6. — Continued.

Species	Oc	GA	WD	TW	BD	TB	IA	PT	T	BH
Summer Tanager	B	2	3	3	3	2	1	3	17	MF
Wilson's Warbler	B	3	3	2	3	2	1	3	17	MF
Palm Warbler	B/W	3	3	2	3	2	1	3	17	MF
Purple Martin	B	2	3	3	2	3	1	3	17	S
N. Rough-winged Swallow	B	3	3	2	1	2	1	4	15	15
Peregrine Falcon	B/W	1	1	1	2	3	1	1	16	S
Blue-gray Gnatcatcher	B	2	3	2	2	2	2	3	16	MF
Common Nighthawk	B	2	2	2	1	2	1	5	15	S
Blue Grosbeak	B	3	3	2	2	3	1	1	15	S
Cliff Swallow	B	2	3	2	1	2	1	4	15	S
Ruby-throated Hummingbird	B	2	3	2	2	1	2	3	15	S
Orchard Oriole	B	2	3	3	3	2	1	1	15	S
Warbling Vireo	B	2	3	3	1	3	1	1	14	MF
Northern Waterthrush	B	2	2	3	2	2	1	2	14	MF
Lincoln's Sparrow	B	2	2	2	2	2	1	4	14	S
Barn Swallow	B	1	1	2	1	2	2	4	13	S
Red-eyed Vireo	B	1	3	2	2	2	2	1	13	MF
Chipping Sparrow	B/W	1	2	2	1	2	2	3	13	S
Common Yellowthroat	B/W	1	2	2	1	2	2	3	13	S
Yellow Warbler	B	1	1	2	1	2	2	1	10	S
House Wren	B/W	1	1	1	1	1	2	3	10	S

APPENDIX A

Research Considerations

Northeast Working Group
Neotropical Migratory Bird Conservation Program
"Partners in Flight--Aves de las Americas"

Geographic Area:

The geographic area of concern to the Northeast Working Group of the Neotropical Migratory Bird Conservation Program corresponds to Administrative Region 5 of the U.S. Fish and Wildlife Service. It includes the states of Maine, Vermont, New Hampshire, New York, Massachusetts, Connecticut, Rhode Island, New Jersey, Pennsylvania, Delaware, West Virginia, Maryland, Virginia, and the District of Columbia. These states represent Administrative Regions 1, 2, and 3 of the U.S. Environmental Protection Agency, and parts of the Eastern and Southern Regions of the U.S. Forest Service.

Initial Premises:

In general, the research direction must be determined by the needs of managers for information. In determining management priorities to achieve conservation of neotropical migrants, minimum essential information requirements include knowledge of geographic distributions, population status (trend and/or relative abundance), and habitat associations during the breeding season (Smith 1991). Initial research efforts should be focused upon collecting, evaluating, synthesizing, and reporting information that has the greatest likelihood of answering questions of immediate relevance to setting priorities and affecting policies leading to conservation of neotropical migratory birds in the Northeast. For those species of neotropical migratory birds occurring in the Northeast, it also would be useful to know with accuracy and precision that minimum set of variables that uniquely specifies their individual distributions and abundances in both time and space.

Research Needs (1991-1994):

Achieving the research objectives outlined here will require coordination and collaboration among individual researchers and cooperating agencies at both state and regional levels. In addition, long-term funding will be required from cooperating agencies to support qualified individuals who wish to pursue these research initiatives. The relative responsibilities of the national and regional working groups, especially with respect to funding, need to be clarified. For example, where does the boundary between national and regional research needs lie, and can the Northeastern Working Group assume that needs identified by the National Research Working Group will be addressed somewhere in the country?

Objective 1. From the working list of neotropical migratory bird species (prepared and distributed by the National Research Working Group), identify those species which breed in or migrate through the Northeast.

Objective 2. In general, explicit checking of the assumptions of the route-regression procedure of the USFWS as applied to Breeding Bird Survey (BBS) data (Geissler and Sauer 1990) is desirable. Confirmation of trends suggested by the route-regression method by use of alternative analytical procedures such as the Mountford method (Mountford 1985), and the chain method of the

Common Birds Census of the British Trust for Ornithology (Bailey 1967, Marchant et al. 1990) will strengthen our findings and lend to their credibility among fellow researchers. Those species with clearly declining population trends, identified by agreement among different analytical procedures, become high priority species for further study. Where they are available and applicable, other databases should be used to cross-check BBS trends.

Objective 3. Where it is available, synthesize breeding bird atlas information from each state to prepare maps of breeding season distributions for declining species identified in Objective 2. In spite of differing scales of geographic resolution among the various state atlases, the proportion of all blocks surveyed from which a species is reported as either actually or potentially breeding will provide a first approximation to the distributional ubiquity (O'Connor 1981) of the species for the Northeast.

Objective 4. Integrate results from Objectives 2 and 3 to identify those species with limited distributions (i.e. distributional rarity), low relative abundances (i.e. numerical rarity), and declining population trends as potential candidates for high priority research and management consideration.

Objective 5. Coordinate research efforts with The Nature Conservancy (state natural heritage programs), the USFWS Gap Analysis Program (Scott et al. 1991), and EPA's Environmental Monitoring and Assessment Program (EMAP, Hunsaker and Carpenter 1990) to identify unambiguous bird/habitat associations. A uniform, generalized habitat classification scheme based upon results from Gap Analysis and EMAP could be followed, building upon the work of DeGraaf (1991) and Reschke (1990), with the objective of identifying relatively rare habitats (possibly using TNC ranking criteria) and those bird species clearly associated with those habitats. Those species of birds identified through Objective 4, occurring in rare or threatened habitats identified through Objective 5, become the highest priority species for initial research and management consideration.

Objective 6. Through analysis of remotely-sensed landscape imagery, determine patterns of habitat change over time and the potential effects of such changes upon bird populations at local and regional scales. Use bird/habitat associations identified through Objective 5. Robust (i.e. both accurate and precise), cost-effective, and efficient procedures for estimating breeding densities of terrestrial birds would contribute significantly to assessing regional effects of changing land-use practices on bird populations.

Objective 7. It is especially important to integrate research, monitoring, and management information to address the following question of particular relevance to setting management priorities: Given a declining population trend, believed to be statistically valid, how steep does the rate of decline have to be, for how long a time period, and over how large a geographic area in order to determine that a species should be given high priority consideration for research or management (e.g. listing as a species of management concern, threatened, or endangered by USFWS)?

Objective 8. Through a comprehensive review of published information and existing databases, determine for which species sufficient information exists about population vital statistics (birth rates, death rates, dispersal patterns, and related parameters) to undertake population viability analysis (Shaffer 1991) in the context of Objective 7. Identify efficient and effective protocols for collecting such information for those species for which it is lacking. Current ideas related to population sources and sinks (Pulliam 1988) and metapopulation dynamics (Gilpin and Hanski 1991) could provide useful conceptual models for such research.

Objective 9. Impress upon decision-makers the ongoing necessity of intensive, long-term studies and regional, standardized monitoring of populations to facilitate Objectives 2 through 8. The value of such studies is clearly stated in Likens (1989), with several avian examples in Ralph and Scott (1981) and Hagan and Johnston (in press).

Objective 10. Sponsor a Regional Conference, with invited papers and a promptly published proceedings, to be held during October 1993, to report and evaluate progress toward Objectives 1 through 9, and determine future research directions.

References

Bailey, R.W. 1967. An index of bird population changes on farmland. Bird Study 14: 195-209.

DeGraaf, R.M. 1991. Breeding bird assemblages in managed northern hardwood forests in New England. Pp. 154-171, in: J.E. Rodiek and E.G. Bolen (eds.). Wildlife and Habitats in Managed Landscapes. Island Press, Washington, DC. 220 pp.

Geissler, P.H. and J.R. Sauer. 1990. Topics in route-regression analysis. Pp. 54-57, in: J.R. Sauer and S. Droege (eds.). Survey Designs and Statistical Methods for the Estimation of Avian Population Trends. U.S. Fish and Wildlife Service, Biological Report 90(1). 166 pp.

Gilpin, M. and I. Hanski. 1991. Metapopulation dynamics: empirical and theoretical investigations. Biological Journal of the Linnaean Society (London), vol. 42, nos. 1 and 2. 336 pp.

Hagan, J.M. and D. Johnston (eds.). In press. Proceedings of the Symposium on Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, DC.

Hunsaker, , C.T. and D.E. Carpenter (eds.). 1990. Ecological Indicators for the Environmental Monitoring and Assessment Program. EPA 600/3-90/060. U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC.

Likens, G.E. (ed.). 1989. Long-Term Studies in Ecology--Approaches and Alternatives. Springer-Verlag, New York. 214 pp.

Marchant, J.H., R. Hudson, S.P. Carter, and P. Whittington. 1990. Population Trends in British Breeding Birds. British Trust for Ornithology, Beech Grove, Tring, Hertfordshire, UK. 300 pp.

Mountford, M.D. 1985. An index of population change with application to the Common Birds Census. Pp. 121-132 in: B.J.T. Morgan, and P.M. North (eds.), Statistics in

Ornithology. Springer-Verlag, Berlin. 418 pp.

O'Connor, R.J. 1981. Comparisons between migrant and non-migrant birds in Britain. Pp. 167-195, in: D.J. Aidley (ed.), Animal Migration. Cambridge University Press, 264 pp.

Pulliam, H.R. 1988. Sources, sinks, and population regulation. American naturalist 132: 652-661.

Ralph, C.J. and J.M. Scott (eds.). 1981. Estimating Numbers of Terrestrial Birds. Studies in Avian Biology No. 6, Cooper Ornithological Society. 630 pp.

Reschke, C. 1990. Ecological Communities of New York State. New York Natural Heritage Program, NYS Department of Environmental Conservation, Latham, NY. 95 pp.

Scott, J.M., B. Csuti, and F. Davis. 1991. Gap analysis: an application of geographic information systems for wildlife species. Pp. 167-180 in: D.J. Decker, M.E. Krasny, G.R. Goff, C.R. Smith, and D.W. Gross (eds.), Challenges in the Conservation of Biological Resources. Westview Press, Boulder, CO. 402 pp.

Shaffer, M.L. 1991. Population viability analysis. Pp. 107-118, in: D.J. Decker, M.E. Krasny, G.R. Goff, C.R. Smith, and D.W. Gross (eds.), Challenges in the Conservation of Biological Resources. Westview Press, Boulder, CO. 402 pp.

Smith, C.R. 1991. Challenges in the conservation of biological resources: an epilogue. Pp. 367-376, in: D.J. Decker, M.E. Krasny, G.R. Goff, C.R. Smith, and D.W. Gross (eds.), Challenges in the Conservation of Biological Resources. Westview Press, Boulder, CO. 402 pp.

Monitoring Neotropical Migrants on Managed Lands: When, Where, Why

Sam Droege[1]

Abstract — Relevant wildlife monitoring on managed lands lies somewhere between monitoring everything and monitoring nothing. Knowing the population status of all birds on a managed area would be potentially useful information but would be costly to collect, but without monitoring no link between management and wildlife populations can be made. A decision making process for developing appropriate monitoring programs on managed lands is outlined.

INTRODUCTION

Monitoring for the manager is a means of assessing consequences of management activities. Monitoring needs are shaped primarily by management goals for the area. Details of any monitoring program should take into account management priorities, regional monitoring programs, the type of feedback information necessary to assess management activities, and the resources available to conduct monitoring surveys.

This paper outlines a decision making process that can be used to develop bird surveys on managed lands. This process focuses on needs of managers and not groups who monitor birds with regional, state, or national mandates to monitor birds as, for example, under the requirements of the Fish and Wildlife Conservation Act and Resources Conservation Act or for the purposes of setting wildlife hunting regulations.

Management Objectives

While monitoring programs can be developed for all species of birds, such a comprehensive system would be exceptionally expensive. Consequently, monitoring is most appropriate for species with active management objectives. Since each management objective involves a unique suite of biological, economic, and political factors monitoring programs may need to be developed separately for each objective.

[1]U.S. Fish and Wildlife Service, OMBM, Laurel, MD 20708, USA.

Management's role in controlling population numbers

If management activities have little impact upon populations of birds using an area, then there is little need for the manager to develop a monitoring program for those species. Monitoring birds during migration is often an example of such a situation. In most instances, neotropical migrants will use a broad range of habitats during migration. Consequently, no special effort in most regions is needed to manage habitat for such migrants. Information on population increases or decreases could be readily collected, however, such information would not be used to modify local activities and would needlessly consume staff time.

While it may not be in the manager's best self-interest to collect monitoring information on bird populations not directly tied to local management goals, there are a number of national and regional monitoring programs that may have or need sampling stations on their property. Programs such as the North American Breeding Bird Survey, and the Monitoring Avian Diversity and Productivity Program provide important early warning signals for declines in a broad range of species. These programs allow conservationists to determine if population declines in species' populations are occuring throughout a species ranage or are merely local. To effectively collect such data over broad geographic ranges these programs depend upon volunteer and agency support. Consequently, monitoring activities by such outside groups should be encouraged and facilitated.

If, as is often the case, management activities have potential to significantly affect the distribution and abundance of birds using the area, then some form of population monitoring is warranted. Prior to the search for the most appropriate monitoring techniques, the relationship between local populations on the management area and regional populations must be considered.

Birds are affected by changes that occur both on the managed area and in the surrounding landscape. Cover, water, and food conditions of the surrounding area influence the number of birds present within the management area. For neotropical migrants, factors during the time of year spent away from the management area could have a greater controlling influence on population numbers present than local management activities do.

Populations of birds that commute seasonally or daily outside of management areas are influenced both by local management activities and by factors outside that area. The percentage of the population using an area at any moment is influenced by the size of the overall regional population and environmental conditions both on and off the management area. Under such circumstances, without additional information on regional populations, surveys conducted only on the management area can yield misleading interpretations of the success of an area's management program for that species.

Regional information on bird populations often exists in accessible, summarized formats. Programs such as the North American Breeding Bird Survey, National Audubon Christmas Bird Counts, and now a number of other state, provincial, and federal programs all attempt to estimate regional population trends. Population trends from the North American Breeding Bird Survey can be obtained from Bruce Peterjohn, USFWS, Laurel, MD 20708. Christmas Count data are published in **American Birds** and computerized data can be obtained from this author. Regional population trends, compiled from many sources, are available for neotropical migrants from each of the regional Partner's in Flight management groups. Each of the regional management groups have also developed schemes for neotropical migrants that rank each of the species in the region by regional vulnerability and conservation need.

Ultimately, monitoring information will be used by the manager to assess how well populations are doing on the managed area and whether such population changes warrent shifts in management activities. To do so will require, in most cases, the evaluation of not just local population trends are on the managed area, but regional and continental population trends. For example, population trends of Red-eyed Vireos may have declined by 50% over a 10-year time period on a local management area. Does such a decline warrent a management response? Maybe. It will depend upon the answers to a number of questions such as: Are Red-eyed Vireos a species of management importance to the local manager? Are Red-eyed Vireos declining regionally? Are they declining continentally? Are Red-eyed Vireos an abundant, ubiquitous species in that region or are they scarce as hen's teeth? Are the factors causing the declines likely to be located in the breeding area or in the wintering area? The answers to such questions will influence decisions regarding when to take management action.

In some instances regional information on population status of birds is non-existent or of insufficient detail. New regional surveys can be instigated by coordinating with other regional Partners in Flight groups (especially the Monitoring Working Group), state, provincial, federal, and private groups interested in developing better information for those same bird species. Alternatively, it may be sufficient to add additional sampling points to existing survey programs.

While such surveys may provide useful general information on the regional population trends of species using managed areas, some level of monitoring must occur on the site to put into perspective the role that site has in maintaining regional population levels.

Local Monitoring Strategies

Intensity of effort

Accurate and precise estimates of population size or trend can be developed for any species or group of species. However, as statistical rigor increases so do costs. Budgetary constraints will require that some compromise be made between statistical robustness and cost. In many situations statistically rigorous techniques are not required. Those situations occur when populations exhibit long-term stability, there are no obvious population threats, management techniques are tested and effective, and when management has little potential to change that site's population status.

The appropriate monitoring intensity for each species/group/habitat fall largely into levels listed below.

1. No Monitoring - Those species/groups/ habitats not currently on the management list. Note, however, that the manager is faced by the dilema of ever changing mangement lists and changes in the relative conservation problems a species faces over time. Common species today can become the species of management concern tommorrow (e.g., would you have put the Passenger Pigeon on your list of speices of managment concern in the early 1700's?). The ultimate solution is to collect information on all species. Unfortrunately, fiscal responsibility dictates the setting of monitoring priorities and that some species will have to remain unmonitored. While complex monitoring programs cannot be developed for all species, a basic inventory list of the species occurring within the mangement region is an ideal project for bird-watching clubs.

2. Low Intensity Monitoring - The species/groups/habitats in this group need only periodic checks on their status due to past stability, large current population size, or low potential for management to affect change in population status. Such monitoring can consist of yearly checks (e.g., local bird watchers report that all the woodland warblers are still present during the breeding season in the management area) or longer cycles of more intensive counts (e.g., Wood Thrush nest success checked every 5 years, cowbird surveys every 3 years).

3. High Intensity Monitoring - For a small group of species/groups/habitats a relatively high intensity monitoring system must be implemented because abrupt changes in population status can occur and management activities may control the species' short- and long-term survival (e.g., Kirtland's Warbler, Golden-winged Warbler).

Identifying management trigger points

One way to think about determining the level of intensity of monitoring necessary for a species is for the manager to ask: Under what circumstances will I react to changes in population status of a species? If the manager is unlikely to take any action to indications of changes in population status, then monitoring birds is superfluous. If a manager reacts only to major changes, then quick and dirty look-sees are usually most appropriate. If management has to respond quickly to changes in distribution or abundance of species, then a monitoring program that yields a good estimate of population status is required.

For each survey, even the quick and dirty type, it is important to outline before the survey begins what types of changes will trigger a response by the group managing those lands (e.g., How big a drop in numbers can be tolerated before further actions or investigations are warranted?).

If the monitoring measures of population status are coarse, changes in population status can trigger greater monitoring effort to confirm that a problem indeed exists. In situations where the current monitoring technique is already yielding precise and accurate estimates, changes in local and regional population numbers should cause direct management actions.

Choice of monitoring techniques

Once species to monitor have been chosen and an appropriate monitoring intensity determined, the process of choosing the best monitoring technique can begin. In practical terms, the best technique will be those techniques that yield an adequate estimate of the species' population size at the lowest cost.

For species/groups/habitats measured at low monitoring intensity, the traditional look-see approach is usually adequate. Specific information collected will vary with species and circumstance. For example, if scrub-nesting birds are managed, some guage to status and numbers can be garnered from area checklists collected by local birdwatchers and from sightings by staff during working hours. If there are a number of heronries on site (not neotropical landbirds, but close enough), a check during the peak breeding season for signs of activity may be sufficient. In the course of collecting such measures, consideration should be given whether information coming in is representative of the population as a whole or only of isolated subpopulations.

For detailed surveys, repeated only at intervals of several years, and more intense level surveys needed for fine-tuned management systems, greater consideration must be given to the statistical techniques employed. The species, geography area to be surveyed, habitat, levels of precision, and number and type of individuals available to collect information all must factor into selection and development of a monitoring program. To establish the optimal sampling scheme and monitoring techniques for the species and situation the manager should consult with regional monitoring experts and especially involve statisticians during the development phase. The Partner's in Flight Monitoring Working Group is another source of statistical consultation.

Development of statistical sampling protocols and monitoring techniques has become quite technical. Cookbook solutions are difficult to apply to the spectrum of situations that a local manager will confront. The manager should take responsibility for making decisions regarding the species and intensity of monitoring most appropriate for their situation, but it will usually require statistical consultation to translate those needs into methods, sampling schemes, and analyses most optimal for the situation and budgetary constraints faced by the manager.

ACKNOWLEDGEMENTS

I would like to thank the many National Wildlife Refuge managers for their feedback during development of these ideas. I would like to specially thank Barry Noon, John Sauer, and Cherry Keller for providing many of the ideas that I have openly plagiarized. Thanks also go to Debbie Finch and Peter Stangel for reviewing this paper.

Overview of National Bird Population Monitoring Programs and Databases

Gregory S. Butcher[1], Bruce Peterjohn[2], and C. John Ralph[3]

Abstract — A number of programs have been set up to monitor populations of nongame migratory birds. We review these programs and their purposes and provide information on obtaining data or results from these programs. In addition, we review recommendations for improving these programs.

INTRODUCTION

Management action to protect wildlife requires good information on status and trends of wildlife species that need protection. Some try to shortcut the process by monitoring the status and trends of habitats, assuming that if habitat is intact, then all wildlife species preferring that habitat will be protected. However, a number of factors can cause one or more wildlife species to disappear from appropriate habitat, including disease, predation, weather extremes, lack of food, and subtle habitat deterioration. In addition, migratory birds can disappear from appropriate habitat due to problems during seasons when the species is away from the habitat under consideration. Thus, the Monitoring Working Group of Partners In Flight strongly recommends that managers have access to current information on status and trends of all birds under their jurisdiction.

In their Needs Assessment (Butcher 1992), the Monitoring Working Group made a number of recommendations to improve monitoring of birds in North America: (1) improve the Breeding Bird Survey (BBS), (2) establish a national system of habitat-specific point counts, (3) establish a new system to monitor northern-breeding species during migration (especially birds breeding in the boreal forests of Canada and Alaska), (4) improve analysis of hawk migration counts, (5) include neotropical migrants in contaminants monitoring programs, (6) analyze constant-effort mistnetting and nest searching to evaluate their validity as indices of reproductive and survival rates, and (7) analyze banding data to link wintering and breeding grounds and to determine survival rates.

Monitoring bird habitats was considered just as important as monitoring bird population levels. Specific recommendations included: (1) summarize what is already known about avian habitat requirements, (2) identify habitat types important to birds but not currently monitored, (3) compare bird trends to trends of their required habitats, (4) identify species most likely to be limited by a particular habitat, (5) for these species, determine the effect of management practices on suitability of their habitat and determine status and trends of limiting habitat, (6) create a common vocabulary of habitats that corresponds with management activities, (7) monitor habitats along BBS routes, and (8) study effect of land use practices (human activities in addition to habitat) on bird populations.

Much more monitoring will be required on government lands; this will require a compromise between quantity and quality of information collected and cost. It is vital that all agencies inventory their lands to measure presence, distribution, and relative abundance of neotropical migrants in specific habitats in all seasons. Inventory and monitoring should be linked to specific management activities that might affect migrants. Some recommendations are: (1) 50% of all monitoring should be systematic, encompassing all habitat types and all bird species, (2) 25% of monitoring effort should be allocated to rare habitat types and rare bird species, (3) 25% of monitoring effort should be allocated to studies of reproductive and survival rates, (4) monitoring should emphasize breeding season first, wintering season second, and migration season third, (5) some effort should be spent to determine importance of particular areas as migration stopover sites, (6) states should be involved in monitoring, (7) the Monitoring Working Group should collate information on costs of running various monitoring schemes, and (8) a National Interagency Data Center for monitoring information should be formed to which all participants in Partners In Flight should contribute.

[1]*Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca NY 14850; Current Address: American Birding Association, P.O. Box 251, Etna NY 13062.*

[2]*Breeding Bird Survey, Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Laurel MD 20708.*

[3]*USDA Forest Service, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata CA 95521.*

Partners In Flight is an international program, and a tremendous need exists for monitoring both birds and their habitats south of the United States border. Specific recommendations include: (1) coordinate bird monitoring with existing biodiversity conservation programs, (2) fund local scientists to do training and fieldwork, (3) promote long-term relationships between U.S.-based and local scientists, (4) determine objectives and priorities of a coordinated international monitoring program for migratory birds and endemics, (5) monitor habitats using remote sensing and GIS techniques, (6) combine bird and habitat information to extrapolate effects of habitat change on wintering bird populations and endemics, (7) promote local analysis of remote sensing data, (8) promote habitat-specific point counts as a major bird monitoring technique, (9) teach local observers to identify birds by sight and sound, (10) promote mistnetting as a major bird monitoring technique, (11) establish bird banding protocols for Latin America and the Caribbean, preferably in cooperation with the U.S. Bird Banding Laboratory, (12) seek sources of long-term funding, but support short-term projects if long-term funding is not available, (13) plan a series of meetings south of the U.S. border to promote monitoring, and (14) prepare a bird monitoring handbook for Latin America and the Caribbean that addresses both migratory birds and endemics.

In addition to the many recommendations for monitoring, the Needs Assessment provided a theoretical perspective on monitoring, reviewed major bird and habitat monitoring programs in North America, provided a bibliography of habitat classification schemes for North America, provided a comparison of the kinds of data collected using a variety of bird monitoring techniques, and provided a preliminary list of high priority species.

The Needs Assessment was prepared under the auspices of Partners In Flight by participants at the Monitoring Working Group meeting in Arlington, Virginia, on September 4 & 5, 1991. Revisions were suggested by many of the participants and a few others through April 15, 1992. Meeting participants were divided into five subgroups: Monitoring Theory and Practice, North American Bird Monitoring, North American Habitat Monitoring, Agency-specific Bird Monitoring, and International Monitoring. Each group was asked to identify goals, describe existing programs and problems, and identify research needs and recommendations.

The Monitoring Working Group will continue, and many issues will be revisited. Thus, the group welcomes comments and suggestions for revision. Please direct these comments to the Chair of the group, Greg Butcher, American Birding Association, P.O. Box 251, Etna NY 13062, (607) 254-2412, FAX: (607) 254-2441, or to another member of the Working Group.

Many states and agencies are implementing new point count programs. It is hoped that a new national data center will be organized to store point count and other data. Contact the author or other representatives of the Monitoring Working Group for progress reports.

Many states have special research and monitoring programs for birds. Contact the Nongame Program of the state fish and wildlife agency, or contact Naomi Edelson, International Association of Fish and Wildlife Agencies, 444 North Capitol Street, Suite 534, Washington DC 20001.

Many states have also implemented a Computerized Fish and Wildlife Information System covering individual species and their characteristics. Information on these databases can be obtained from the Fish and Wildlife Information Exchange, 2206 S. Main Street, Suite B, Blacksburg VA 24060. The exchange also has a number of national databases, including the BBS, endangered species information system, and marine and coastal species information system. New databases are being acquired by the Exchange.

NORTH AMERICAN BIRD MONITORING

Goal Statement

To identify a suite of data collection methods and analytical techniques that would adequately monitor populations of all neotropical migrant species in every geographic region of the continent, and would monitor demographics of a select group of neotropical migrant species in all regions of the continent.

Existing Programs

This subgroup identified a number of existing survey programs that have potential to contribute to a national monitoring scheme. These programs fit into two major categories: those measuring population trends and those measuring demographic parameters.

I. Population Trends.

A number of international and national programs provide information on population trends. They can be classified into four groups based on sampling procedure used to obtain data: point counts, spot-mapping, area searches, and banding.

A. Point counts

1. Breeding Bird Survey (BBS)
   a. Purpose: To monitor populations of North American breeding birds.
   b. Geographic extent: North America (United States and Canada).
   c. Resolution: 1-16 routes per degree block of latitude and longitude.
   d. Frequency: Once per year.
   e. Methods: Randomly placed roadside counts throughout North America. Each route is run once during the breeding season, and consists of 50 3-minute point counts spaced 1/2 mile apart. 3500 routes total, about 2200 run each year, all done by volunteers.
   f. Availability and form of data: Data available in many forms to researchers with no charges; summaries of population trends printed regularly.
   g. Status: Ongoing, 1966-present.
   h. Contact: Bruce Peterjohn, FWS, Breeding Bird Survey, Laurel, MD 20708, (301) 498-0330, FAX: (301) 497-6335.
   i. Cooperators: Joint venture between Canadian Wildlife Service (CWS), FWS, state/provincial coordinators, and thousands of volunteers.

2. Forest Bird Monitoring Program
   a. Purpose: To determine species of birds breeding in forest stands of known vegetation and in a known landscape.
   b. Geographic extent: Ontario, similar projects in Vermont and Connecticut.
   c. Resolution: Single unlimited distance point counts, grouped by five points to cover a forest stand of about 25 hectares.
   d. Frequency: Each point is visited twice per year.
   e. Methods: Unlimited distance point counts.
   f. Availability and form of data: Contact Dan Welsh (address under h.).
   g. Status: Ongoing since 1987.
   h. Contact: Dan Welsh, CWS, 49 Camelot Drive, Nepean, Ontario, CANADA, K1A 0H3, (613) 952-2405.
   i. Cooperators: CWS and volunteers.

3. Hawk Migration Counts
   a. Purpose: To monitor populations of diurnal raptors as they fly by particular locations chosen for good visibility or for possibility that migrant raptors are concentrated at those sites.
   b. Geographic extent: Most sites are in eastern U.S., although more western sites are being added each year.
   c. Resolution: Unknown.
   d. Frequency: Some sites covered daily during spring or fall migration seasons; many sites covered each weekend during migration; others covered sporadically.
   e. Methods: Most hawkwatch sites have a single official counter each day; some sites have one or a few individuals for an entire season. Counters mostly observe with naked eye and binoculars.
   f. Availability and form of data: Data published in Hawk Migration Studies, the journal of the Hawk Migration Association of North America (HMANA). Many sites fill out standard HMANA forms; data from some sites have been computerized.
   g. Status: Many sites ongoing; Hawk Mountain counts date back more than 50 years.
   h. Contact: Seth Kellogg, 377 Loomis Street, Southwick MA 01077; Steve Hoffman, Western Foundation for Raptor Conservation, Box 304, Albuquerque NM 87103; Hawk Mountain, Route 2, Kempton PA 19529.
   i. Cooperators: FWS, many others.

B. Spot-mapping

1. Breeding Bird Census (BBC)
   a. Purpose: To determine population densities of breeding birds in specific habitats.
   b. Geographic extent: North America (United States and Canada).
   c. Resolution: Plots of 10-200 hectares, chosen by local observers.
   d. Frequency: Most sites censused only once; a few have been done for 50+ years.
   e. Methods: Each year more than 100 BBCs are done on plots of uniform vegetation. The BBC uses spot-mapping method, which requires at least eight visits to a study site during the breeding season (Anonymous 1970). Many BBCs are accompanied by quantitative vegetation studies (James and Shugart 1970, James 1978).
   f. Availability and form of data: A computerized database exists of more than 4,000 BBCs dating back to 1937. BBCs published each year in Supplement to Journal of Field Ornithology; previous years published in publications of National Audubon Society.
   g. Status: Ongoing, 1937-present.

h. Contact: Sam Droege, Office of Migratory Bird Management, Patuxent Wildlife Research Center, Laurel MD 20708, (301) 498-0940.
i. Cooperators: Association of Field Ornithologists (publisher of supplement), National Audubon Society (original sponsor of BBC program).

C. Area searches
1. Breeding Bird Atlases (BBAs)
a. Purpose: To determine distribution and reproductive status of breeding birds.
b. Geographic extent: 28 U.S. states and seven Canadian provinces have completed or will soon complete atlas projects (Smith 1990).
c. Resolution: Varies by state, often blocks that are three miles by three miles, occasionally one latilong (one degree of latitude by one degree of longitude).
d. Frequency: Most BBAs are five-year projects; some have suggested that atlases should be repeated perhaps 20 years later, but no North American atlas has yet been repeated.
e. Methods: Volunteers go out into an atlas block during the height of breeding season, seeking evidence of breeding. Evidence ranges from "possible" through "probable" to "confirmed" breeding (adult feeding young, nest with eggs, etc.). Some but not all atlases include quantitative methods to estimate abundance of breeding birds. See Smith (1990) for details.
f. Availability and form of data: Varies by state and province. Most atlases are fully computerized, but may be difficult to access once atlas is completed.
g. Status: Varies by state and province. Many completed in the past few years; rest will be completed in next few years.
h. Contact: Most recent list of contacts by state and province is available from Sally Laughlin, North American Ornithological Atlas Committee, P.O. Box 157, Cambridge VT 05444, (802)644-5651, for $2.
i. Cooperators: Most atlases have been cooperative ventures between the state wildlife department and the state bird club, often with a variety of other cooperators.

2. Audubon Christmas Bird Count Database (CBC)
a. Purpose: Count: To provide a forum to express recreational and conservation interest in birds during the winter holiday season. Database: To monitor population dynamics of North American birds in winter.
b. Geographic extent: 1,600 locations in North America, Hawaii, West Indies, Mexico, and Central America.
c. Resolution: 15-mile diameter circles.
d. Frequency: Once per year.
e. Methods: A variety of methods are used to collect data; most frequent methods include travel by foot or motorized vehicle during the day and night and counting birds at feeders by stationary observers (Butcher 1990). Most analyses control for effort when comparing numbers of birds through space or time (Bock and Root 1981, Butcher and McCulloch 1990).
f. Availability and form of data: Data published by National Audubon Society as an issue of American Birds. Data available from the FWS database by species or by count location on paper or in a computer file.
g. Status: Ongoing, 1900-present. Database: 1960-89; FWS may add more recent years and Latin American locations.
h. Contact: Count Organizer: Geoff LeBaron, American Birds, 950 Third Avenue, New York NY 10022, (212) 546-9191. CBC Database: Sam Droege, Office of Migratory Bird Management, Patuxent Wildlife Research Center, Laurel MD 20708, (301) 498-0940.
i. Cooperators: Count: Leica, most state and local bird clubs in North America. Database: John Shipman, Carl Bock, Terry Root, National Audubon Society, Cornell Lab of Ornithology.

* Banding programs will be considered in the next section, since banding allows collection of demographic data in addition to population levels.

II. Demographic Information.

At present, only three sampling procedures provide demographic information on bird populations: mistnetting, nest monitoring, and bird banding.

A. Mistnetting
1. Monitoring Avian Productivity and Survival (MAPS)
a. Purpose: To use constant effort mistnetting to provide annual regional estimates of post-fledging productivity, adult survivorship, recruitment into adult population, and adult population size for both resident and neotropical migrant landbird species.
b. Geographic extent: North America (U.S. and Canada).

c. Resolution: MAPS sites cover about 10 hectares.
d. Frequency: One to ten days during 12 10-day periods from May through August; repeated annually.
e. Methods: MAPS uses standardized, constant-effort mistnetting during breeding season at a continent-wide network of stations. It uses methods pioneered in Great Britain (Baillie et al. 1986, Baillie and Holden 1988, Peach and Baillie 1989, 1990, Peach 1991, Ralph et al. 1992).
f. Availability and form of data: Contact David DeSante (see address under h.).
g. Status: Ongoing since 1989.
h. Contact: David F. DeSante, The Institute for Bird Populations, P.O. Box 1346, Pt. Reyes Station CA 94956, (415) 663-1436.
i. Cooperators: FWS, FS, NPS, numerous state agencies and private organizations, many individual bird banders.

B. Nest Monitoring

1. Breeding Biology Research Database (BBIRD)
   a. Purpose: To use nest monitoring to measure breeding productivity in microhabitats and across broad geographic regions.
   b. Geographic extent: Program currently active in Arizona, Arkansas, California, Idaho, Utah, Texas, Minnesota, Ohio, New York, Missouri, and North Carolina; it could potentially operate throughout North America.
   c. Resolution: 50 hectare study plots.
   d. Frequency: Intensive nest searching throughout breeding season; nests revisited every 3-4 days.
   e. Methods: Finding and revisiting bird nests, recording number of eggs and young birds in nest during each visit; plus series of point counts.
   f. Availability and form of data: Contact Tom Martin (see address under h.).
   g. Status: Ongoing in 11 states.
   h. Contact: Tom Martin, Arkansas Cooperative Fish and Wildlife Research Unit, Biological Sciences SCEN 632, University of Arkansas, Fayetteville AR 72701, (501) 575-6709, FAX: (501) 575-4010.
   i. Cooperators: State Coop Units.

2. Nest Record Program (NRP)
   a. Purpose: To determine nesting habitats, nesting seasons, clutch size, incubation and nestling periods, and nesting success rates for North American birds.
   b. Geographic extent: 49 continental United States; there are six regional Canadian nest record schemes.
   c. Resolution: Single nest sites, plus habitat in immediate vicinity.
   d. Frequency: Half the nests are revisited once or twice per week.
   e. Methods: Finding and revisiting bird nests, recording the number of eggs and young birds in nest during each visit.
   f. Availability and form of data: All data available as xeroxed 4x6 cards; about half data on computer. Fee charged to defray retrieval costs.
   g. Status: Ongoing, 1965-present
   h. Contact: Pixie Senesac, Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca NY 14850, (607) 254-2416, FAX: (607) 254-2415.
   i. Cooperators: Nebraska Ornithologists Union, Brooks Bird Club, Michigan Audubon Society, Detroit Audubon Society, Kalamazoo Nature Center, Iowa Nongame Program, Upstate New York Bluebird Society, other bird clubs and individuals.

C. Bird Banding

1. Bird Banding Laboratory (BBL)
   a. Purpose: To organize and regulate bird banding permitting process in North America, especially for information on migration, movement, survival, and population status of species. Estimates of survival cannot be calculated from nongame banding information currently collected by BBL. However, some individual banders do collect that information and can be reached through BBL. BBL does not currently encourage routine collection, dissemination, and analysis of recapture and return data (see below).
   b. Geographic extent: North America (U.S. and Canada).
   c. Resolution: Uncertain.
   d. Frequency: Variable.
   e. Methods: Most birds captured with mistnets; many captured in a variety of traps. Birds banded with metal leg bands; many color-marked with plastic leg bands or by other means.
   f. Availability and form of data: Bird banding data available on computer from BBL.
   g. Status: Ongoing since the 1920s.
   h. Contact: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel MD 20708, (301) 498-0423.

i. Cooperators: CWS, three regional bird banding associations (Eastern, Inland, and Western), and a number of state and provincial associations.

A number of federal, state, and private agencies, as well as citizens, have developed (or are developing) smaller scale programs to monitor bird populations on their lands. We urge these people to adopt standard methods recommended by this working group and to contribute their data to the proposed National Data Center.

Actions to be Taken

Most programs listed above are undergoing statistical evaluation. Thus final recommendations for a system of nationwide monitoring programs cannot be made until those evaluations are complete. However, enough is known to recommend several items for immediate action.

Population Trend Monitoring Programs

Improve the Breeding Bird Survey (BBS). The BBS should continue to monitor roadside bird populations under direction of FWS and CWS. This program needs to be expanded in regions currently inadequately covered, especially portions of Canada and the western U.S. Increased cooperation and coordination with various federal and state agencies and private groups will be necessary to cover these remote areas. Responsibility for coverage of BBS routes located on federal or state lands should be that of the agency that manages that land. The critical agencies will be BLM and FS in the West and BLM, NPS, FS, and state in Alaska. On lands controlled by Native Americans, surveys should be coordinated through their natural resources group. Increases in coverage began during the 1992 field season and should continue in 1993.

Two potential biases have been identified that could compromise the meaning of population trends calculated from BBS data. Overcoming these biases will require two major actions:

Improve Coverage of North America. BBS statisticians estimate that over 80% of all neotropical migrants whose breeding range is primarily in the United States are adequately surveyed by the BBS. For some species, however, the BBS monitors only a portion of the species' entire range; core populations of many of these species are under-represented or entirely missed by BBS coverage. Boreal breeders and species whose range is primarily Mexican are two groups poorly surveyed by BBS. BBS trends for these species are not representative of the species as a whole. Presentation of "continental" BBS trend data must be qualified to factor in the match between surveyed and unsurveyed portions of species ranges.

Study the bias caused because BBS is a roadside survey. Since BBS is a roadside survey, roads are over-represented by definition. Boreal areas of Canada and Alaska and the arid lands of the western U.S. all have vast roadless areas that cannot be represented by this system. Within paved areas, the bias varies with region and hasn't been quantified. However, habitats such as peatlands, marshes, and alpine areas are probably under-represented by BBS.

While most common bird species may not occur on BBS routes in proportion to their population size, they almost always occur in sufficient numbers to calculate population trends. If population trends along roads do not mirror population trends away from roads, then roadside bias is a problem. We suggest that research into roadside bias of trends be made a high priority by agencies that use information from roadside surveys. Some work in this area is underway (e.g., R. Hutto, C. Keller and M. Fuller, R. O'Connor).

Develop a system of habitat-specific point counts to complement BBS. This system would use point counts both on and off roads. We envision the following framework:

Many details of point count methodology were worked out at the point count workshop in November of 1991. However, a sampling framework needs to be developed. Preferably, the program would be integrated and managed within EPA's EMAP system. A Canadian counterpart to EMAP sampling frame could be developed. Data would be stored at a single interagency data center where it would be analyzed and disseminated to managers and researchers.

The multiscale data collection system would be hierarchical. Information collected by governmental agencies, private organizations, and individuals would be standardized and could be recombined at different scales with the system maintained within EMAP. In this manner, local monitoring projects could provide data that would become valuable at a regional or national level.

Habitat information would be collected at each site through both remote sensing analysis and point sampling techniques.

If widely adopted in the U.S. and Canada, this program would eliminate many deficiencies associated with BBS coverage (possible roadside bias in habitat sampling or in bird sampling, lack of habitat-specificity in analyses). The EMAP scheme within the U.S. could provide a good portion of the sampling framework and logistical support. However, directly surveying boreal Canada will be expensive.

Conduct a workshop on monitoring during migration. Bird populations breeding in boreal habitats are unlikely ever to be monitored on the breeding grounds. Migration banding stations provide an opportunity to monitor these populations as they move north or south. While many migration banding stations exist, little has been done to systematically evaluate potential of these data for calculating trends. CWS is currently funding a summary of current status of migration monitoring stations. We suggest a workshop be held in 1992 or 1993 to evaluate potential of these stations and to look at ways to validate population indices derived from migration counts. After the workshop, validation studies should be funded to experiment with methods and to determine if migration population indices can be valid. Deployment of additional stations should await validation studies.

If validation studies are positive, a series of migration monitoring stations should be established along the northern edge of more densely inhabited regions of Canada in 1994. These stations would be used to estimate population trends for species breeding to the north. These stations would be staffed with members of provincial ornithological societies with information entered and analyzed by CWS. Migration monitoring stations may also prove useful farther south; results of such stations should be compared to breeding season studies in nearby areas for validation.

Techniques should be reviewed for establishing importance of particular areas as migration stopover sites. Areas of particular importance may be mostly coastal sites (Gulf of Mexico, Atlantic Coast, Pacific Coast, Great Lakes), but might include small forest fragments in corn and wheat belts, in deserts, along riparian corridors, and in urban areas.

Point counts can be used in addition to or instead of captures to monitor birds during migration. Standardization of techniques and effort is as important during migration as it is during the breeding season. Thus, most recommendations of the point count workshop of November, 1991, apply to point counts in all seasons.

Use data from raptor migration counts. As with migration banding data, questions have been raised concerning suitability of raptor migration data for monitoring population trends. Recommended methodology such as that established by the Hawk Migration Association of North America (HMANA) will improve the quality of raptor migration data for these purposes.

Expansion of hawk migration data collection at the expense of other programs is not recommended. Current efforts in the Midwest and the East are enough to monitor trajectories of boreal populations of common raptors. Raptors breeding south of the boreal forest will be monitored more effectively by BBS and other systems being set in place. Western boreal populations are difficult to monitor because there are relatively few raptor migration concentration points in the West; however, HawkWatch International and others are expanding efforts to monitor western raptors.

Monitor exposure to toxic chemicals. Exposure to toxic chemicals may be a substantial threat to survival and reproduction of neotropical migrants. The major toxic chemicals that should be monitored are heavy metals, polychlorinated biphenyls (PCBs), and pesticides (carbamates, organophosphates, and organochlorines). Monitoring of toxic chemicals may be more important for neotropical migrants than for resident birds because a number of organochlorine pesticides that are banned in North America are still used in Latin America. We need a focused program to determine impact of organochlorines on neotropical migrants, as well as a more general program to assess impact of other listed chemicals.

FWS has had a National Contaminant Biomonitoring Program in place since the mid-1960s and is currently considering a proposal to expand that program under the name of Biomonitoring of Environmental Status and Trends (BEST). Neotropical migrants should be included in the FWS program.

The Environmental Protection Agency plans to monitor toxic chemicals as part of its Environmental Monitoring and Assessment Program (EMAP). If birds are monitored on the same scale as chemicals, the EMAP program might produce useful information on effects of toxic chemicals on birds.

Use data from other established programs. Data from other programs that collect bird population information can provide a valuable supplement to information gathered by the aforementioned programs. Some of those programs include Breeding Bird Censuses, Christmas Bird Counts, May counts, and checklist databases.

Demographic Monitoring Programs

Data on productivity, survivorship, and recruitment are essential for understanding dynamics of bird populations. These data also assist in identifying possible causes for population declines; for example, high productivity and poor survivorship for a given species may indicate that population declines are a result of factors on wintering grounds rather than breeding grounds. These demographic data would supplement population trend data obtained from other programs and are considered important for a continental monitoring program.

Constant effort mistnetting can provide habitat-specific survivorship data as well as data on productivity (although mistnets may catch some birds more typical of nearby habitats). It is less labor intensive than systematic nest searching and appears to be more suitable for a regional/continental monitoring program. Since the MAPS program has only been recently implemented, its full potential is uncertain. However, a similar program in Great Britain seems to provide useful demographic data for a number of passerine species (Baillie et al. 1986, Baillie and Holden 1988, Peach 1991).

Systematic nest searching produces habitat specific information on habitat requirements, nesting success, productivity, and population trends of neotropical migrants. These data provide an extremely useful supplement to population trend and demographic data obtained from other programs.

To understand the full capabilities of constant effort mistnetting and systematic nest searching programs, we recommend the following actions:

1. Constant effort mistnetting should be implemented as a pilot project in the northeastern and northwestern portions of the continent to test applicability in North America.

2. Efforts should be made to validate indices derived from constant-effort mistnetting by in-depth studies at a sample of sites.

3. If results of this pilot project indicate that constant effort mistnetting will provide useful demographic data for a variety of neotropical migrants, then it should be expanded to a continental program. At least 240 constant effort stations would be required to achieve continental coverage.

4. Systematic nest searching (as envisioned by the BBIRD program) should be implemented as a pilot project in at least 10 states.

5. Both mistnetting and nest searching should be simultaneously implemented at a number of sites to produce a more complete picture of habitat-specific demographic parameters and to compare usefulness of the two approaches.

6. Sites where mistnetting or nest searching are ongoing should include point count data for integration into population trend databases.

Make more use of bird banding data. The Bird Banding Lab (BBL) should promote publication of an atlas of recoveries of neotropical species by the end of 1992. More banding of neotropical species on their breeding and wintering grounds should be encouraged to better connect the breeding and winter ranges of specific populations of these species. However, banding recovery rates for birds banded in migration is so low (far less than 1%) that a specific program to increase migration banding would not be a wise use of limited funds, unless constant effort mistnetting during migration provides a valid index of trends and productivity of a defined population.

Unlike programs ongoing in Great Britain, U.S. and Canadian bird banding data maintained by BBL cannot be used to calculate estimates of survival. Information on recaptures and returns of banded birds are not stored, and without this information survival estimates cannot be calculated. A means of collecting, storing, and disseminating this information needs to be developed at BBL, along with recommendations on how to collect this information to avoid bias. A simple software package, similar to the current banding schedule generator, that permits the bander to enter, store, and mail that information to BBL is currently under development. Upon completion, data from this program would be stored at the Lab and made available to outside groups. The FWS's Office of Migratory Bird Management should assign their statistician the task of developing a standard analysis of the cumulated information with the object of determining sources of bias and the possibility of obtaining national survival estimates.

Distribution Monitoring Programs

At this time, the best source of distributional data for rare neotropical migrants are provided by Breeding Bird Atlas projects (the BBS data are better for common species). These projects can provide reliable data on current ranges. If regularly repeated, these projects can provide reliable data on range expansions and contractions. The standards for coverage should follow those developed by the North American Ornithological Atlas Committee (Smith 1990). Complete coverage of all blocks is essential to obtain data useful for establishing range changes.

Checklist databases may provide useful distributional and trend data. Successful projects based on checklists have been developed in Quebec and Wisconsin and could be applied elsewhere. These databases provide information on all seasons of the year, not just during the breeding season, and may provide useful information on changes in migrating birds. We recommend that the FWS Office of Migratory Bird Management investigate potential for developing an International Checklist Program, including validation studies.

The Measure of a Successfully Established National Bird Monitoring Program

A North American bird monitoring program will be considered to be successfully established when all of the following goals have been met:

1. Population levels of 99% of all neotropical migrant species are monitored within at least 75% of their total ranges.

2. We have a monitoring program for each species that will permit us a 90% chance of detecting a 50% decline in a species' population over a 25-year period.

3. Demographic parameters are monitored on a continental basis for 20% of neotropical migrant species so that we have a 90% chance of detecting a 50% decline in productivity between years. Demography of rare and declining species should be studied in species-specific research projects.

4. Significant distributional changes of all neotropical migrant species in North America are being monitored and described.

AGENCY-SPECIFIC BIRD MONITORING

Introduction

Local monitoring programs face a number of challenges. The money used to implement monitoring programs is usually limited, is usually not considered part of the base operating expenses, and is often taken from other nongame projects. In some cases monitoring is not optional but mandated by law. Whether or not monitoring is mandated, close inspection of the purpose behind monitoring, long-term expense of the system, and statistical design should be considered prior to the project's start.

The need for monitoring does not decrease with time. Design of a permanent system must be flexible enough to withstand most long-term changes projected for the site. With a permanent design comes permanent costs associated with collection and analysis of data. The system must be robust to changes in observers, the likelihood of not having someone on staff who is capable of censusing birds, and changes in access to sampling sites.

Any monitoring system for neotropical birds will miss some species. In almost all cases, common species will be most accurately tracked while rare species will be missed. However, rare and uncommon species are usually in the most need of monitoring and protection. In such circumstances, the monitoring program will need to be supplemented by an inventory program and a research program focused on species of special concern.

Given that not all agency managers will have budgets to develop all-inclusive monitoring programs, compromises will be made. Fortunately, monitoring is not an all-or-nothing proposal. Inexpensive techniques exist that, while coarse, give managers some notion of species presence and perhaps an index to relative abundance and population changes. For this purpose, we recommend habitat-specific point counts as the most likely method of choice.

Goal Statement

To standardize collection of bird and habitat monitoring data on properties managed by public and private groups.

Existing Programs

These will be compiled in the project directory of Partners In Flight.

Actions to be Taken

This subgroup addressed the questions pertaining specifically to monitoring needs of agencies and nongovernmental organizations (NGOs) and their abilities to carry out such programs. If a specific need was especially important to a certain agency or NGOs, it is indicated in parentheses. Monitoring needs are listed below in approximately their priority.

Agency-expressed needs for monitoring neotropical migrants.

Determine the effects of managing habitat on populations of birds (land management agencies). This is a primary goal of the program. Management activities include, but are not limited to: timber, mining, and grazing activities; recreational uses; fire suppression and prevention; water removal; and herbicide application.

Determine standards to identify trends of species that need monitoring, research, or management before they become candidates for listing (FWS). This is being addressed by Theory and Practice Subgroup and is the subject of two recent publications (Sauer and Droege 1990, O'Connor in press).

Determine status of neotropical migrants by regional patterns, by habitat, and by management practices. This is the overall purpose of the monitoring program. Regional priority lists are being developed by the regional working groups.

Determine most effective monitoring practices for each habitat. This is being addressed by North American Bird Monitoring Subgroup. In fact, monitoring techniques may not vary greatly among habitats; point counts, mistnets, and nest searches are equally valid (and have similar constraints) in all habitats.

Establish an interagency data management center, for purposes of national and/or regional coordination, implementation, and data management. The data management center would be responsible for tabulation, consultation, interpretation, and dissemination of data collected during the program.

Produce a directory of existing monitoring programs. This action is nearly completed. A national directory should be distributed to every agency and individual involved in Partners In Flight.

Produce a training manual for monitoring and standardize monitoring methods to insure compatibility of format and methods. Ralph et al. have published Field Methods for Monitoring Landbirds and Managing and Monitoring Birds Using Point Counts: Standards and Applications. These are available by writing C.J. Ralph, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata CA 95521. In addition, this paper and the Needs Assessment (Butcher 1992) include many recommendations for standardizing techniques.

Set up a protocol and curriculum for training, as well as facilities and materials (e.g., song tapes) for doing so. We suggest that non-governmental organizations are in an excellent position to provide much of this training.

Needs suggested by the Monitoring Working Group

Build a network of monitoring programs with compatible, independent, statistically valid projects. The statistical power of any monitoring program depends on the questions asked, the abundance of the species, and the scale considered. The statistical power and sample sizes needed will determine costs and practicality.

Insure that a proportion of overall monitoring in a given area be systematic, encompassing all habitat types and all bird species. At least 50% of sampling should be in proportion to frequency of habitat types. The other 50% should be determined by local or regional agencies; this effort might be allocated to rare habitats likely to host rare species.

Spend about 25% of monitoring effort on demographic monitoring. Statistical power of demographic techniques is less well known than for techniques for status and trends. We need research on power of these techniques, and we will need to shift proportions as needs become apparent.

Concentrate monitoring efforts on breeding season first, with less effort during winter and migration. In northern U.S. and Canada, 60-80% of effort should occur during breeding season, with 10-15% during migration and during winter (of course, this winter work would not directly relate to Partners in Flight). In southern U.S. and Latin America, 50-60% of effort should occur during breeding season, 10-20% during migration, and 20-40% during northern winter.

Research appropriate techniques for documenting the importance of migration stopover sites and for monitoring boreal-breeding birds during migration. Such documentation may be difficult, but stopover sites may be critical for many species. In appropriate habitat, birds may be studied during migration to determine trends of species otherwise unobtainable. CWS is currently reviewing techniques, and there may be a workshop in 1992 or 1993.

Involve state agencies as soon as possible. Not enough states are currently involved. States may require some form of cost-sharing from federal agencies in order to participate fully.

Quickly determine the cost of implementing a "typical" monitoring program of adequate sample size for each technique. Obviously, costs will limit what can be done. Some techniques will have national coordinating costs as well as local fieldwork costs. Some costs are estimated later in this document.

Share all data gathered in the program, preferably by storing data in a common format and at a national data center. We suggest that data sharing be required in all agreements within Partners In Flight.

A. Recommended Monitoring Methods

Various monitoring methods have differing applicability to questions asked by various groups involved in monitoring. Table 1 describes various methods and their strengths and weaknesses. To summarize:

1. Point Counts: Provide the most cost-effective method of estimating relative abundance of birds because they provide the most independent data points per unit of effort.

2. Spot-mapping: Can provide best density information (although there can be problems interpreting results), plus information on many aspects of life history. However, spot-mapping is extremely expensive per data point (in time and money) and is best applied for a research project or for an extremely high priority area, such as a unique local habitat threatened with development.

3. Area Search (where observers are permitted to walk around a defined area while creating a bird list): Has wide appeal to volunteer observers, but standardizing size of area involved in each count is difficult, especially in dense vegetation and rugged terrain. Costs can be somewhat high as well.

4. Strip Transects: Can use both fixed and variable distance methods. They are very good for some habitats, such as grasslands, but are much more expensive per independent data point than are point counts.

5. Variable Distance Methods: Include both point count and transect methods. All involve training observers to estimate distance to birds seen or heard. Standardization is extremely difficult, as observers vary greatly in their skills.

B. Demographic Measures

Demographic information is required to properly evaluate the causes of declines or habitat associations. If demographic features are not monitored, such studies may be initiated too late to effectively change a declining population trend. These methods sample relatively few species in any given area and are thus not generally applicable to rare species. The methods are also more expensive than censuses per data point.

Table 1. — An evaluation of a variety of monitoring methods.

	Census		Demographic				
	Point Count	Spot Map	Area Search	Variable Distance	Constant Effort Mistnets	Nest Search	
Variables Measured							
Index to abundance	Yes	Yes	Yes	Yes	Yes	Part.	
Density	No	Yes	No	Yes	No	Part.	
Survivorship		No	No	No	No	Yes	Part.
Productivity		No	No	No	No	Yes	Yes
Recruitment		No	No	No	No	Yes	No
Habitat relations		Yes	Yes	Yes	Yes	Part.	Nests Only
Nest site characters	No	No	No	No	No	Yes	
Clutch size		No	No	No	No	No	Yes
Predation/Parasitism	No	No	No	No	No	Yes	
Indivs. identified		No	No	No	No	Yes	Yes
Breeding status known	No	Yes	No	No	Part.	Yes	
General Characters							
Habitat types meas.	All	Some	Most	All	Some	Some	
Rare spp. measured	Many	Few	Many	Many	Few	Few	
Canopy spp. measured	All	All	All	All	Some	Few	
Area sampled known	Part.	Yes	Yes	Yes	No	Yes	
Training necessary	Much	Much	Mod.	Much	Much	Much	
Observer error pot.	High	High	Mod.	High	Mod.	Mod.	
Use in non-breeding	Yes	No	Yes	Yes	Yes	No	
Costs per data point	Low	High	Low	Low	High	High	
Applicable scale		Broad	Local	Broad	Broad	Broad	Local

1. Constant Effort Mistnetting: Provides information on productivity and survivorship of populations; sample size requirements for answering local or broad-scale questions are not yet known.

2. Nest Searching: Provides information on productivity at a very local scale, but is very expensive per data point and requires a relatively high degree of training. Causes of nest failures can often be inferred when nests are followed.

Costs of Monitoring

We determined approximate costs for three major activities an agency might undertake: point counts, mistnetting, and nest searches. Costs were estimated for a region, defined as an area of several thousand acres, including several drainages. All monitoring programs will require trained personnel, field forms, computerized data entry, database management, and data analysis. Details on methods are available from Ralph et al. (1992).

Extensive point counts are conducted primarily on roads to monitor relative abundances of birds and changes of abundance through time; habitat information is collected at each point. Ten to 50 points can be covered in a day; collection of habitat information requires a separate day from the collection of bird information.

Each region includes six-eight monitoring stations, each in an area of about 50 ha (125 acres). At each station, mistnetting, nest searches, and intensive point counts are done, and habitat information is collected. Mistnetting involves capturing birds, banding them, and recording data on age, sex, breeding status, molt, and survivorship. At a minimum, each monitoring station should operate 8-12 nets at least once every 10 days throughout the breeding season. Nest searching involves finding nests, monitoring their outcome, and measuring associated vegetation. A study plot should be visited at least once every three or four days to find and check nests. Point counts should be done at four to nine points at least twice during the breeding season at each monitoring station.

1. Point counts throughout region:
   - one person for two months
   - one vehicle
   - additional equipment - $500

2. Mistnetting:
- two persons for four months
- one vehicle
- additional equipment - $1,500

3. Nest searching:
- four persons for four months
- two vehicles
- additional equipment - $800

4. Point counts at monitoring stations:
- one person for one month (could be done by mistnetters or nest searchers)
- one vehicle - same as vehicle in #2 or #3 above
- additional equipment - 0

ACKNOWLEDGMENTS

Much of this document is taken from the Needs Assessment prepared by participants at the Monitoring Working Group meeting held in Arlington, Virginia, on September 4 & 5, 1991

under the auspices of Partners In Flight. Sam Droege is Vice-chair of the Monitoring Working Group and helped prepare much of the content. The following served on the Agency-specific Bird Monitoring Subgroup and contributed especially to the second half of this paper: Dawn Carrie, Geoffrey Geupel, Gary Hartman, Karen Kozie, David Krueper, Teri Raml, Christopher Rimmer, and Susan Sferra. The following served on the bird monitoring subgroup and contributed especially to the first half of this paper: David DeSante, David Hussell, Tom Martin, James Tate, Keith Watson, Richard Weisbrod, and Dan Welsh. Others at the meeting included: John Sauer, Dan McKenzie, Barry Noon, Cherry Keller, Steve Brady, Gerald Niemi, Raymond O'Connor, Dean Stauffer, Brent Bailey, Coppelia Hays, Marshall Howe, Herbert Raffaele, and Steven Sader.

The following correspondents helped improve various written drafts of the Needs Assessment and this paper: Cindy Berger, Paul Bolstad, Ted Cordery, David DeSante, Curt Flather, Coppelia Hays, Chuck Hunter, Frances James, Dave Krueper, Jim Lowe, Jim Lynch, Jane Lyons, Raymond O'Connor, Gerald Niemi, Nadav Nur, Jeff Price, John Rappole, Steven Sader, Pixie Senesac, Susan Sferra, John Tautin, Diane Tessaglia, John Trapp, and Richard Weisbrod.

LITERATURE CITED

Anon. 1970. Recommendations for an international standard for a mapping method in bird census work. Aud. Field Notes 24:723-726.

Baillie, S.R., R.E. Green, M. Boddy, and S.T. Buckland. 1986. An evaluation of the constant effort sites scheme. BTO Research Report 21. British Trust for Ornithology, Tring, U.K.

Baillie, S.R., and B.J. Holden. 1988. Population changes on constant effort sites 1986-1987. BTO News 155:8-9.

Bock, C.E., and T.L. Root. 1981. The Christmas Bird Count and avian ecology. In C.J. Ralph and J.M. Scott, eds., Estimating Numbers of Terrestrial Birds. Stud. Avian Biol. 6:17-23.

Butcher, G.S. 1990. Audubon Christmas Bird Counts. In J.R. Sauer and S. Droege, eds., Survey Designs and Statistical Methods for the Estimation of Population Trends. FWS Biol. Rep. 90(1):5-13.

Butcher, G.S., ed. 1992. Needs Assessment: Monitoring Neotropical Migratory Birds, Partners In Flight. Ithaca NY, 58 pp.

Butcher, G.S., and C.E. McCulloch. 1990. Influence of observer effort on the number of individual birds recorded on Christmas Bird Counts. In J.R. Sauer and S. Droege, eds., Survey Designs and Statistical Methods for the Estimation of Population Trends. FWS Biol. Rep. 90(1):120-129.

James, F.C. 1978. On understanding quantitative surveys of vegetation. Am. Birds 32(1):18-21.

James, F.C., and H.H. Shugart. 1970. A quantitative method of habitat description. Aud. Field Notes 24:727-736.

O'Connor, R.J. in press. The analysis of geographic scale and population processes in bird population monitoring data. In D.H. McKenzie et al., eds., Ecological Indicators, Elsevier, London.

Peach, W. 1991. The constant effort sites scheme. In D. Stroud and D. Glue, eds., Britain's Birds in 1989-90: The Conservation and Monitoring Review, Echo Press, Leicestershire, U.K.

Peach, W., and S.R. Baillie. 1989. Population changes on constant effort sites 1987-1988. BTO News 161:12-13.

Peach, W., and S.R. Baillie. 1990. Population changes on constant effort sites 1988-1989. BTO News 166:6-7.

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1992. Field Methods for Monitoring Landbirds. USDA Forest Service, Redwood Sciences Laboratory, Arcata CA.

Sauer, J.R., and S. Droege, eds. 1990. Survey Designs and Statistical Methods for the Estimation of Population Trends. FWS Biol. Rep. 90(1):1-166.

Smith, C.R., ed. 1990. Handbook for Atlasing American Breeding Birds. Vermont Institute of Natural Science, Woodstock VT.

Designing and Implementing a Monitoring Program and the Standards for Conducting Point Counts

C. John Ralph[1]

Abstract — Choosing between the apparent plethora of methods for monitoring bird populations is a dilemma for a person contemplating beginning a monitoring program. Cooperrider et al. (1986) and Koskimies and Vaisanen (1991) describe many methods. In the Americas, three methods have been suggested as standard (Butcher 1992). They are: point counts for determining habitat relationships, population size, and population trends; and two demographic methods, constant effort mist netting and nest searching. Below, I discuss the process of choosing methods and suggest priorities. Then, for point counts, I describe in some detail the standards that have been put in place for this method.

CHOOSING MONITORING METHODS

Before monitoring methods are decided upon, goals of the program should be clearly outlined. As part of the goal-setting process, the purposes behind development of a monitoring program should be stated explicitly. I suggest that the following questions be addressed:

1. What is the intent of the monitoring?
   a. Regional trends or habitat specific monitoring?
   b. Evaluation of all species, a target group of species, or a single species?
   c. What is the expected relationship between results of a population change and management actions?
2. How is monitoring to be accomplished?
   a. What will be the protocol used at each station?
   b. How will the samples be allocated?
   c. When will the survey be conducted?
3. How do we judge if the monitoring is successful?
   a. What are the initial goals of precision?
   b. What analytical methods will be used to determine if goals are met?

[1]*U.S. Forest Service, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, California 95521, USA.*

Once these decisions are made, then the manager can proceed with decisions of the methods involved.

A good monitoring program should integrate both population size with demographic measures. A comparison of both types of methods is found in Butcher et al. (this volume). In such a program I would suggest that the basic entity is an administrative **unit**, such as a Forest Service District, a park, a refuge, or a nature center.

The data taken in this program can be used at two geographic scales. At the smaller level, for instance, a state park, they will provide a local assessment of status and trends of landbirds, and permit statements such as: "Scarlet Tanagers have significantly increased on sampled units in the park," or "Hermit Thrushes breeding in the park have had high mortality during migration or the winter in the past two years."

At the larger scale, perhaps a state, the program will permit evaluation of geographic patterns of various attributes of landbirds. Statements that this approach can answer are, for example: "Thrush population increases or reproductive failures are more prevalent in some regions or states." It is important to realize that the program cannot evaluate population status of birds of the entire geographic area, whether regional, state, national, or continental. For example, if samples are only from forested environments, only statements about birds using forested lands can be made.

I suggest four levels of program be carried out on each unit.

Priority I. Breeding Bird Survey

If the unit has an official Fish and Wildlife Service Breeding Bird Survey route within or near it that is not being surveyed, I recommend that the standard survey be conducted. This involves 50 3-minute point counts along roads at 1/2 mile (1 km.) intervals. The effort takes one person-day at the height of the breeding season, usually in early June. The surveyor must know all vocalizations of species likely to be encountered. This Survey will help detect regional trends in many species in the unit, or its vicinity.

Priority II. On-road Point Counts

As a second priority, I recommend the unit put in at least 250 point count stations. Methods for conducting point counts are described below, and in Ralph et al. (in press a). I suggest that stations be: in habitats representative of the unit; stratified by these major habitats; systematically placed; and placed primarily along secondary roads. This level of effort will require about 10 person-days during the early breeding season, usually in May or June. It is based on the assumption that in the 10-day period, an average of about 25 stations can be censused each day. While we acknowledge the fact that an on-road monitoring program is not without bias, benefits are considered by most workers to outweigh disadvantages, and are at least partly offset by Priority IV, below.

Priority III. Demographic Methods.

Constant Effort Mist-netting Sites

As a third priority, I recommend that the unit establish at least one site to measure demographic parameters by operating 10 mist nets, once per 10-day period, through the breeding season. The methods are described by DeSante (this volume), and detailed in Ralph et al. (in press b). This effort will require about 10 person-days per site, beginning about June and continuing through the end of August. The program will provide information on productivity, survivorship, and movement of many species.

Nest Searching Sites

The substitution of nest searches, the alternative demographic method in the place of mist-netting, is also possible. This method is described by Martin (this volume), Martin and Geupel (in press), and also in Ralph et al. (in press b). Nest searches involve intensively finding nests in a plot. Typically, one plot can be done in about 20-40 person-days, beginning about May and continuing to about August. At the present time, fewer nest searching sites than mist-netting stations are in operation, enabling fewer comparisons between units.

Priority IV. Off-road Point Counts

As a fourth priority, I recommend that the unit conduct point counts on at least 100 off-roads stations in habitats not covered by on-road point counts. This will require up to 10 person-days during the same period as on-road counts, and assumes about 10 stations per day covered along trails or cross-country.

As more time, personnel, and funding is available, the above programs can be expanded with more stations or sites monitored.

STANDARDS FOR POINT COUNTS

The point counts referred to above are modifications of the unlimited distance point counts (Blondel et al. 1981), and often represent the best compromise between economy of collection effort and precision and accuracy of estimates of population trends or population indexes (Verner 1985, Ralph et al. in press a).

Point counts and their variables

In point counts, birds are counted at a preselected point for a specified period of time. Because counts are greatly affected by many factors, any comparison of counts is strictly dependent on controlling time spent counting, time of day, seasonal effects, observer differences, and other factors that influence probability of detecting birds at a point.

The following standards are some of those developed at a workshop held in Maryland in November 1991, and have been fully developed in a paper in those proceedings (Ralph et al., in press a). The workshop's purpose was to develop components of point count methodology sufficient to: (1) provide trend data for monitoring population changes; and (2) predict population responses to habitat manipulations.

The need for standards has become apparent. Many new bird monitoring programs are currently under development, and most are on a local or regional scale. These local programs have potential to provide a wealth of data, both on local aspects of regional trends, and on comparisons of bird-habitat studies. To permit comparisons between areas and projects, standardization of effort is essential. Point count methodology has applicability in seasons and circumstances beyond those I discuss. Point counts have been used in both the tropics in all seasons, and in temperate areas to monitor wintering migrants.

While there have been many variations of point counts, the standards below comprise the important aspects of doing these censuses.

1. Locate census points systematically on or off-roads. Census points should systematically located with a random starting point, either on roads or off roads. On-road more efficient, but number recorded is different, usually more.

2. Census if possible on tertiary roads, secondary roads, and trails. Observers should attempt to carry out censuses primarily on tertiary roads, then secondary roads, avoiding wide, primary roads. Off-road censuses should be carried out in major habitats not covered by road systems. These should be done on trails, if possible.

3. The number of stations depends upon objectives, but will usually be more than 250. The number of samples necessary to meet program objectives should be derived from statistical evaluation of pilot data. One observer can do about 25 stations per day.

4. Length of each census should usually be five minutes. Time spent at each count station should be five minutes if travel time between counting stations is less than 15 minutes and ten minutes if travel time is greater than 15 minutes. Data should be separated into those individuals seen or heard during the first three minutes and those additional individuals heard in the remaining minutes.

5. Points should be at least 250 m apart. The minimum distance between point counts is 250 m, or 500 m in open habitat, such as grasslands.

6. Record all birds only once. Birds previously recorded at another sampling station should not be recorded again. All individual birds detected at a point should be recorded.

7. Separate birds within and more than 50 m. Birds detected within a radius of 50 m surrounding the center of the point should be recorded separately from those at all distances.

8. Census each station once a season. It is usually better to increase the number of sampling stations, than to repeatedly count a smaller number of stations. An exception should be made for habitats which are very limited and important.

9. Census when detection rate is most stable. Breeding season point counts should be conducted during the time of day and tine of year when the detection rate of species being studied is most stable. This is usually before 10:00 in May and June.

10. Avoid inclement weather. Birds should not be surveyed when it is raining, during heavy fog, or when noise from wind on vegetation interferes with counting.

11. Use only highly trained observers. Only observers able to identify all targeted birds by sight and sound should participate in a monitoring or research project using point counts. Proposed national standard training standards with syllabi are underway.

DATA CENTER

In light of additional uses these data have to researchers and managers, it would be useful to have copies of data sent to an accessible central repository, either a national or several regional data centers. A crucial element in implementing a national program would be establishment of these data center(s) to help maintain uniformity of methods, provide data tabulation, interpretation, analysis, and act as a conduit for providing data to agencies and researchers for analysis. Each unit should contribute its data to such a center with personnel having competency in analysis. This center will tabulate data from throughout the region and disseminate information on patterns of change in demography or population trends of species or groups of species. Emergent patterns should confirm current inventory and management practices as adequate or trigger more intensive inventory or research as questions are raised.

CONCLUSIONS

1. Standardization is essential. All methods are compromises. The methods presented here are, as much as possible, compatible with variety of other techniques. When different methods are used, the biologist using them runs a real risk of lack of comparability.

2. Data must be shared fully. An essential part of science is making data available to wide variety of investigators, such as through a data center. If we are not successful in this aspect, the whole enterprise could fail.

3. National or regional data center(s) must be established very soon. A center will tie together the above requirements.

With these programs and standards fully in place, we can expect a continent-wide program to be well underway with widely-compatible data available to all.

ACKNOWLEDGMENTS

This paper is derived from the collaborative work I have enjoyed over the past two years with many people involved in the Neotropical Migratory Bird Conservation Program, especially Dave DeSante, Sam Droege, Geoff Geupel, Barry Noon, John Sauer, and Jerry Verner. They have all contributed immensely to the content of this paper.

LITERATURE CITED

Blondel, J., C. Ferry, and B. Frochot. 1981. Point counts with unlimited distance. Pp. 414-420 *in* C.J. Ralph and J.M. Scott (Eds.) Estimating Numbers of Terrestrial Birds. Studies in Avian Biology 6.

Butcher, Greg. 1992. Needs Assessment: Monitoring neotropical migratory birds. Prepared by participants at the Monitoring Working Group Meeting, Arlington, Virginia, September 4 & 5, 1991. Neotropical Migratory Bird Conservation Program. Cornell Laboratory of Ornithology, Ithaca, New York. July 1992.

Cooperrider, A.Y., R.J. Boyd, and H.R. Stuart. 1986. Inventory and monitoring of wildlife habitat. U.S. Dept. Interior, Bureau of Land Management, Service Center, Denver, CO. 858 pp. [Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; GPO # 024-011-00170-1; $38.00].

DeSante, D.F. 1992. An invitation and instructions for participation in the Monitoring Avian Productivity (MAPS) program. Institute for Bird Populations, P.O. Box 1346, Point Reyes Station, CA 94956.

Koskimies, P. and R.A. Vaisanen. 1991. Monitoring bird populations. Zoological Museum, Finnish Museum of Natural History, University of Helsinki, Helsinki. 145 pp.

Martin, T. E., and G. R. Geupel. in press. Nest-monitoring plots: Methods for locating nests and monitoring success. J. Wildl. Manage.

Ralph, C. John, Sam Droege, and John R. Sauer. in press a. Managing and monitoring birds using point counts: Standards and applications. *in* Monitoring landbirds with point counts (Ralph, C.J., J.R. Sauer, and S. Droege (Eds.). USDA Forest Service, General Technical Report PSW.

Ralph, C. John, Geoffrey R. Geupel, Peter Pyle, Thomas E. Martin, and David F. DeSante. in press b. Handbook of field methods for monitoring landbirds. General Technical Report, PSW. xxxx.

Verner, J. 1985. Assessment of counting techniques. Current Ornithol. 2:247-302.

The Monitoring Avian Productivity and Survivorship (MAPS) Program: Overview and Progress

David F. DeSante[1], Oriane E. Williams[2], and Kenneth M. Burton[1]

Abstract — It is generally agreed that populations of many North American landbird species, especially forest-inhabiting Neotropical migratory species in eastern North America, are declining. Existing population-trend data, however, provide no information on primary demographic parameters (productivity and survivorship) and thus provide no means for determining at what point in the life cycle problems are occurring or to what extent observed population trends are driven by causal factors that affect avian birth rates (e.g., temperate forest fragmentation) or death rates (e.g., tropical deforestation), or both. Data on primary demographic parameters of these species are crucial for the implementation of effective management practices to reverse their population declines. The Monitoring Avian Productivity and Survivorship (MAPS) program, a cooperative effort among public agencies, private organizations, and bird banders in North America, was designed to provide these critical long-term demographic data.

MAPS uses constant-effort mist netting, banding, and intensive point counts during the breeding season at a continent-wide network of stations. It provides, for a suite of target landbird species in each of seven major regions of the continent: (1) annual regional indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured; (2) annual regional estimates of adult population size, adult survivorship and recruitment into the adult population from capture-recapture data on adult birds; and (3) additional annual regional indices of adult population size from point-count data collected in the immediate vicinity of the mist-netting stations.

MAPS has grown from 17 stations in 1989 to about 165 stations in 1992. Data from the first three years suggest that post-fledging productivity decreased from 1989 to 1990 over much of the continent. This was followed in 1991 by a significant decrease in the adult population sizes of several target species and all species combined in northeastern North America, where productivity tended to increase in 1991 compared to 1990. An opposite pattern was suggested in northwestern North America, where populations sizes tended to increase from 1990 to 1991 but productivity tended to decrease.

Capture-recapture analyses of data from the first three years of MAPS provide estimates of capture probability of about 0.3 and estimates of survival probability of about 0.5 for various species in both the Northeast and Northwest regions. These analyses suggest that a network of 40 or more stations in a region will produce estimates of adult population size and adult survivorship with sufficient precision (a CV of 20% for the mid-year annual estimate or a CV of about 5% for the mean annual estimate in a 10-year study) to provide reliable information on demographic trends of some 12-18 target species in the region.

INTRODUCTION

Recent analyses of long-term population-trend data from the North American Breeding Bird Survey suggest that populations of many landbird species, especially forest-inhabiting Neotropical migratory species in eastern North America, are declining (Robbins et al. 1989). Analyses of other more limited and local datasets and considerable anecdotal information provide additional support for this large-scale

[1]*The Institute for Bird Populations, P.O. Box 1346, Point Reyes Station, CA 94956-1346.*

[2]*Department of Wildlife, Humboldt State University, Arcata, CA 95521.*

decline (e.g., Morton and Greenberg 1989, Terborgh 1989). The Neotropical Migratory Bird Conservation Program ("Partners in Flight"), was established to reverse the apparent population declines of these Neotropical migratory birds.

Unfortunately, however, existing population-trend data on Neotropical migrants provide no information on the primary demographic parameters (productivity and survivorship) of these birds. As a result, the existing data provide no means for determining at what point in the life cycle problems are occurring or to what extent observed population trends are driven by causal factors that affect birth rates or death rates or both (Temple and Wiens 1989). In particular, the existing population-trend data on Neotropical migratory landbirds has generally not permitted a determination of the causes for the declining populations of these species (Wilcove 1985, Holmes and Sherry 1988, Hutto 1988). Suggested causes range from forest fragmentation on the temperate breeding grounds to deforestation on the tropical wintering grounds. Indeed, without critical data on productivity and survivorship, it will be extremely difficult, if not impossible, to identify effective management and conservation actions to reverse the current population declines.

Clearly, an integrated avian monitoring system that can supply accurate annual estimates of demographic parameters as well as detailed information on population trends is a real necessity. The Monitoring Working Group (MWG) of Partners in Flight voiced this need in its recent document, "Needs Assessment: Monitoring Neotropical Migratory Birds", (Monitoring Working Group 1992), as did the U.S. Fish and Wildlife Service (USFWS) in its document, "Conservation of Avian Diversity in North America" (Office of Migratory Bird Management 1990). Establishment of an integrated population-monitoring system for North America is a realistic and achievable goal. In fact, such a scheme already has been pioneered for the breeding birds of Britain and Ireland and implemented by the British Trust for Ornithology (BTO).

Baillie (1990) described the requirements for an effective integrated population-monitoring scheme. He asserted that effective wildlife-monitoring programs must be capable of identifying changes in population variables that call for conservation action. This implies establishment of some pre-defined threshold to trigger further research and/or management action, a concept that was also stressed in the MWG Needs Assessment document. Baillie pointed out that such thresholds must be based on a thorough understanding of "normal" patterns and dynamics of population variability and must also take into account life-history characteristics of individual species. Thus, an ideal integrated monitoring scheme should provide data on stage(s) of the life cycle during which changes are taking place as well as indications of possible or probable causes of these changes.

Baillie (1990) described the Integrated Population Monitoring Programme that has been undertaken by BTO for breeding populations of birds in Britain and Ireland. This scheme involves the standardized collection of data on the numbers, productivity and survival rates of birds through the Common Bird Census, Waterways Bird Survey, Nest Record Scheme, Constant Effort Sites Scheme, and Ringing Scheme and interpretation of these data using population-modelling techniques. The program involves routine data gathering and analysis by region and habitat to provide annual indices of abundance, productivity, survival rates and, in some cases, dispersal. Models are then developed to describe interrelationships between population variables and readily measured environmental co-variables. These models are used to assist in establishing action thresholds and to compare observed population trends with those predicted from environmental data and from preceding population levels. This facilitates identification of changes caused by anthropogenic factors.

It must be emphasized that it is unrealistic to expect any monitoring system, even a well-integrated population monitoring scheme like that established in Britain, to identify positively the causes of population changes in birds. A well-designed monitoring system can, however, identify those factors most likely responsible, thereby allowing unlikely hypotheses to be rejected quickly. A well-designed system that monitors demographic parameters can also point to the stages of the life cycle that are being affected. Such information will allow subsequent limited research resources to focus on those factors most likely to yield an explanation.

Many elements of an integrated avian population monitoring system are already in place in North America. They include the North American Breeding Bird Survey, Breeding Bird Census, Winter Bird Population Study, Christmas Bird Count, and North American Nest Record Cards Program. Until recently, however, the means for monitoring both post-fledging productivity and survivorship of landbirds were conspicuously missing from the North American program. The Monitoring Avian Productivity and Survivorship (MAPS) Program fills this need.

THE MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP PROGRAM

Background

One component of the British scheme, also recommended by the MWG (1992), is a program to monitor demographic parameters of common landbirds through constant-effort mist netting and banding during the breeding season at a network of stations. The British program, in operation since 1981, is called the Constant Effort Sites (CES) Scheme. In 1986, CES was endorsed by the BTO and became one of the cornerstones of its integrated avian biomonitoring strategy (Baillie et al. 1986). By 1990, more than 100 constant-effort sites were in operation in Great Britain (Peach and Baillie 1991). Other constant-effort banding projects are being established in Finland, France, Netherlands, and Denmark, and are being considered by ornithologists in New Zealand, Australia, Spain, and Israel.

The value of constant-effort mist netting at even a single station was confirmed in a now 17-year on-going study at the Point Reyes Bird Observatory's Palomarin Field Station, in central coastal California. Data from this study elucidated the relationship between landbird productivity and annual rainfall and documented massive and unprecedented reproductive failures of most landbird species in 1986 (DeSante and Geupel 1987). This study showed that the apparent driving force behind much of the annual variation in the number of young birds produced at Palomarin between 1976 and 1985 was the amount of annual (winter) rainfall that occurred in this Mediterranean ecosystem. In particular, numbers of young birds captured peaked in years of relatively average rainfall, and decreased as annual rainfall either increased or decreased from average levels. Productivity thus tended to be lowest in both very dry years (the 1976-1977 drought) and in very wet years (the 1983 El Nino Southern Oscillation). Determining whether this relationship of maximum productivity at average weather conditions holds in other landbird communities and in other areas of the continent is especially important.

In 1989, The Institute for Bird Populations initiated MAPS, a cooperative effort among federal, state, and private agencies and organizations and among individual bird banders in North America to operate a continent-wide network of constant-effort mist-netting stations to capture and band landbirds during the breeding season. Patterned after the successful British CES Scheme, MAPS has been endorsed recently by both the MWG (1992) and the Bird Banding Laboratory as a potentially important tool for determining changes in productivity and survivorship of landbirds. As a follow-up to these endorsements, a four-year pilot project (1992-1995) was approved by the USFWS to evaluate the utility and effectiveness of MAPS in both the Northeast and Northwest.

Now in its fourth year, MAPS has expanded from 17 stations in 1989 and 38 stations in 1990 (DeSante 1991, 1992) to 64 stations in 1991. In 1992, The Institute for Bird Populations established partnerships with: Regions 1 and 6 of the USDA Forest Service to establish and operate 42 MAPS stations in Oregon, Washington, and Montana (six stations on each of seven national forests); Denali National Park to establish five stations there; Shenandoah National Park for six stations; Kings Canyon National Park for two stations; Yosemite National Park for one station; and the Department of the Navy (through the National Fish and Wildlife Foundation) for five stations on three Navy installations in Maryland and Virginia. More than 100 additional stations were operated independently by various governmental and non-governmental agencies and organizations and by individual bird banders, so that about 165 stations were operated across the continent in 1992.

Objectives and Goals

The primary objective of MAPS is to provide long-term population and demographic information on target landbird species that can be used to: (a) aid in establishing thresholds and trigger points to notify appropriate agencies and organizations of the need for further research and/or management actions; (b) aid in identifying stage(s) in life cycles at which changes in population dynamics are taking place; and (c) assist in identifying causes of population changes.

A second objective is to provide a means whereby the public can participate directly in conservation efforts for landbirds. Specifically, MAPS provides a rigorous framework that encourages bird banders to collect capture-recapture data in a manner that can be used to provide critical information on landbird survivorship and productivity.

The third objective is to use public lands as critical locations for large-scale, long-term monitoring efforts. National forests, national parks, and other federal and state lands can provide one subset of ideal sites for a network of stations because they provide large areas of diverse and often pristine ecosystems that promise to remain accessible for long-term monitoring. MAPS thus aims to forge cooperative partnerships among federal and state agencies, avian researchers, and bird banders by facilitating the operation of MAPS stations on public lands. Establishment of such partnerships underlies the basic strategy of Partners in Flight.

The specific, narrowly-defined goals of MAPS are to:

a. Provide annual regional indices of adult population size and post-fledging productivity for 15 to 25 target species in each region from analysis of numbers and proportions of adult and young birds captured at a network of constant-effort mist-netting stations operated during the breeding season.
b. Provide annual regional estimates of adult survivorship, adult population size, and recruitment into the adult population for about 12 target species in each region from analysis of capture-recapture data gathered at the network of constant-effort mist-netting and banding stations.
c. Provide independent, annual regional indices of adult population size for target (and other associated) species in each region from analysis of point count data taken in the vicinity of the mist-netting stations.

These indices and estimates are used to determine annual changes and longer-term trends in population and demographic parameters of target species in each region. They also will be used in statistical models to identify and describe interrelationships between population and demographic variables and readily measured environmental co-variates. Population and demographic indices and estimates can also be used to refine current population models and to develop new models for population processes. Finally, data from various stations will be analyzed in a comparative manner to provide information regarding the effects of habitat type and management practice on population and demographic parameters of target species.

Design of the Program and Analysis of Data

To facilitate the analysis of MAPS data, North America (north of Mexico) was divided into eight major regions (Fig. 1) based on both biogeographic and meteorological considerations, including the apparent east-west periodicity of the jet stream. Political boundaries were ignored in forming these regions, but may be important for management-related aspects of landbird

Figure 1. — Map showing eight major regions into which North America is divided for MAPS.

conservation. If so, MAPS data can be analyzed easily using different regional boundaries. The long-term goal for MAPS is the operation of at least 260 stations across North America, with at least 40 stations in each of the six more southerly regions of the continent and at least 20 stations in Alaska (none is expected to be established in the Boreal and Arctic Canada region).

A major assumption of MAPS (and of the British CES effort) is that significant changes in population and demographic parameters between a given pair of years or over a longer time period tend to be similar for a given species at many banding stations within a region. This is because seasonal weather in a given year generally tends to be rather uniform within a region, although it often varies considerably among regions. This assumption is testable using constant-effort mist-netting data and, in fact, has been verified in Great Britain by CES data (Baillie et al. 1986, Peach and Baillie 1991). If this assumption is also verified by MAPS data in North America, then data on a given species can be combined from all stations in the region, thereby greatly increasing sample sizes and precision of the resulting population and demographic indices and estimates.

Indices of post-fledging productivity for each target species are obtained from the number and proportion of young birds captured at each station. Annual regional changes in these indices are inferred statistically from confidence intervals calculated from the standard errors of the mean percentage changes for target species captured at several stations within the region. This analytical method has been applied successfully to constant-effort mist-netting data generated by the CES Scheme (Baillie et al. 1986).

Estimates of adult survival rate for each target species are obtained from modified Jolly-Seber capture-recapture analyses. Major advances have been made in recent years in both theory and application of data from capture-recapture experiments (Pollock et al. 1990, Lebreton et al. 1992). Recent advances provide for increased precision in the resulting estimates, allow age and/or time dependence to be built into survival and capture rates, permit some parameters to be set equal to fixed *a priori* values, and allow any of the parameters to be related to external variables (Clobert et al. 1987). This approach has been applied successfully to capture-recapture data from Great Tits (*Parus major*) and Common Black-headed Gulls (*Larus ridibundus*) in Europe (Clobert et al. 1987) and from Sedge Warblers (*Acrocephalus schoenobaenus*) and Reed Warblers (*A. scirpaceus*) in Britain (Peach et al. 1991).

Analyses of MAPS data do not provide direct survival estimates for young birds during their first year of life. First-year survivorship may be a key factor in the population dynamics of some landbirds, but because first-year landbirds have poorly-known, but typically quite large, natal dispersal distances, it is virtually impossible to determine first-year survival rates from capture-recapture techniques alone. However, by simultaneously using recruitment estimates (obtained from capture-recapture analysis) and indices of post-fledging productivity, it may be possible to infer useful information about first-year survivorship.

The MAPS program provides three measures for adult population size. The first is an index obtained simply from the number of adult birds captured. This index has been shown to correlate well with density estimates obtained from spot-mapping color-banded individuals of several species of coastal scrub birds (M. Silkey, G. R. Geupel, S. J. Dougill, and N. Nur, unpubl. data) and with density estimates obtained from the Common Bird Census for several species of British birds (Peach 1991). The second is an estimate obtained from capture-recapture analysis that is expected to correlate closely with the above index since it is derived from the same data. The third is an independent index obtained from point count data collected in the vicinity of the mist-netting stations. Comparison of results obtained from each method will provide valuable information about the efficacy of each.

Analyses of 1989-1991 MAPS data have identified suites of target species for both the Northeast and Northwest Regions that can be captured in adequate numbers and at an adequate proportion of the stations in the region to provide sufficiently precise indices and estimates for various population and demographic parameters. These target species include a mix of both Neotropical migrant and temperate-zone wintering species. Target species for the Northeast are Black-capped Chickadee (*Parus atricapillus*), Veery (*Catharus fuscescens*), Wood Thrush (*Hylocichla mustelina*), American Robin (*Turdus migratorius*), Gray Catbird (*Dumetella carolinensis*), Red-eyed Vireo (*Vireo olivaceus*), Yellow Warbler (*Dendroica petechia*), American Redstart (*Setophaga ruticilla*), Ovenbird (*Seiurus aurocapillus*), Common Yellowthroat (*Geothlypis trichas*), Northern Cardinal (*Cardinalis cardinalis*), and Song Sparrow (*Melospiza melodia*). Target species for the Northwest are Dusky Flycatcher (Empidonax oberholseri), Western Flycatcher complex (*E. difficilis* and *E. occidentalis*), Swainson's Thrush (*Catharus ustulatus*), American Robin, Warbling Vireo (*Vireo gilvus*), Orange-crowned Warbler (*Vermivora celata*), Yellow Warbler, MacGillivray's Warbler (*Oporornis tolmiei*), Wilson's Warbler (*Wilsonia pusilla*), Song Sparrow, Lincoln's Sparrow (*Melospiza lincolnii*), and Dark-eyed Junco (*Junco hyemalis*). As the number of stations contributing to MAPS grows, additional target species may be added to this list.

METHODOLOGY FOR ESTABLISHING AND OPERATING A MAPS STATION

Because a major objective of MAPS is to obtain estimates of annual variations in productivity and survivorship, standardization from year-to-year and continuation for a number of years at each station are critical. Continuity is also important for minimizing fluctuations in population parameters that may result from year-to-year changes in geographical composition of the sample of stations. The protocol summarized here is in complete agreement with that described in Ralph et al. (in press).

Siting a MAPS Station

Two different spatial scales must be considered when siting a MAPS station: first, the large-scale landscape or general region within which the station is located, and second, the smaller-scale habitat where the station is actually sited. The large-scale landscape should be representative of the general habitat and/or management practice for which local information is desired. The specific site location should adhere to the following requirements: (1) a location that will allow long-term operation, at least five to ten years; (2) a location that will permit capture of substantial numbers of many common species of landbirds breeding in the area, including, in the Northeast or Northwest, at least one of the above-mentioned target species; (3) a location where floating, transient, and migrant birds do not tend to concentrate (so that derived population and demographic estimates will best reflect actual productivity and survivorship parameters); (4) a location in (or on the edge of) upland woodland or forest habitat, lowland forest or riparian habitat, or scrub habitat (because the target species tend to be forest- or scrub-inhabiting species); and (5) a location in (or on the edge of) a relatively mature habitat or a habitat held in a lower successional stage by active management (because population and demographic parameters are likely to be highly sensitive to successional changes in the habitat sampled). Managed, successional-stage locations are particularly desirable for monitoring species that inhabit scrub and/or second growth habitats.

Number, Density, and Distribution of Net Sites at Each Station

The number of nets should be the maximum number that can be operated safely and efficiently given available personnel. Thus, station operators should only establish the number of nets they will be able to operate in a standardized manner over the long term. We suggest that about ten 12-meter mist nets might be the optimal number that can be operated at a single station by one or two people. With more people and fewer birds, 15 or even 20 nets might be operated. With fewer people and more birds, only five or six nets might be operated. It is unlikely that useful data can be obtained from a station that operates fewer than five nets; thus, five is recommended as the minimum number of nets that may be operated at any given station.

Size of the study area covered by nets and net density are important variables affecting precision of the results obtained from capture-recapture analyses. Area covered by nets will affect the number of different individuals captured, thus the population size sampled. Net density will affect capture probability which is defined as the conditional probability of capturing a bird in any one year, given that it is still alive in that year. Spreading nets as widely as possible will tend to increase the number of territories intersected, thus the population size sampled, but will tend to decrease capture probability for the birds on any single territory, and vice versa. Thus, there must be an optimal intermediate density of nets that will maximize precision by simultaneously optimizing both capture probability and population size sampled. Furthermore, this optimal density may vary from species to species and from station to station depending upon average densities and territory sizes of various species.

Analyses of 1989-1991 MAPS data indicated that stations that used about ten nets and captured large numbers of birds while producing high capture probabilities operated with net densities of about one to two nets per hectare. We suggest optimal net density is about 1.25 to 1.5 nets per hectare. Thus, ten nets should be placed in a study area of about seven or eight hectares (about 17 to 20 acres). This is predicated on the ability of station operators to run the nets safely. Nets should be close enough to each other that a person can visit all net locations within about 10-15 minutes walking time if no birds are caught. This can easily be accomplished on relatively flat terrain with ten nets covering about seven or eight hectares. On steep or rough terrain with difficult walking, nets should be closer together and the area covered less.

Nets should be placed opportunistically at sites where target species can be captured efficiently, such as brushy portions of wooded areas, forest breaks or edges, and near water. Establishment of net sites at a station must strike a balance between conflicting needs of capturing substantial numbers of breeding birds and their young, and of not capturing large numbers of migrant, floating, and transient birds. To optimize both number of birds captured and capture probabilities, nets should be placed relatively uniformly over the available habitat at each station. Because all net sites should be kept constant throughout all years of operation, new stations must be set up carefully.

Net Operation

It is strongly recommended that all MAPS nets be 12-meter, 30-mm mesh, four-tier, black, tethered, nylon mist nets. Nets may be stacked two-high at any given site, provided at least five to ten sites are established. Each 12-meter net operated for one hour, however, should be counted as 1.0 net-hour. If 6-meter nets are used, their operation for one hour should be counted as 0.5 net-hour. Although net size, mesh, stacking, color, material and source are ultimately the prerogative of each station operator, these variables must be standardized for each net site at each station. Tape-recorded playbacks of birds' calls or songs, and the use of bait or water to lure birds to net sites are not permitted because they make standardization among stations impossible.

The breeding season, in general, is divided into twelve 10-day periods from May 1 through August 28. Each station should be operated for all consecutive 10-day periods beginning with the first period when transient or migrant individuals of the locally-breeding species are no longer passing through the area, and continuing until substantial numbers of fall migrant individuals of the locally-breeding species begin to inundate the area. The specific 10-day periods of operation will vary, therefore, from station to station depending on timing of the breeding season at each station. The number and timing of 10-day periods, however, should be held constant at each station for all years.

It is important not to begin operation of a MAPS station before spring migrant individuals of target species have finished moving through the area because such individuals will bias survivorship and productivity estimates. In general, stations located in mid-latitudes of the United States should begin operation during Period 3, May 21-30. Stations in more northerly states and southern Canada should begin in Period 4, May 31-June 9, while far northerly stations may not want to begin until Period 5, June 10-19. Stations in more southerly states should, in general, begin in Period 2, May 11-20, while only those stations in extreme southern U.S. should begin in Period 1, May 1-10 (or earlier). It is not so important to stop the operation in late summer before fall migrants begin passing through, because data from these periods can be eliminated after the fact. This is because very few, if any, breeding adults are captured late in the season that were not already captured earlier in the season. This is not the case early in the season when most breeding adults are captured and when net-avoidance by adults can become an issue.

Because of possible net-avoidance, it is important that MAPS net sites not be operated before the start of MAPS data collection, nor be operated on non-MAPS days during the MAPS data collection period. This is because locally-breeding adults of a given species are often the first individuals to arrive at a location and, if captured before the start of MAPS data collection (or on non-MAPS days), may learn to avoid nets later during the MAPS data collection period. Capture-recapture analysis of 1989-1991 MAPS data suggested that apparent survival rates and capture probabilities may have been lowered substantially for stations that operated MAPS nets prior to the start of the MAPS data collection period. As a result, banders or agencies that wish to operate MAPS and a migration monitoring program at the same location should use different net sites for each program.

It is recommended that nets be operated for only one day during each 10-day period and the interval between dates of operation in consecutive 10-day periods normally be at least six days. While increasing the number of days of operation in each 10-day period will tend to increase resulting capture probabilities, pay-off from this increase seem to fall off rapidly after two or three days of operation. Although two days per 10-day period may offer the best return on capture probability per effort spent, the two days in each 10-day period will certainly be better spent by operating two different stations for one day each and thereby effectively doubling the total number of birds handled. Thus, if personnel at a given station have the ability to operate on multiple days in each 10-day period, we strongly recommend they operate multiple stations for one day each. Long-established stations that must operate on more than one day per 10-day period must keep both timing of their operation and total effort constant from year to year.

The number of nets operated and their location and timing should, if possible, be standardized for all days of operation, but must be kept constant from year to year at each station. The first net should be opened beginning at a specified time relative to local sunrise or the clock, and a standardized route should be followed in opening the nets. Nets should be closed in the same order they were opened, beginning at a specified time after the first net was opened. We recommend opening the first net at about local sunrise and running the nets for about six hours during each day of operation. If ten net-sites were operated and each net site contained one 12-meter net, a total of 60 net-hours would be accumulated during each day of operation. At staions in hot climates, it may be necessary to close nets earlier than six hours after opening. Nets should not be operated if average wind speed exceeds ten knots or gusts exceed 20 knots, or if other weather variables (e.g., precipitation, extreme heat or cold) are likely to endanger captured birds. If nets are closed early or opened late (relative to the station standard) and more than half of a normal day's operation is lost, operators should try to recover the missing hours on another day within the same 10-day period. If the missing hours amounted to less than half of a normal day's operation, making up the missing hours is not recommended.

Determination of Breeding Species

Including capture data for a species from stations where it is not a summer resident and attempting to breed will both bias and lower the precision of survivorship estimates from capture-recapture analyses. It is important, therefore, to include data on a species only from those stations where the species is actually a breeding summer resident. This does not mean that species that do not breed in the study area should not be banded, but rather that each station must submit a list of species that are actually resident and probably breeding in the study area. This list should be compiled like a Breeding Bird Atlas, that is, by gathering anecdotal information concerning the breeding and residency status of the species (i.e., nest found; adult seen carrying nesting material, food, or fecal sacs; male singing on territory throughout the breeding season, etc.). This information can be gathered during the course of normal banding and point count operations and no special effort should be needed to verify breeding in most cases.

Collection of Banding Data

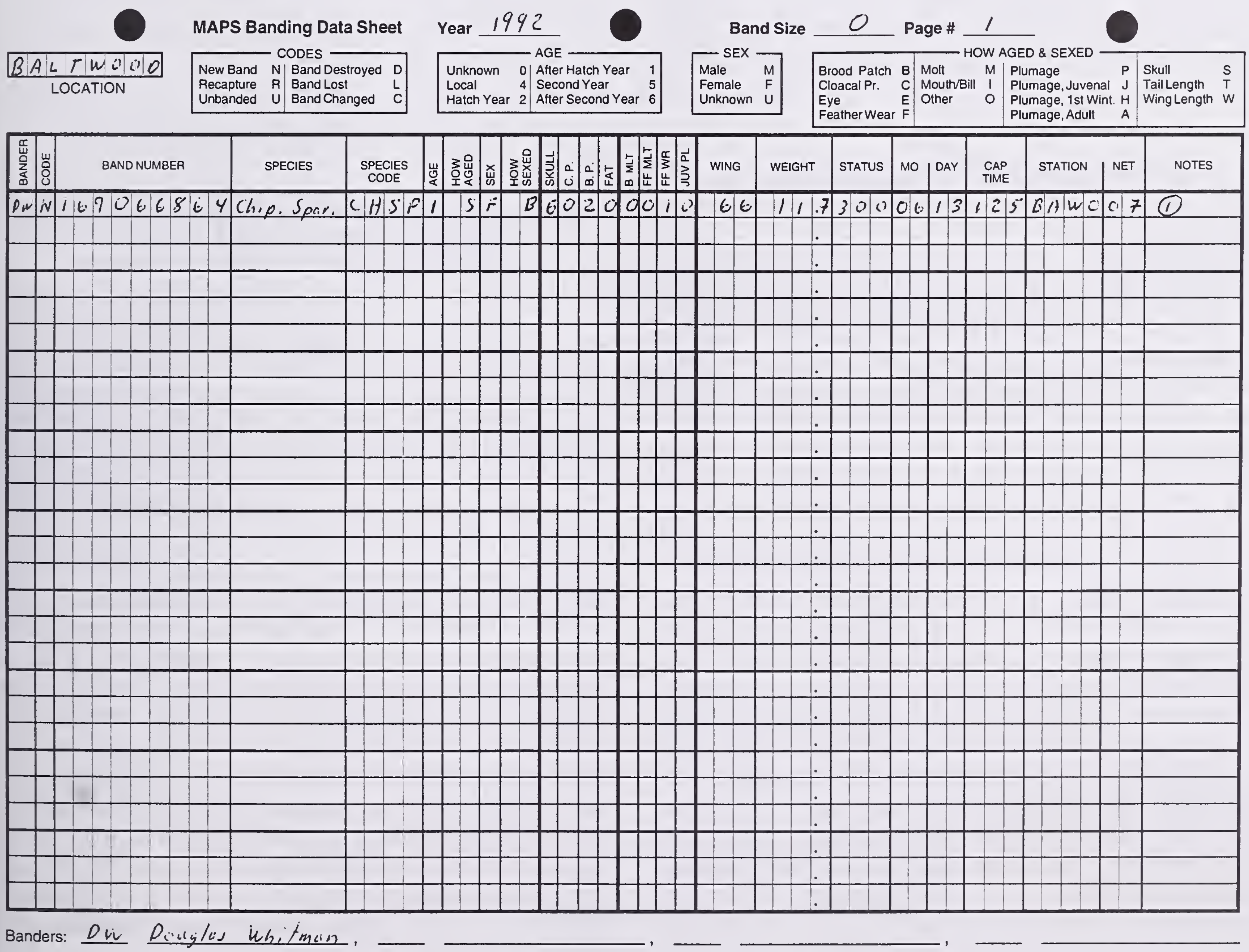
All birds captured, including recaptures, must be identified to species and correctly aged, if possible, by the extent of skull pneumatization and/or other appropriate plumage, mensural or molt characters (Bird Banding Offices 1977, Pyle et al. 1987). If unbanded, they also must be banded with a U.S. Fish and Wildlife Service numbered aluminum band.

The following data must be taken on all birds captured, including recaptures: capture code (e.g., newly banded, recaptured, band replaced); date; time of capture; net site; band number; species; age; how aged; sex; how sexed. Information on capture time and net site will allow screening of data taken at non-standardized times or locations. Information on how aged and how sexed will allow screening of improperly aged or sexed birds. It is also highly recommended that extent of skull pneumatization, breeding condition of adults (presence or absence of a cloacal protuberance or brood patch), extent of juvenal plumage in young birds, extent of body and flight feather molt, extent of primary feather wear, and wing chord also be recorded. These data are used in verification programs to assure accuracy of species, age, and sex determinations. Other data, such as weight, fat content, and tail length, may also be taken but are not required. All data should be taken according to standardized guidelines using standardized codes (Ralph et al. in press), and should be recorded on standardized banding data sheets (Fig. 2). All personnel should be required to use a binocular magnifier or other form of optical magnification to examine skull pneumatization and to read band numbers.

In addition to capture data described above, station operators are required to record dates and timing of operation, number of nets operated, and total net-hours each day, and total numbers of newly banded and recaptured birds of each species in each 10-day period.

Collection of Point Count Data

To provide additional information on population sizes of birds at each station and to sample species not captured efficiently by mist nets, a series of standardized point counts should be conducted along a route following the rough outline of a rectilinear grid centered on the constant-effort mist-netting study area. All participating MAPS stations are strongly encouraged to conduct these point counts, but their completion is not an absolute requirement for the operation of a MAPS station.


MAPS Banding Data Sheet Year 1992 Band Size 0 Page # 1

BALTWOOO LOCATION

CODES: New Band N, Band Destroyed D, Recapture R, Band Lost L, Unbanded U, Band Changed C

AGE: Unknown 0, After Hatch Year 1, Local 4, Second Year 5, Hatch Year 2, After Second Year 6

SEX: Male M, Female F, Unknown U

HOW AGED & SEXED: Brood Patch B, Cloacal Pr. C, Eye E, Feather Wear F, Molt M, Mouth/Bill I, Other O, Plumage P, Plumage, Juvenal J, Plumage, 1st Wint. H, Plumage, Adult A, Skull S, Tail Length T, Wing Length W

BANDER	CODE	BAND NUMBER	SPECIES	SPECIES CODE	AGE	HOW AGED	SEX	HOW SEXED	SKULL	C.P.	B.P.	FAT	B MLT	FF MLT	FF WR	JUV PL	WING	WEIGHT	STATUS	MO	DAY	CAP TIME	STATION	NET	NOTES
DW	N	167066864	Chip. Spar.	CHSP	1	S	F	B	6	0	2	0	0	0	1	0	66	11.7	300	06	13	125	BAWO	07	(1)

Banders: DW Douglas Whitman

Figure 2. — Sample MAPS Banding Data Sheet with the first line of data filled out.

The methodology for these point counts follows guidelines recommended at the symposium and workshop on point counts held at the Patuxent Wildlife Research Center in November 1991 and summarized by Ralph et al. (in press). These guidelines call for counting at 9 to 12 points spaced at least 75 (preferably about 150) meters apart for either a 5- or 10-minute count period, and replication of these points three or four times during the first three or four 10-day periods of the season.

Counting should commence at about local sunrise. Because 10 or 15 minutes will be required for each count (assuming about 5 minutes walking time between points and 5 or 10 minutes counting time at each point), the series of 9 to 12 counts will take between one and one-half and three hours to complete. The starting point on subsequent replications should be varied so that each part of the census area will be counted, on average, at the same time of morning. The exact location of points, order of visiting the points, and order of replication, however, should remain constant from year to year.

All individual adult birds seen or heard for unlimited distances from each point should be tallied, although individuals already counted at previous points should be indicated as such. Care should be taken not to tally the same individual twice at the same point. Individuals should be tallied separately for distances from the point of less than 50 meters and greater than 50 meters and all flyovers should also be tallied separately.

Collection of Habitat Mapping Data

Type and structure of vegetation at a station can affect number of breeding birds present, productivity, and survivorship, as well as the efficiency with which birds can be monitored by mist nets. Because changes in vegetation at a station can cause changes in population and demographic parameters, standardized habitat maps and descriptions must be prepared that will identify, locate, and characterize major habitat types present in an area extending at least 100 m beyond the outermost net sites. Rough habitat maps, sketched at a scale of 1:2500 (1 cm = 25 m), should delineate boundaries of major habitat types in the study area and should show exact locations of all net sites, point counts, bodies of water, structures, roads and trails (Fig. 3).

The following information should be estimated for each habitat type identified and for an approximately 25-m-radius plot centered around each census point (Ralph et al. in press): major tree species present and approximate canopy cover and average canopy height of each species; major shrub species present and approximate cover and average height of each species; major ground cover types present (e.g. grasses, rushes, forbs, bare ground, litter, water) and approximate cover and average height (if appropriate) of each type. Maps and descriptions should be prepared each year at the time when maximum canopy and shrub covers have first been reached so that changes in vegetation can be monitored.

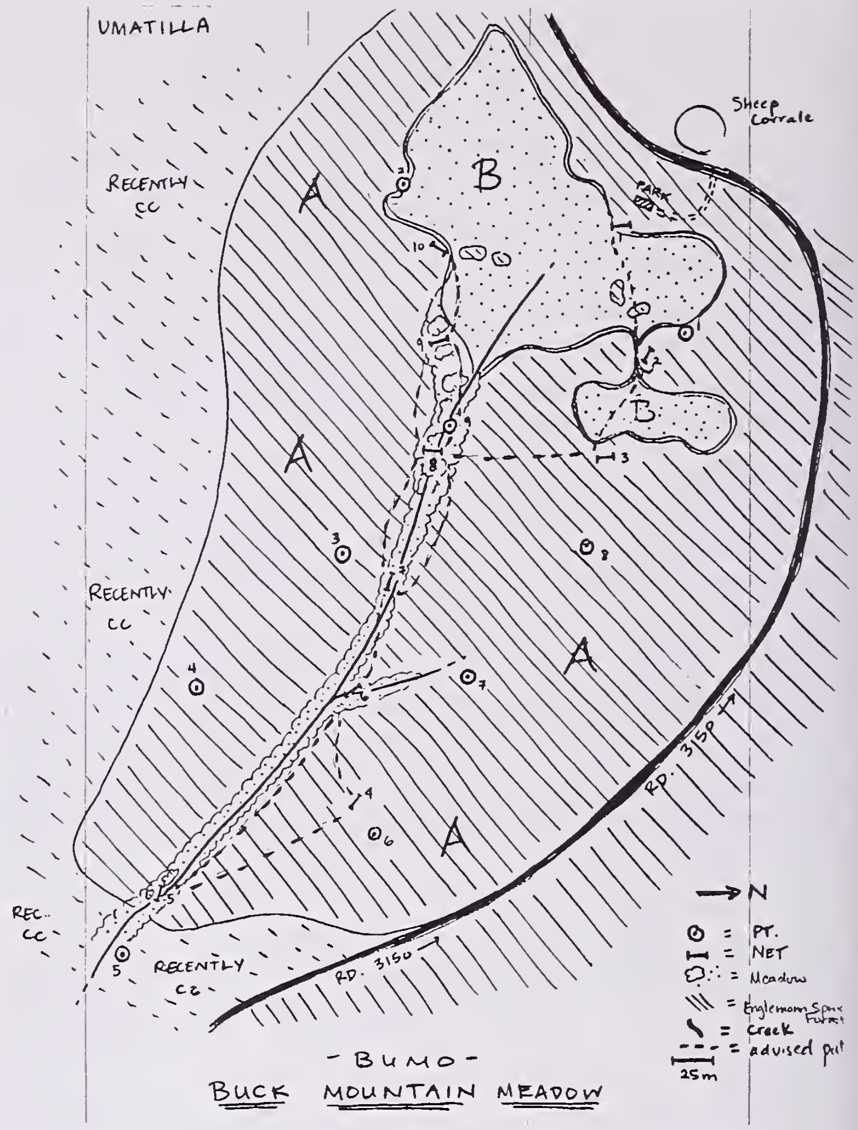


Figure 3. — Sample habitat map for Buck Mountain Meadow on the Umatilla National Forest in Oregon. Area A = Engelmann spruce forest; Area B = Meadow.

RESULTS

Constant-effort data on numbers of adult and young birds captured per 600 net-hours and proportion of young in the catch for all species combined were obtained for 1989 and 1990 from 12 MAPS stations spread across the continent (Tab. 1). Strikingly different values among stations for numbers and proportions of birds captured may relate primarily to widely differing netting regimes rather than actual differences in bird density or productivity. Many of these initial MAPS stations were bird observatories and research stations that already had long-established constant-effort mist-netting operations in place differing from recommended MAPS protocol. Despite lack of uniformity in procedures from station to station, meaningful information on annual changes in adult population size and post-fledging productivity can be extracted because operations at each station were kept constant from year to year.

Number of adults captured per 600 net-hours for all species combined increased between 1989 and 1990 at five stations and decreased at seven. Most changes were relatively small,

Table 1. — Changes between 1989 and 1990 in number of birds captured and in proportion of young in the catch for all species combined at twelve MAPS stations across North America.

	Number of birds captured per 600 net-hours								
	Adults			Young			Proportion of young		Change in proportion of young
Station[1]	1989	1990	Percent change	1989	1990	Percent change	1989	1990	
Northwest									
A	103.7	75.9	-26.8	51.9	33.3	-35.8	.333	.305	-.028
B	306.7	293.3	- 4.3	360.0	190.0	-47.2	.540	.393	-.147
C	20.9	18.4	-12.0	36.0	36.1	0.4	.633	.663	.030
Southwest									
D	32.4	28.4	-12.3	37.8	38.8	2.7	.538	.577	.072
North-central									
E	150.2	152.8	1.7	114.6	129.9	13.4	.433	.460	.062
F	97.7	102.6	5.0	34.6	13.9	-59.8	.262	.119	-.143
G	53.0	57.1	7.7	24.3	7.4	-69.4	.314	.115	-.199
H	113.7	88.3	-22.3	73.6	60.0	-18.4	.393	.404	.028
South-central									
I	19.4	22.9	18.2	18.2	18.2	0.0	.484	.443	-.041
Northeast									
J	50.0	46.4	- 7.1	6.8	4.3	-37.4	.120	.085	-.035
K	80.0	63.6	-20.5	17.9	3.6	-80.0	.182	.053	-.129
Southeast									
L	75.3	93.2	23.8	29.2	13.3	-54.4	.279	.125	-.154
Total	1102.9	1043.0	- 5.4	804.8	549.0	-31.8	.422	.345	-.077
SE[2]			4.3			10.4*			.066

[1] Stations: A. Seventeen Mile Creek, MT, mixed coniferous forest, montane meadow;, B. Siskiyou National Forest, OR, mixed conifer-hardwood forest, montane meadow; C. Point Reyes Bird Observatory, CA, mixed evergreen forest, coastal scrub; D. Coyote Creek Riparian Station, CA, willow riparian woodland, scrub; E. Beaverhill Bird Observatory, AB, aspen parkland; F. Crow Wing, MN, northern hardwood forest, riparian; G. Schlitz Audubon Center, WI, mixed wooded "islands" in grassland; H. Rogers City, MI, aspen-cedar woodland, brush; I. Driftwood Wildlife Association, TX, oak-juniper and riparian woodlands. J. Hubbard Brook Experimental Forest, NH, northern hardwood forest; K. Mount Moosilauke, NH, northern hardwood forest; L. Shawnee National Forest, IL, eastern deciduous forest.

[2] Standard error of the change. See Tab. 2 for how calculated.

* Statistically significant: P < 0.02

generally less than about 25%. The overall combined change in number of adults captured was a non-significant decrease of only 5.4% between 1989 and 1990 (P>0.2).

In contrast, however, number of young birds captured per 600 net-hours for all species combined decreased substantially between 1989 and 1990 across most of the continent. Decreases ranging from 18.4% to 80.0% were recorded at eight of 12 stations, while increases of less than 13.4% were recorded at three stations and no change was recorded at one. The overall combined decrease of 31.8% in number of young birds captured was significant (P<0.2). This decrease in productivity may have been particularly severe in the Northeast region where the number of young captured at two constant-effort stations declined by 68.2%.

This same general result was evident in changes between 1989 and 1990 in proportion of young for all species combined, which decreased at eight stations and increased at four. The overall combined change in proportion of young was a decrease of 0.077 young from 0.422 young in 1989 to 0.345 in 1990. This overall trend was not significant (P>0.2), however, possibly because of the small sample size of just 12 stations.

We suggest, however, that the significant decrease in number of young birds captured and the decreasing trend in proportion of young in the catch for all species combined may represent a real and widespread decline in productivity in 1990 compared to 1989. This productivity decrease may have been caused by extremes in weather conditions that characterized spring and early summer of 1990 all across North America, when severe droughts were recorded over much of the West and locally excessive rainfall occurred over much of the East.

The decrease in productivity in 1990 was followed by a significant decrease ($P<0.02$) of 19.3% in 1991 adult population size for all species combined at ten constant-effort stations in the Northeast (Tab. 2). Moreover, nine of 12 target species in the Northeast independently showed decreases in adult population size in 1991; four of these (Black-capped Chickadee, Wood Thrush, Gray Catbird and Common Yellowthroat) showed significant ($P<0.05$ to $P<0.001$) decreases that ranged from 25.5 to 58.7%. Because these four species have widely differing winter ranges and winter habitat preferences (one is a temperate-wintering permanent resident, two are scrub-wintering Neotropical migrants, and one is a forest-wintering Neotropical migrant), we suggest decreased adult population sizes in the Northeast in 1991 may have resulted directly from low productivity in 1990 rather than from low adult survivorship during the winter of 1990-91. These data support a growing body of evidence on single species and local avian communities suggesting that productivity in a given year can have a major effect on population sizes and population dynamics in subsequent years (Holmes et al. 1991, 1992, Sherry and Holmes 1992). The MAPS data, however, are among the first in North America to suggest that observed decreases in adult population size for many landbird species over a large geographical area could be caused by decreases in productivity in the preceding year.

Changes between 1990 and 1991 in number of young captured in the Northeast (Tab. 2) varied greatly among 12 target species with 6 species increasing (Gray Catbird increased significantly) and 6 decreasing (Black-capped Chickadee decreased significantly). Number of young captured for all species combined showed a non-significant decrease of 2.7%. Productivity, as determined by proportion of young in the catch, increased from 1990 to 1991 for eight species (Wood Thrush increased significantly) and decreased for four species. The proportion of young for all species combined increased by 0.045

Table 2. — Changes between 1990 and 1991 in number of birds captured and in proportion of young in the catch at ten MAPS stations in the Northeast Region.

	Number of birds captured per 600 net-hours														
	Adults					Young						Proportion of young			
Spec[1]	Num sta[2]	1990	1991	% change	SE[3]	Num sta	1990	1991	% change	SE[3]	Num sta	1990	1991	Change in prop of young	SE[3]
BCCH	10	85.8	35.9	-58.2	6.5***	9	62.0	35.7	-42.4	16.7*	9	.422	.499	.076	.097
VEER	8	65.6	66.1	0.7	15.3	5	29.7	19.3	-34.9	31.9	7	.320	.226	-.094	.145
WOTH	8	50.0	20.6	-58.7	14.3**	5	1.2	11.8	850.7	1055.0	7	.024	.367	.342	.079*
AMRO	7	61.0	48.1	-21.3	14.0	7	32.1	14.2	-55.6	23.7	8	.344	.229	-.116	.119
GRCA	8	240.4	179.1	-25.5	9.9*	8	116.6	157.2	34.8	9.7**	8	.327	.467	.141	.092
REVI	8	42.6	45.8	7.6	35.8	5	12.5	20.8	66.0	51.9	7	.236	.312	.076	.122
YEWA	7	86.8	66.3	-23.6	15.3	5	233.6	258.5	10.6	7.4	6	.749	.796	.047	.101
AMRE	7	25.8	25.3	- 1.8	10.1	7	23.2	10.4	-55.1	31.7	8	.473	.291	-.182	.148
OVEN	7	31.0	39.2	26.6	26.4	7	24.0	37.7	56.6	27.4	8	.437	.490	.053	.082
COYE	9	95.7	47.0	-50.9	12.3**	8	68.1	55.8	-18.1	14.2	8	.424	.543	.120	.210
NOCA	6	19.3	18.3	- 5.1	25.0	6	7.2	12.9	79.3	126.4	6	.215	.413	.197	.173
SOSP	7	66.0	54.6	-17.3	17.0	7	116.2	77.1	-33.6	18.6	6	.647	.586	-.062	.081
All sp.	10	1538.3	1241.6	-19.3	6.1*	10	997.0	970.0	- 2.7	7.6	10	.393	.439	.045	.135

[1] Target Species: BCCH - Black-capped Chickadee, VEER - Veery, WOTH - Wood Thrush, AMRO - American Robin, GRCA - Gray Catbird, REVI - Red-eyed Vireo, YEWA - Yellow Warbler, AMRE - American Redstart, OVEN - Ovenbird, COYE - Common Yellowthroat, NOCA - Northern Cardinal, SOSP - Song Sparrow.

[2] Number of stations (out of the total of 10) where that age class of that species was captured.

[3] Standard error of the change in number of adult (or young) birds was determined from Baillie et al. (1986) as:

$$SE(r_i) = \sqrt{\left(n\sum_{j=1}^{n}(d_{ij} - r_i a_{(i-1)j})^2\right) / \left((n-1)\left(\sum_{j=1}^{n} a_{(i-1)j}\right)^2\right)} \text{ where}$$

$$r_i = (a_i - a_{(i-1)})/a_{(i-1)} \text{ and } d_{ij} = a_{ij} - a_{(i-1)j} \text{ and where}$$

a_i is the number of adult birds captured (per 600 net hours) at all stations in year i, a_{ij} is the number of adult birds captured (per 600 net hours) at the jth station, and n is the number of stations.

Standard error of the change in proportion of young determined from Baillie et al. (1986) as:

$$SE(V_i - V_{(i-1)}) = \sqrt{(SE(V_i))^2 + (SE(V_{(i-1)}))^2} \text{ where}$$

$$SE(V_i) = \sqrt{\left(n\left(\sum_{j=1}^{n} b_{ij}^2 - 2V_i\sum_{j=1}^{n} b_{ij}(a_{ij}+b_{ij}) + V_i^2\sum_{j=1}^{n}(a_{ij}+b_{ij})^2\right)\right) / \left((n-1)\left(\sum_{j=1}^{n}(a_{ij}+b_{ij})\right)^2\right)} \text{ where}$$

$V_i = b_i/(a_i+b_i)$ and where

b_i is the number of young birds captured (per 600 net hours) at all stations in year i, b_{ij} is the number of young birds captured (per 600 net hours) at the jth station, and a_i, a_{ij}, and n are as defined above.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

from 0.393 to 0.439. Although this increase was not significant, these data suggested some 1991 recovery from low 1990 productivity may have occurred in the Northeast.

In contrast to the Northeast, number of adults captured at six constant-effort stations in the Northwest in 1991 increased from 1990 for nine of 12 target species and all species combined, although none of the changes was significant (Tab. 3). Number of young captured at six Northwest stations, however, decreased for seven of 12 target species and all species combined. Decreases for Western Flycatcher and Oregon Junco were significant (P). Proportion of young in the catch also decreased at six Northwest stations for nine of 12 target species and all species combined. The decrease for Oregon Junco was significant ($P<0.05$). This trend toward decreased productivity in 1991 may have been caused by unusually cool summer weather that characterized much of western North America, especially in higher elevation interior areas. Thus, changes in population and demographic parameters from 1990 to 1991 for species in the Northwest were opposite those in the Northeast.

Because three years of capture-recapture data are required to calculate estimates for capture probability, adult survivorship, and adult population size, and four years of data are required for an estmate for recruitment into the adult population (Pollock et al. 1990), little information regarding these parameters is yet available from the MAPS program. Three years of capture-recapture data from the 1989-1991 MAPS program were available, however, for eight stations across the country, three in the Northwest, three in the North-Central, and one each in the Northeast and South-Central regions. We used the capture histories of each bird banded at the station and the program SURVIV to calculate maximum likelihood estimates for both 1990 capture probability and 1989 to 1990 survival rate for select species from each of these stations and for regional combinations of stations. Six target species captured at two stations operated according to strict MAPS protocol averaged about 0.3 for 1990 capture probability and 0.5 for 1989 to 1990 adult survival rate and produced an annual return rate of about 0.15. These values are comparable to those calculated from longer term capture-recapture studies of passerine birds (Loery et al. 1987, Pollock et al. 1990).

Because of small sample sizes and a very small number of stations, estimates of capture and survival probabilities, as expected, had very little precision. Coefficients of variation (CVs) for 1990 capture probability and 1989 to 1990 survival rate estimates averaged 96% and 82% respectively. Capture rate and return rate data from various species banded at many additional stations operated in 1990 and 1991 (but not 1989), however, suggest that capture probability and adult survivorship estimates with adequate precision (a CV of 20% for the mid-year annual estimate or a CV of about 5% for the mean annual estimate in a ten-year study) will be obtained for 12 to 18 species by using a network of about 40 MAPS stations in a region. Based on these analyses, 12 target species each were listed for the Northeast and Northwest.

Table 3. — Changes between 1990 and 1991 in number of birds captured and in proportion of young in the catch at six MAPS stations in the Northwest Region.

	Number of birds captured per 600 net-hours														
	Adults					Young						Proportion of young			
Spec[1]	Num sta[2]	1990	1991	% change	SE[3]	Num sta	1990	1991	% change	SE[3]	Num sta	1990	1991	Change in prop of young	SE[3]
DUFL	2	20.2	21.4	6.1	16.5	1	11.7	4.3	-63.0	----	1	.368	.180	-.187	----
WEFL	4	12.7	17.9	40.7	16.3	4	21.0	11.6	-45.0	9.4*	4	.624	.393	-.231	.199
SWTH	6	20.6	27.6	33.8	61.3	4	12.9	13.5	4.8	18.5	6	.385	.329	-.056	.128
AMRO	6	13.4	14.5	8.1	43.9	2	1.9	0.1	-94.8	10.5	5	.144	.007	-.137	.106
WAVI	5	78.1	72.0	- 7.8	10.8	4	29.3	28.1	- 4.1	4.1	4	.283	.281	-.002	.048
OCWA	5	26.7	30.2	13.2	20.3	4	98.2	75.9	-22.7	12.8	4	.786	.733	-.053	.213
YEWA	5	12.5	12.7	1.3	35.1	5	5.2	7.6	44.6	79.0	5	.295	.374	.079	.130
MGWA	4	74.4	60.3	-19.0	22.2	4	51.1	49.3	- 3.5	25.7	3	.431	.450	.019	.099
WIWA	4	14.7	23.5	59.1	90.7	4	9.4	13.8	46.6	64.9	4	.390	.371	-.019	.213
SOSP	5	29.3	23.0	-21.3	28.9	5	53.5	62.7	17.3	20.5	5	.646	.731	.085	.117
LISP	3	9.6	11.8	23.1	16.0	3	4.1	4.8	17.6	46.5	2	.295	.289	-.007	.115
DEJU	5	25.9	38.6	41.5	23.0	4	44.0	24.4	-44.6	10.1*	4	.630	.418	-.212	.065*
All sp.	6	740.7	871.5	17.7	14.7	6	574.3	542.4	- 5.6	18.2	6	.437	.384	-.053	.067

[1] Target Species: DUFL - Dusky Flycatcher, WEFL - Western Flycatcher (complex), SWTH - Swainson's Thrush, AMRO - American Robin, WAVI- Warbling Vireo, OCWA - Orange-crowned Warbler, YEWA - Yellow Warbler, MGWA - MacGillivray's Warbler, WIWA - Wilson's Warbler, SOSP - Song Sparrow, LISP - Lincoln's Sparrow, DEJU - Dark-eyed Junco.

[2] Number of stations (out of the total of six) where that age class of that species was captured.

[3] Standard error of the change. See Tab. 2 for how calculated. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

DISCUSSION AND CONCLUSIONS

The limited number of stations established during the first three years of MAPS (17 in 1989 to 64 in 1991) was insufficient to evaluate the program's ability to detect differences in population or demographic parameters as a function of habitat type or management practice. As MAPS expands, its ability to determine habitat-specific differences will increase. About 165 stations were operated in 1992, of which about 70 were located in the Northwest. This level of effort should produce precise indices of population size and post-fledging productivity for the target species and should at least permit habitat and management relationships to be explored.

It must be conceded, however, that productivity indices derived from constant-effort mist netting and banding can never be completely habitat-specific because the dispersing young sampled are drawn from areas larger than the habitat-specific area where nets are located. Rigorous habitat-specific estimates for productivity can only be derived from a program of direct nest monitoring, such as the Breeding Biology Research Database (BBIRD) program coordinated by T. E. Martin. In some cases, however, the information of most value to managers is how productivity varies over larger areas (landscapes) subjected to differing management practices, rather than how productivity varies among specific habitat types. Constant-effort mist netting and banding is well-suited to determine some of these landscape-scale differences, provided enough stations can be established to provide valid comparisons.

Another limitation of MAPS, and of virtually all broad-scale monitoring programs, is that it is inherently suited for common, widely-distributed species rather than rare or endangered species. Because rare species are often associated with rare or declining habitats, every effort should be expended to augment MAPS by establishing additional stations in these limited habitats. Demographic data on the more common species in these habitats can be compared to data on these same species in more widespread habitats to provide some indication of the overall health of these limited habitats.

A final limitation of MAPS is that productivity data generated by constant-effort mist netting cannot be partitioned into different parts of the reproductive cycle (e.g., clutch size, egg and nestling mortality) as can data from nest monitoring. On the other hand, the index of post-fledging productivity obtained from constant-effort mist netting takes into account the sometimes severe mortality suffered by recently fledged juvenile birds both while under parental care and immediately after they become independent. These aspects of fledgling mortality cannot be detected by nest monitoring. As a result, constant-effort mist netting and banding may provide a better indicator of future recruitment than direct nest monitoring for some species. This possibility was recently confirmed in a study of locally-fledged juvenile Wrentits, a non-migratory species, in coastal California. Post-fledging productivity of Wrentits, as determined by constant-effort mist netting and banding, was found to be highly correlated with total number of nestlings fledged each year as determined by direct nest monitoring and was actually a better indicator of future recruitment than were productivity estimates based on nest monitoring (Geupel G. R., N. Nur, and D. DeSante, unpubl. data).

An ideal integrated avian population monitoring program, therefore, should include both constant-effort mist-netting and banding to provide a large-scale approach and to integrate post-fledging mortality into the equation, and direct nest monitoring to provide habitat-specific information on clutch size, hatching success, and fledging success. These two approaches are complementary.

The first three years of MAPS data detected regional and continental year- to-year differences in adult population size and post-fledging productivity for select target species. The data further suggest that post-fledging productivity may be highly sensitive to weather conditions prior to and during the breeding season and, in turn, may be capable of greatly influencing adult population sizes in subsequent years. These weather conditions, moreover, may exert their effects as relatively large-scale, synoptic patterns that extend over areas at least as large as the regions delineated for MAPS. It is possible that the weather extremes of 1990 that promoted low productivity over much of North America may themselves have resulted from the high global temperature that characterized 1990 (now established as the hottest year ever recorded).

Current thinking suggests that one of the most important ecological results of global warming may be a redistribution of moisture regimes such that markedly higher or lower precipitation than usual will be characteristic of most temperate zone localities. If this is the case, and if lowering of productivity by unusual weather (DeSante and Geupel 1987) is a widespread phenomenon, then years of high global temperature would also be years of notably low landbird productivity over much of the temperate zone. It is noteworthy that six of the seven warmest years on record occurred between 1981 and 1990 (Brown 1991). Perhaps documented decreases in landbirds during the past decade may be attributed at least partially to reduced productivity associated with the highly abnormal weather of these same years.

The manner in which adult survivorship and recruitment of adults are affected by such large-scale weather phenomena are only now beginning to be investigated (Peach et al. 1991). Moreover, the manner in which survivorship and recruitment factor into the dynamics of landbird populations, and the manner in which these parameters are affected by habitat characteristics and management practices, are still very uncertain. One thing is certain, however: constant-effort mist-netting and banding programs using modified Jolly-Seber analyses (e.g., Clobert et al. 1987, Lebreton et al. 1992, Peach 1992) offer the only means for obtaining broad-scale information regarding these critical survivorship and recruitment parameters. Such analyses were recently applied to breeding-season mist-netting data on Sedge Warblers in Britain (Peach et al. 1991). They found that breeding population sizes and annual adult survival rates were strongly correlated with indices of wet-season rainfall in the species' west-African, sub-Saharan winter range, indicating that winter habitat availability was probably the main factor controlling Sedge Warbler breeding population sizes in Britain during the 15-year study period, 1969-1984. Modified Jolly-Seber capture-recapture analyses of the limited data available from MAPS suggest that a fully-operational program with at least 40 stations in each of the major regions will also be capable of producing survivorship estimates with sufficient precision to provide useful, statistically powerful, predictive information.

The few data available regarding changes in demographic parameters of North American landbirds are insufficient to allow conclusions regarding either relationships between environmental or management variables and demographic parameters, or causes of population declines in Neotropical migrants. The very paucity of such data underscores the importance of continuing and expanding programs that can provide regional estimates of demographic parameters in landbirds. The data presented here suggest that MAPS can provide critically needed information on productivity and survivorship of target species that will aid in identifying stage(s) in the life cycle at which population changes are taking place and will assist in identifying causes of recently observed population decreases in landbirds. As part of an integrated avian monitoring program, MAPS should play a major role in aiding efforts to conserve avian diversity in North America. In addition, constant-effort mist netting and banding are enjoyable hands-on activities that give people a sense of empathy and empowerment in matters of avian conservation that is difficult to aquire in any other way. Moreover, the results from even a single banding station can provide rapid feedback on important biological issues.

Finally, as with so many aspects of applied ornithology, the provision of useful monitoring results must be based on a sound understanding of population processes. As pointed out by Baillie (1990), appropriate analyses of data from an integrated population monitoring scheme can form the basis for development of sound population models, particularly as statistical modelling methods capable of incorporating environmental and populational co-variates become available. In this respect, population and demographic estimates from MAPS will be useful for refining current population models and for developing new models for population processes. It is important for the development and testing of these models that several methods capable of providing population and demographic indices and estimates be implemented and compared at a series of key monitoring locations. We recommend establishing a hierarchy of monitoring efforts at several key MAPS stations that include the use of point counts, spot-mapping censuses, color marking and resighting of individual birds, constant-effort mist netting, and direct nest monitoring. In addition, research on the applicability, accuracy and interpretation of population monitoring methods and results should be included in an overall integrated population monitoring scheme. Such research could also be conducted in conjunction with key MAPS stations and Partners in Flight. In this way both the tools and the information needed to provide effective managment of Neotropical migratory landbirds can be provided.

ACKNOWLEDGEMENTS

We express our sincere apprciation to the many individuals, organizations, and agencies that have contributed data to MAPS. We thank S. Droege, J. D. Nichols, C. J. Ralph, and T. W. Sherry for many constructive comments on earlier versions of this manuscript. Financial support for MAPS has been provided by the National Fish and Wildlife Foundation, the U.S. Fish and Wildlife Service, Regions 1 and 6 of the U.S.D.A. Forest Service, the Department of Navy, Denali and Shenandoah National Parks, Yosemite Association, and Sequoia Natural History Association. This is Contribution No. 6 of The Institute for Bird Populations.

LITERATURE CITED

Baillie, S. R. 1990. Integrated population monitoring of breeding birds in Britain and Ireland. Ibis 132:151-166.

Baillie, S. R., R. E. Green, M. Boddy, and S. T. Buckland. 1986. An Evaluation of the Constant Effort Sites Scheme. British Trust for Ornithology, Thetford, U.K.

Bird Banding Offices. 1977. North American Bird Banding Manual, Vol. II. U.S. Fish and Wildlife Service and Canadian Wildlife Service, Ottawa, Canada. Brown, L.E. 1991. State of the world, 1992. Worldwatch Institute, Washigton, D.C.

Clobert, J., J. D. Lebreton, and D. Allaine. 1987. A general approach to survival rate estimation by recaptures or resightings of marked birds. Ardea 75:133-142.

DeSante, D. F. 1991. The Monitoring Avian Productivity and Survivorship (MAPS) program: first annual report. The Institute for Bird Populations, Point Reyes Station, California.

DeSante, D. F. 1992. Monitoring Avian Productivity and Survivorship (MAPS): a sharp, rather than blunt, tool for monitoring and assessing landbird populations. Pp. 511-521 in McCullough, D. C., and R. H. Barrett, eds. Wildlife 2001: Populations. Elsevier Applied Science, London, U.K. DeSante, D. F., and G. R. Geupel. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall, and a reproductive failure in 1986. Condor 89:636-653.

Holmes, R. T., and T. W. Sherry. 1988. Assessing population trends of New Hampshire forest birds: local vs. regional trends. Auk 105:756-768. Holmes, R. T., T. W. Sherry, P. P. Marra, and K. E. Petit. 1992. Multiple brooding and productivity of a Neotropical migrant, the Black-throated Blue Warbler (*Dendroica caerulescens*), in an unfragmented temperate forest. Auk 109:321-333.

Holmes, R. T., T. W. Sherry, and F. W. Sturges. 1991. Numerical and demographic responses of temperate forest birds to annual fluctuations in their food resources. Acta XX Congressus Int. Ornithol 1559-1567.

Hutto, R. L. 1988. Is tropical deforestation responsible for the reported decline in neotropical migrant populations? American Birds 42:375-379. Lebreton, J., K. P. Burnham, J. Clobert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecol. Monogr. 62:67-118.

Loery, G., K. H. Pollock, J. D. Nichols, and J. E. Hines. 1987. Age-specificity of avian survival rates: an analysis of capture-recapture data for a black- capped chickadee population, 1958-1983. Ecology 68:1038-1044. Monitoring Working Group of Partners in Flight. 1992. Needs Assessment: Monitoring Neotropical Migratory Birds. Neotropical Migratory Bird Conservation Program, Arlington, Virginia.

Morton, E. S., and R. Greenberg. 1989. The outlook for migratory songbirds: "future shock" for birders. American Birds 43:178-183.

Office of Migratory Bird Management. 1990. Conservation of avian diversity in North America. U.S. Fish and Wildlife Service, Washington, D.C. Peach, W. 1991. CES News. British Trust for Ornithology, Thetford, U.K. Peach, W. J. In press. Combining mark-recapture data sets for small passerines. Proc. EURING 1992 Technical Conference, Thetford, U.K.

Peach, W., and S. Baillie. 1991. Population changes on constant effort sites 1989-1990. BTO News 173:12-14.

Peach, W., S. Baillie, and L. Underhill. 1991. Survival of British Sedge Warblers Acrocephalus schoenobaenus in relation to west African rainfall. Ibis 133:300-305.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs No. 107. Pyle, P., S. N. G. Howell, R. P. Yunick, and D. F. DeSante. 1987. Identification Guide to North American Passerines. Slate Creek Press, Bolinas, California.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. In press. Field Methods for Monitoring Landbirds. USDA Forest Service, Gen. Tech. Rep. PSW.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proceedings of the National Academy of Sciences (USA) 86:7658-7662.

Sherry, T. W., and R. T. Holmes. 1992. Population fluctuations in a long- distance Neotropical migrant: Demographic evidence for the importance of breeding season events in the American Redstart. In Ecology and conservation of Neotropical migrant landbirds (J. M. Hagan and D. W. Johnson, Eds.). Smithsonian Institution Press, Washington, D.C.

Temple, S. A., and J. A. Wiens. 1989. Bird populations and environmental changes: can birds be bio-indicators? American Birds 43:260-270. Terborgh, J. 1989. Where have all the birds gone? Essays on the biology and conservation of birds that migrate to the American tropics. Princeton University Press, Princeton, New Jersey.

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1212.

EMAP and Other Tools for Measuring Biodiversity, Habitat Conditions, and Environmental Trends

Eric M. Preston[1] and Christine A. Ribic[1]

Abstract — We describe research efforts that contribute to assessment and monitoring of neotropical migratory birds, including: 1) use of neotropical migrants in the Environmental Monitoring and Assessment Program (EMAP) as potential indicators of general environmental condition and biodiversity; 2) EPA's Habitat/Biodiversity Research Initiative to assess comparative risks to biodiversity, including neotropical migrant birds; and 3) other EPA research to develop tools for assessing status and trends of neotropical migratory birds at various spatial scales.

INTRODUCTION

In September, 1990, the U.S. Environmental Protection Agency (EPA) Science Advisory Board (SAB) released a report entitled: *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* (U.S. Environmental Protection Agency 1990). In this report, SAB made several recommendations about existing and emerging ecological problem areas and EPA's effectiveness in resolving these problems. One broad recommendation was that EPA attach as much importance to reducing ecological risks as to reducing human health risk. Citing both ecological and human welfare concerns, SAB also strongly encouraged EPA to address loss of terrestrial and aquatic habitats. In short, SAB ranked habitat degradation and loss, species extinction, and loss of biodiversity among the highest environmental risks facing EPA and other governmental agencies today.

Historically, EPA has assumed a secondary role in habitat protection compared to several other federal agencies. Now, habitat protection is a more common factor in EPA actions. Current directions at EPA include increased emphasis on risk-based assessment of environmental problems and nationwide monitoring of status and trends in ecosystem extent and condition. These activities illustrate EPA's movement towards a more comprehensive approach to environmental risk management. In support, EPA's Office of Research and Development is developing the methods and technical information needed to address ecological risks to habitat and biodiversity.

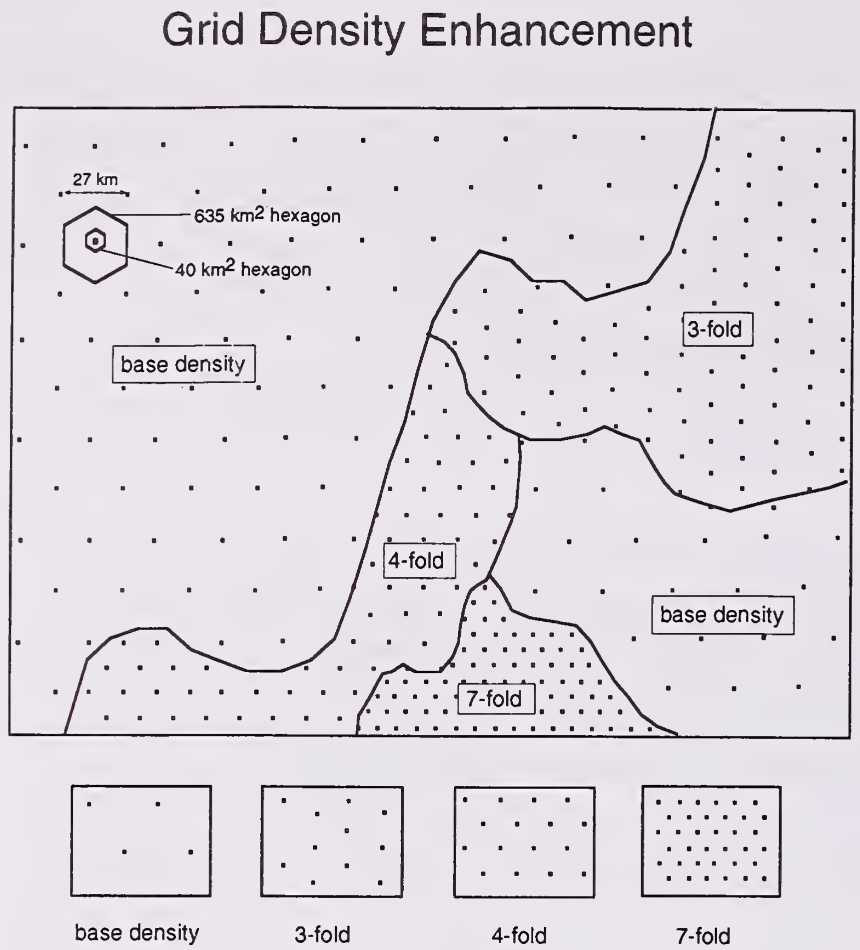
We describe several research efforts that will potentially contribute to assessment and monitoring of neotropical migratory birds. These include: 1) use of neotropical migrants in the Environmental Monitoring and Assessment Program's (EMAP) as indicators of general environmental condition and biodiversity; 2) EPA's Habitat/Biodiversity Research Initiative to assess comparative risks to biodiversity, including neotropical migrant birds; and 3) Other EPA research to develop tools for assessing status and trends of neotropical migratory birds at various spatial scales.

NATIONAL

EMAP Design as a Tool for Monitoring Neotropical Migrants and Biodiversity

EMAP is a nationally integrated ecological research, monitoring, and assessment program (Messer et al. 1991). Its objectives call for monitoring the condition of the nation's ecological resources and providing unbiased estimates of status, extent, change, and trend with known confidence. Building on the experience of previous surveys, the EMAP sampling design incorporates a randomized systematic triangular grid (fig. 1) to ensure random selection and appropriate spatial distribution of samples (Overton et al. 1990, White et al. 1992). The base density results in approximately 12,600 grid points in the

[1]*U.S. Environmental Protection Agency, Environmental Research Laboratory-Corvallis, Corvallis, Oregon*



Enhancement factors for increasing the base grid density.

Figure 1. — EMAP randomized systematic triangular grid system.

conterminous U.S. The grid arrangement makes it easy to either increase or decrease grid density. The triangular grid system establishes a hierarchical relationship among grid densities, so those grid points from lower density grids are subsets of higher density grids. Specific multiple factors (e.g., 3-,4-, and 7-fold) are available to increase or decrease the base grid density to accommodate sampling requirements for ecological resources of differing spatial density.

Several features of the EMAP grid make it appropriate for planning and conducting regional and national level biological surveys. The design structure provides for good spatial distribution of sampling sites and for repeated sampling in time while maintaining the spatial distribution. Spacing and timing of sampling may be adapted to characteristics of the resource. The probability basis of EMAP design provides quantitative inferences with known confidence.

EMAP has organized sampling efforts around major resource groups (e.g., surface waters, wetlands, forests) that provide one focus for surveying of biodiversity, as exemplified in pilot studies already underway on fish, bird, and vegetation diversity. The resource group focus can be supplemented by surveys conducted by taxonomic group (i.e., neotropical migrants) to capture wide-ranging and habitat-transitional species. Finally, EMAP design is based on a global geometric model (White et al., 1992) and, therefore, provides a basis for an international survey.

Biodiversity as an Indicator of Ecosystem Condition

Two projects are underway within EMAP to evaluate habitat and biodiversity metrics as indicators of ecosystem condition.

EMAP - Forests

In the first, EMAP-Forests is sponsoring a project under Thomas E. Martin, U.S. Fish and Wildlife Service, to develop indices of biotic integrity (after Karr 1981) for forest ecosystems. Dr. Martin is attempting to identify suites of bird species clearly indicative of either undisturbed ("healthy") or disturbed ("unhealthy") forests. Forests are classified as healthy or unhealthy based upon the total number of species and their abundances in each group for a given forest stand. Thus, the approach is aimed at identifying those tracts of forest that are suitable (i.e., healthy) for forest-dwelling migratory birds as a group.

The work in progress is investigating indicators of bird populations and a parallel set of indicators based on vegetative characteristics of the breeding habitat. The thrust of the work is to establish relationships between habitat characteristics and health of forest bird communities on a site-by-site basis. Preliminary results indicate that vegetative indicators based on breeding habitat show promise in reflecting health of breeding bird communities. This means that collection of vegetative characteristics can be done in the EMAP framework in lieu of collecting information directly on bird populations.

EMAP - Surface Water

The second project is supported by EMAP - Surface Waters and conducted by Dr. Raymond J. O'Connor, University of Maine. It is similar to EMAP - Forests in that it is attempting to identify metrics of suites of bird populations indicative of the condition of lake ecosystems. Bird censuses at 20 selected lakes in New England were conducted during the 1991 breeding season. Habitat measurements were also made at census locations.

Individual bird species showed little evidence of sensitivity to anthropogenic impacts. However, when species were classified by guild membership, the relative abundance of several guilds proved sensitive to anthropogenic impacts. Two indicators based on bird data were developed and were shown to detect anomalous lakes (O'Connor, personal communication). One indicator predicted species richness at each lake on the basis of physical attributes of the lake, with deviations from predicted values reflecting anomalous conditions. The other characterized lakes as a multivariate function of bird guild composition, with the function value altering with stressor intensity.

Biodiversity as an Endpoint

This project, also conducted by Dr. O'Connor, is currently investigating usefulness of U.S. Fish and Wildlife Service Breeding Bird Survey (BBS) protocol for developing indices of biodiversity within the EMAP sampling frame. Specifically, the project is developing ways to add habitat measurements to BBS routes and to analyze BBS data in conjunction with these habitat characteristics. This project is investigating local and landscape habitat characteristics and is developing guild classifications for bird species. In addition, biases in the BBS are being addressed, such as road-bias of routes, by investigating alternatives, such as checkplots, and comparing results to those from BBS.

Habitat/Biodiversity Initiative

Habitat alteration and destruction with consequent biological depletion are among the greatest ecological threats facing the nation (U.S. EPA 1990). Three factors are thought to contribute to the problem. First, habitat modification may often be the inadvertent result of independent and poorly coordinated land use decisions that result in habitat fragmentation. This isolates certain species in ever smaller patches of suitable habitat and creates barriers to movement between patches. Second, cumulative effects of local habitat modification and contamination reduce quality of remaining habitat patches. Third, these factors in combination alter competitive relationships and predator/prey relationships within habitats. Invasive, introduced species then displace native indigenous species, with consequent loss of native biodiversity in the landscape.

Along with other federal and state agencies, EPA shares a responsibility for conservation of natural resources and protection of the environment. Implicit in many of EPA's legislative mandates, and found throughout its regulatory authorities, is the notion of maintaining natural biodiversity. One problem facing federal agencies is that habitat stewardship is divided among many land ownerships, each with a different perspective on risks and values. As stated by the Council on Environmental Quality (1991) "Piecemeal management -- ignoring the interdependence of parts of any ecosystem that happen to be separated by political boundaries or by lines of land ownership -- can lead to environmental and biological decline." To stem further loss of habitat and biodiversity, it is necessary to develop a federal partnership that recognizes complexity of multiple-ecosystems, multiple-values and multiple-stresses associated with landscape mosaics of interacting ecological systems distributed among federal, state, and private ownerships.

In response, we are proposing a multi-agency, collaborative project to develop the methods and data needed to assess risks to biodiversity. We propose to categorize and map relative species diversity and landscape type diversity of each of about 12,000 sampling units (hexagons) based on the EMAP sampling grid covering the conterminous U.S. (fig. 2). The process (fig.

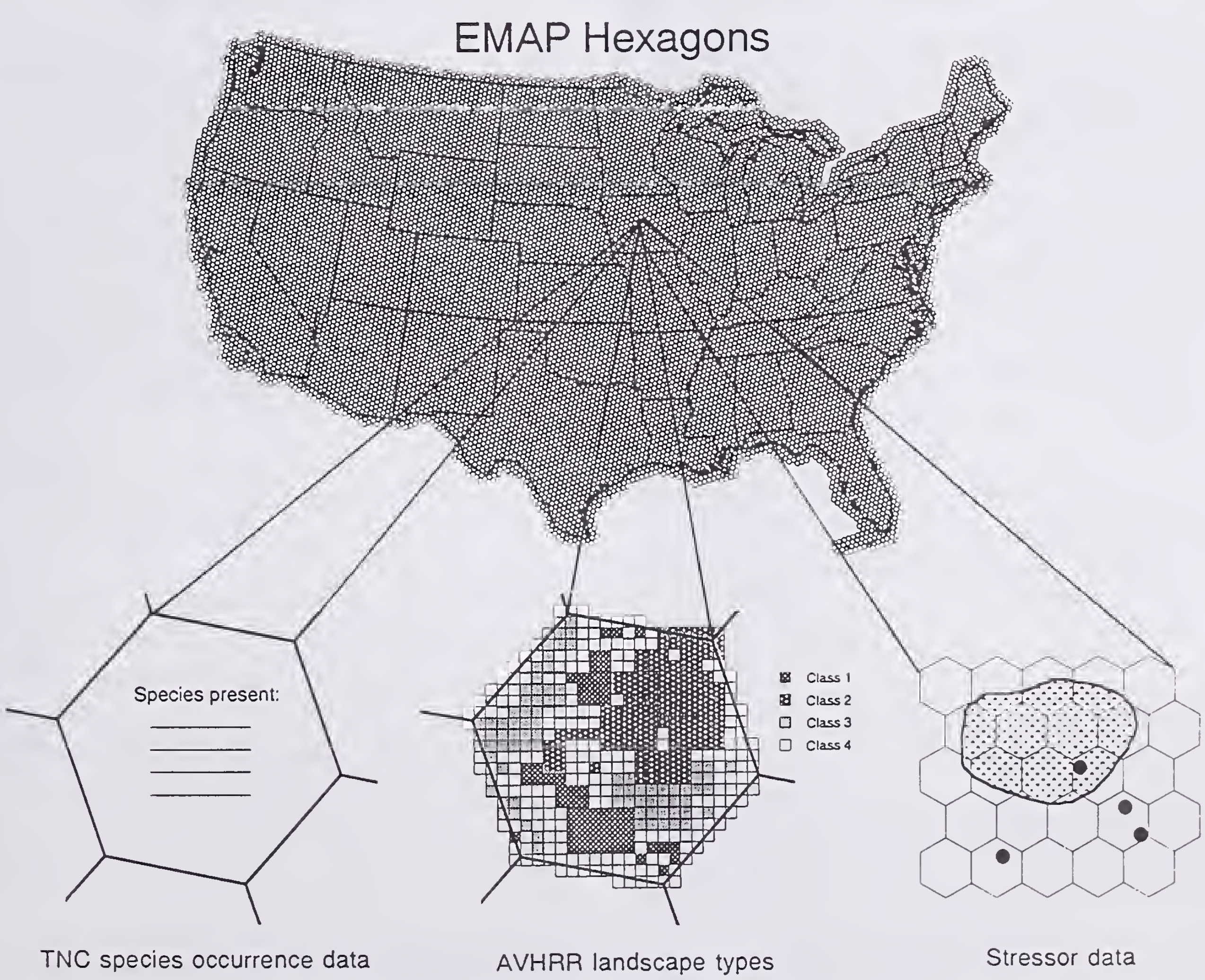


Figure 2. — EMAP grid as an organizing framework for biodiversity, landscape, and stressor data.

3) will include (1) compilation of The Nature Conservancy's detailed vertebrate species distribution and attribute data for each hexagon, (2) compilation of remotely sensed land characterization data , (3) determination of whether low-cost remote sensing data (Advanced Very High Resolution Radiometry, AVHRR) that describe landscape types will be an acceptable surrogate for habitat at the national scale, and (4) analysis of species and land characterization data by different ecological weighting methods, spatial analyses, multivariate statistical pattern analyses, and protection optimization methods. This information, along with stressor data compiled from existing databases, will be evaluated and synthesized to quantify relative risks to biodiversity and landscape types by region and landscape type. Overall patterns that lead to high importance and vulnerability of natural landscapes and biodiversity will be identified.

In completing an assessment of risks to landscape and biodiversity, methods of prioritizing protection of both wildlife and landscape types are needed. Any policy recommendations must initially consider a variety of options and the amount of habitat and diversity protected under each option must be known.

Prioritization recognizes the need to establish a sequence of target areas for application of management and regulatory resources. Prioritization in this study will be done in two ways. First, individual species will be weighted by a variety of factors that represent their contribution to differing values associated with biodiversity. Such values might include importance in ecosystem function and sustainability, genetic "uniqueness", vulnerability to habitat fragmentation, and conservation importance (rarity). Second, individual landscape types, as represented by number and proportion of the spatial areas of particular remotely sensed classes, will be evaluated as a surrogate for landscape structural diversity.

Prioritization will be implemented by ranking cells according to the joint criteria of maximum coverage but minimum redundancy in species or landscape type occurrence. We will perform sensitivity analyses to examine robustness of methods of weighting, aggregation, and ranking.

Expected benefits include (1) establishment of baseline conditions of species distributions and landscape types, (2) comparative risk assessment of stressors that threaten biodiversity, and (3) testing of methods that hold promise for significantly reducing costs of habitat monitoring, evaluation,

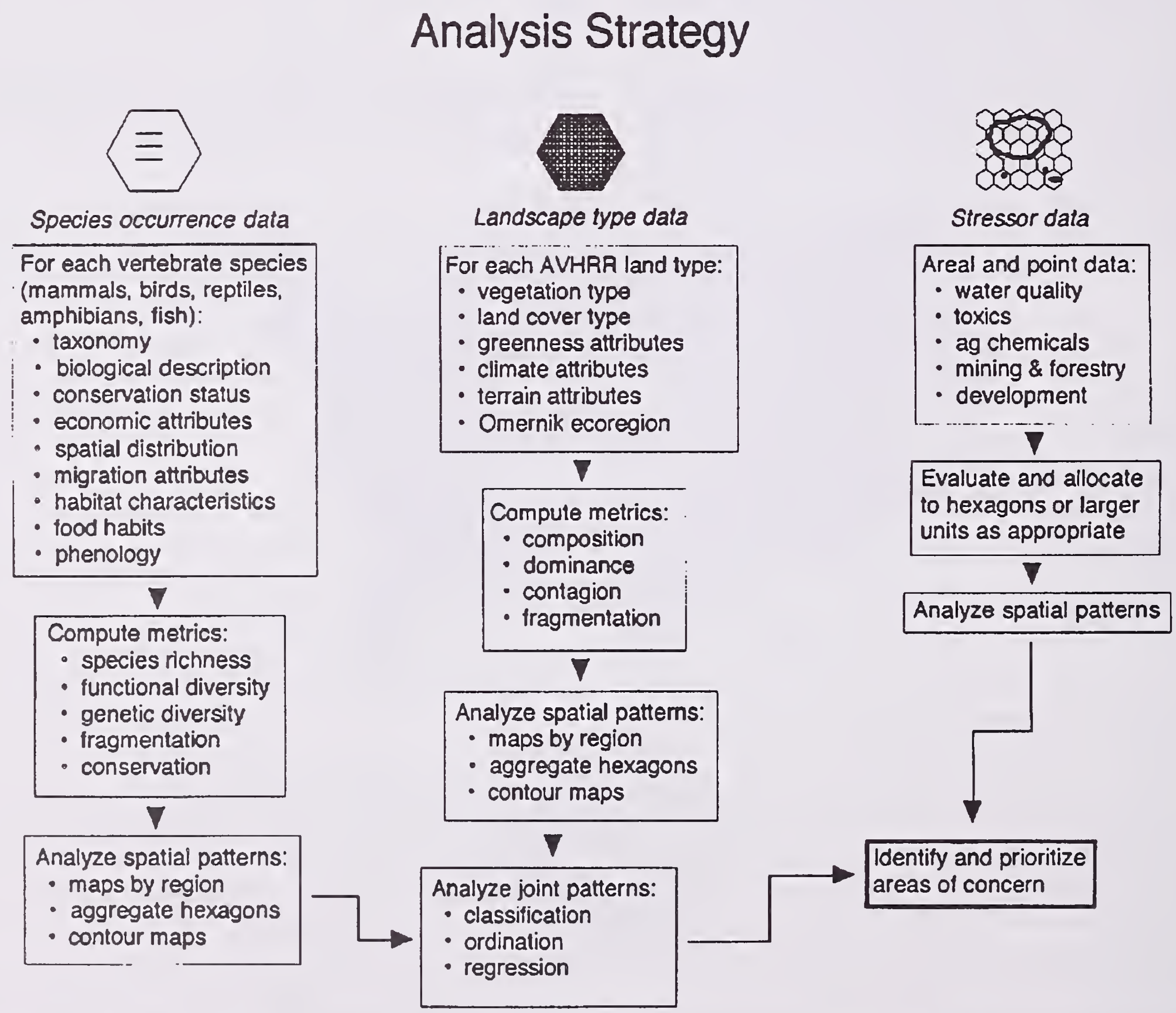


Figure 3. — Analysis strategy for a synoptic national assessment of comparative risk to biological diversity and landscape types.

and management. The project is designed to complement the higher resolution analyses of the USFWS's GAP Analysis Program by explicitly relating distribution of anthropogenic stressors to biodiversity and landscape types through the risk assessment process.

Although the program's objectives are national in scope, several scientific issues will be addressed initially and resolved in an integrated series of pilot projects in different landscape types. Criteria used in selecting areas for pilot projects will include availability and completeness of appropriate biological, landscape, and stressor data bases; a variety of cover types representative of those to be encountered in the national assessment; and ability to support ongoing research in EMAP and the U.S. F.W.S. GAP Analysis Project.

The pilot projects are being designed to address the following research issues and questions:

- Is the AVHRR land classification (Loveland et al. 1991) an ecologically meaningful representation of landscape diversity?
- Can vertebrate diversity be meaningfully associated with landscape diversity?
- Will existing stressor data bases allow an adequate characterization of risks to biodiversity?

The pilot projects will have somewhat different research orientations due to differences in data availability, scale, and issues being addressed. One or more of the following activities will occur as appropriate:

- Vertebrate species will be allocated to hexagons. In some cases rare plants and some invertebrates will be allocated as well.
- AVHRR landscape representations will be compared to GAP Thematic Mapper vegetation maps.
- Landscape and species data will be analyzed for spatial pattern, type of diversity represented, and interaction effects between the two kinds of data.
- Stressor data will be prioritized, analyzed for allocation to the hexagon spatial framework, and developed into a data base as feasible.

REGIONAL

EPA's Global Change Research Program has recently awarded a competitive cooperative agreement to Dr. W. Carter Johnson, South Dakota State University, to evaluate potential consequences of global climate change and other environmental factors on migratory waterfowl populations in the glaciated prairie region of North America. The investigators will be working in collaboration with related research programs in the USFWS, U.S. Bureau of Reclamation, and the U.S. Geological Survey. Global circulation models project a warmer and drier climate for this region, and initial model simulations indicate that this could cause a dramatic decline in habitat quality and waterfowl production. The research will investigate major factors affecting waterfowl populations through literature review, agency statistics, statistical analyses, simulation model development, and remote sensing. Simulations will enable assessment of the waterfowl resource and its vulnerability to singular effects of climate change. A remote sensing protocol will be developed for early detection of the climate change signal in prairie wetlands.

WATERSHED

As a part of EPA's Midwest Agrichemical Surface/Subsurface Transport and Effects Research Project (MASTER), EPA is evaluating how changes in composition and quality of habitat types and their spatial arrangement affect environmental quality, ecological processes, and species composition and abundance. The Walnut Creek watershed in Iowa, a watershed containing one of the U.S. Department of Agriculture Management Systems Evaluation Areas (MSEA), was selected for study.

The long-term goal of terrestrial research is to develop a land-use plan for the watershed that maximizes ecological benefits to terrestrial flora and fauna while maintaining an acceptable level of agricultural production. Among major research objectives are: (1) development of a landscape model for evaluating potential benefits to terrestrial biota from alternative land uses, management practices, and habitat manipulations without compromising commodity yields, and (2) evaluation of impact of agrichemicals, other agricultural practices, and habitat factors on terrestrial biota.

SUMMARY

EPA is currently developing tools that will enable managers to evaluate changes to biodiversity at national, regional, and watershed scales. These tools are being developed in cooperation with other federal agencies as well as with universities and will provide a framework for risk based assessment and management of habitat and biodiversity.

ACKNOWLEDGEMENTS

We would like to acknowledge Ross Kiester, Denis White, Thomas Loveland, Lawrence Master, J. Michael Scott, and others who have contributed to EPA's Habitat/Biodiversity Initiative. We would also like to thank the cited researchers who graciously allowed us to reference their unpublished research in progress.

REFERENCES

Council on Environmental Quality. 1991. Environmental Quality: 21st Annual Report.

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries (Bethesda) 6:21-27.

Loveland, T. R., J. W. Merchant, D. O. Ohlen, J. F. Brown. 1991. Development of a land-cover characteristics database for the conterminous U.S. Photog. Eng. Remote Sensing 57:1453-1463.

Messer, J. J., R. A. Linthurst, W. S. Overton. 1991. An EPA program for monitoring ecological status and trends. Environ. Monit. Assess. 17:67-78.

Overton, W.S., D. White, and D. L. Stevens. 1990. Design Report for EMAP. EPA/600/3-91/053. Environmental Research Laboratory, Corvallis, Oregon.

U.S. Environmental Protection Agency (EPA). 1990. Reducing Risk: Setting Priorities and Strategies for Environmental Protection. Science Advisory Board SAB-EC-90-021, Washington, DC.

White, D., A. J. Kimmerling, and W. S. Overton. 1992. Cartographic and Geometric Components of a Global Sampling Design for Environmental Monitoring. Cart. Geog. Inf. Syst. 19:5-22.

A Checklist Approach for Monitoring Neotropical Migrant Birds: Twenty-year Trends in Birds of Québec Using ÉPOQ

André Cyr[1] and Jacques Larivée[2]

Abstract — ÉPOQ (Studies of Bird Populations in Québec) is a data base on birds of Québec containing more than 2.2 million records of observations recorded on 158,000 checklists from 3,600 observation sites since 1950. Trends were measured for each of four subsets of ÉPOQ data between 1970 and 1989 (all year, spring (April-May), summer (June-July), and fall (August-October) as well as for BBS (Breeding Bird Survey of U.S. Fish Wildl. Serv.) data for Québec (1969 to 1989). Species were then separated into neotropical and temperate migrants, and trends compared between ÉPOQ subsets and data bases. The all year-ÉPOQ subset reflects very well the dominantly decreasing trends of many neotropical and temperate migrant species that are also decreasing in the other data subsets (spring, summer and fall). In the summer-ÉPOQ subset and in BBS, there are more increasing trends when no trend was recorded in the all year-ÉPOQ subset. Most trends are similar for both ÉPOQ and BBS, except for nine of 74 species studied. General trends indicate significant decreases for 25 neotropical and 17 temperate migrants, and significant increases for 10 neotropical and 8 temperate migrants. Significantly decreasing species in all year-ÉPOQ belong to bird assemblages from maple forests, agricultural habitats, insectivorous in flight, and edge species, whereas non-significant trends in all year ÉPOQ or significantly increasing trends mainly in the summer-ÉPOQ or in BBS reveal more species belonging to boreal forest ecosystems.

INTRODUCTION

Several methods have been used to monitor bird populations on broad scales (Kendeigh 1944, Anonymous 1970, Berthold 1976, Källander *et al.* 1977, Ralph and Scott 1981, Verner 1985). In North America, long term trend studies have been possible mainly through the Breeding Bird Survey (BBS) (Robbins *et al.* 1986).

Temple and Cary (1990) provide evidence that checklists relate well to other data sets, including the Christmas Bird Count. In Québec, Victor Gaboriault (David 1978) started in 1948 a program of collecting sightings of birds recorded on field checklists. In 1975, a computer coding of all data was undertaken, and expanded to the present. The data base, called ÉPOQ (*Étude des Populations d'Oiseaux du Québec* or Studies of Bird Populations in Québec) currently includes over 2.2 million data from 158,000 checklists, and 3,600 localities. Since 1970, between 2,000 and 10,000 checklists have been completed per year. These sample sizes fulfill one criteria for using EFP (Gradual Frequency Sampling) of Blondel *et al.* (1981) which have proven useful to generate estimates of richness and abundance as long as sample size was large.

Cyr and Larivée (1980) and Larivée (1989) presented preliminary studies of ÉPOQ data. Otherwise, there has been no attempt to analyse in some detail the value of these data, nor to compare trends derived from them with other data sets, except for a very brief mention in Droege (1990), and Dunn (1991). In this paper we present ÉPOQ, and evaluate trends in neotropical and temperate migrant birds of Québec, comparing

[1] *Biology Dept., Sherbrooke University, Sherbrooke, J1K 2R1, Québec, Canada.*

[2] *CEGEP de Rimouski, Rimouski, G5L 4R5, Québec, Canada.*

data and trends from different subsets of EPOQ and BBS over a 20 year period. From these results we expect to provide managers with a new tool to evaluate trends in migrant birds that would help to understand, and manage properly all species for which there is definite concern in regard to their decline.

METHODS

ÉPOQ contains information from checklists. A standard one contains all species regularly seen or heard in Québec. Volunteer observers report in field checklists the number (or its closest estimate) of all bird species seen or heard at any one observation site (locality or area coded to the nearest 00°01' of latitude and longitude) on any single day. The most important criteria for filling a checklist are one observation site and one date per checklist, whatever the season, duration of field trip, habitats covered, and number of observers. Observers also report date, time of beginning and end of the field trip (for coding of duration), name of site (or distance and direction to nearest locality or geographical feature), and names of observers. Each species is given a coding number on the checklist.

Data extracted for the present study, south of 52°N latitude in Québec, cover 1970 to 1989. Data were further separated into subsets: all year, spring (April-May), summer (June-July), and fall (August-October). Species reported on 100 or more checklists were considered for this study. Total sample size considered was all year (four seasons): 125,713, spring: 39,157, summer: 61,150, and fall: 26,302 checklists.As data were still being entered in ÉPOQ between the data extraction process for each sample, sample size for all year data set is smaller than the samples per season.

From ÉPOQ, given the total number of checklists (S) for any time period or area considered, and number of checklists (or sample size per species) on which each species was encountered (N), frequency (in %) of checklists that contain a species (C=N*100/S) was calculated for each species for each subset. The slope of the regression over years for frequency (C) was used as a measure of trend for each species.

BBS data used are from Québec routes only. Refer to Robbins and Van Velzen (1967) and Robbins *et al.* (1986) for a technique description. Data represent bird numbers per route of 50 stops censused during three minutes each, once during the breeding season between a half hour before to about 4 $^{1}/2$ hours after sunrise. Species reported on 10 or more BBS routes were considered for this study. Median estimate percent of change in population size was calculated according to a procedure currently used at the U.S. Fish and Wildlife Service (Sam Droege kindly provided the analysed data for Québec). See Robbins *et al.* (1986) for other trend analyses.

Seventy four (74) species were selected and separated into neotropical and temperate migrants after Droege and Sauer (1988), Hussell *et al.* (1992), and Witham and Hunter (1992). Comparisons were then made between different subsets of ÉPOQ, and between ÉPOQ and BBS data.

RESULTS

Of 74 species considered, 46 were neotropical and 28 temperate migrants, all breeding in Québec (Table 1). Species sample sizes from total checklist number (all year-ÉPOQ) varied between 1,195 (Olive-sided Flycatcher, *Contopus borealis*) to 47,000 for European Starling (*Sturnus vulgaris*). Samples were smaller for any one season ranging from 122 (Indigo Bunting, *Passerina cyanea*, in fall) to 20,854 (American Robin, *Turdus migratorius*, in spring).

Since number of species showing a significant trend in any ÉPOQ subset was larger in all year subset, the neotropical and temperate migrants were separated into two groups each, one in which all species showed a significant trend, positive or negative, in the all year subset and one in which no species showed a significant trend. In Table 2, species were grouped according to statistical significance in combinations of ÉPOQ subsets or BBS data.

All year-ÉPOQ showed the highest number of significant trends for neotropical (25, all declining) and temperate (18, 17 of which were declining) migrants (Table 2A). Species showing a significant trend were not always the same between subsets, but all year-ÉPOQ decreasing trends were often reflected by similar trends in more than one season. Increasing trends were more often obvious in summer-ÉPOQ and BBS (Table 2B and 3). Compared to ÉPOQ subsets, BBS showed fewer species with a significant trend (Table 2A,B).

More trends followed the same direction between ÉPOQ and BBS, except for six of 74 species studied (see also Dunn 1991). Red-eyed Vireo (*Vireo olivaceus*), American Redstart (*Setophaga ruticilla*), American Robin, American Crow (*Corvus brachyrhynchos*), Olive-sided Flycatcher (*Contopus borealis*), and Cedar Waxwing (*Bombycilla cedrorum*) were noteworthy for contradictory trends between the two methods (Table 2A), the contradictory trends never exceeding 2,7% for any one data set. For both neotropical and temperate migrants for which BBS results showed a significant negative trend, ÉPOQ results were also significantly decreasing for all species in all subsets except for one season for Bobolink (*Dolichonyx oryzivorus*)(summer, n.s.).

For species showing a positive significant trend in BBS, the trend analysis from ÉPOQ revealed mixed trends for all subsets for both neotropical and temperate migrants, but summer-ÉPOQ follow the same positive significant trend as BBS more often than results from other seasons (Table 2B and 3), and more so for neotropical migrants with almost 70% showing consistency (Table 3).

All species were assigned a general habitat type or guild to which each belonged and the total number of species presenting a significant trend, either positive or negative in ÉPOQ subsets or BBS were then calculated per habitat type or guild. Guilds and bird assemblages were quite different for species showing a significant decreasing or increasing trend.

Table 1. — Number of checklists containing each species (N), slope of the frequency distribution (C), and significance level (P) for ÉPOQ-all year, spring, summer and fall bird data (1970-89), and BBS median estimate of trend and significance level (1969-89). Significance levels are * = P < 0.05, ** = P < 0.01, *** = P < 0.001; n.s. = non significant. See appendix for scientific names.

DATA BASE	ÉPOQ												BBS	
Species	ALL YEAR			SPRING			SUMMER			FALL				
	N	C	P	N	C	P	N	C	P	N	C	P	Median	P
NEOTROPICAL MIGRANTS														
Broad-winged Hawk	3742	-0,01	n.s.	1771	0,01	n.s.	1215	0,13	n.s.	708	-0,02	n.s.	4,5	
Common Nighthawk	1997	-0,1	***	279	-0,05	***	1097	-0,33	***	619	-0,10	**	-3,1	**
Chimney Swift	3807	-0,28	***	1397	-0,30	***	1830	-0,68	***	580	-0,20	***	-1,1	
Ruby-throated Hummingbird	5231	-0,07	*	1240	-0,05	n.s.	2264	0,02	n.s.	1727	-0,14	n.s.	-1,5	
Olive-sided Flycatcher	1611	-0,03	n.s.	291	0,01	n.s.	1125	-0,02	n.s.	193	-0,07	***	4,3	*
Eastern Wood-Pewee	4996	-0,16	***	794	-0,06	*	2935	-0,27	*	1265	-0,31	**	0,7	
Yellow-bellied Flycatcher	1195	0,01	n.s.	181	0,00	n.s.	811	0,19	*	200	-0,04	**	12,6	
Alder Flycatcher	5370	0,06	n.s.	652	0,04	*	3885	0,5	**	832	0,02	n.s.	9,9	***
Least Flycatcher	7162	-0,15	***	2682	-0,15	**	3900	-0,18	n.s.	579	-0,05	n.s.	0,4	
Great crested Flycatcher	3478	-0,04	n.s.	1544	0,02	n.s.	1622	-0,03	n.s.	308	-0,05	n.s.	0,9	
Eastern Kingbird	9300	-0,06	n.s.	2537	0,04	n.s.	4967	0,09	n.s.	1794	-0,11	n.s.	2,1	
Purple Martin	2386	-0,15	**	1043	-0,19	**	819	-0,23	*	523	-0,18	**	-3,5	
Bank Swallow	7497	-0,24	***	2061	-0,28	***	4168	-0,21	n.s.	1266	-0,29	***	0,9	
Cliff Swallow	3344	-0,03	n.s.	1229	-0,02	n.s.	1724	0,07	n.s.	388	-0,04	n.s.	2,8	
Barn Swallow	16130	-0,65	***	5964	-0,68	***	7138	-1	***	3007	-0,77	***	-1,7	*
Veery	8741	-0,16	***	2864	-0,25	***	5083	0,04	n.s.	789	-0,06	n.s.	-1,5	
Swainson's Thrush	7788	-0,12	n.s.	1526	-0,11	*	4576	-0,03	n.s.	1669	-0,15	n.s.	2,7	
Wood Thrush	2941	-0,18	***	1340	-0,20	**	1381	-0,41	***	220	-0,14	***	-2,5	
Gray Catbird	7197	-0,33	***	2090	-0,35	***	2988	-0,56	**	2108	-0,42	***	-2,2	*
Solitary Vireo	2321	0,01	n.s.	1003	0,00	n.s.	833	0,17	**	484	-0,02	n.s.	13,3	***
Warbling Vireo	2433	0,02	n.s.	972	0,02	n.s.	1151	0,19	n.s.	310	0,01	n.s.	2,6	*
Philadelphia Vireo	3066	0,01	n.s.	784	0,05	n.s.	1622	0,12	n.s.	658	-0,01	n.s.	2,7	
Red-eyed Vireo	8564	-0,1	*	1276	0,02	n.s.	5600	-0,18	n.s.	1684	-0,12	n.s.	5,4	***
Nashville Warbler	7193	-0,15	*	2819	-0,24	*	2674	0,11	n.s.	1698	-0,16	n.s.	10,9	
Parula Warbler	2247	-0,05	n.s.	1013	-0,10	*	811	0,01	n.s.	423	-0,02	n.s.	-2,2	
Yellow Warbler	8420	-0,14	**	3065	-0,04	n.s.	4322	-0,02	n.s.	1030	-0,25	***	2,2	
Chestnut-sided Warbler	5106	-0,12	*	1731	-0,12	n.s.	2900	-0,16	n.s.	474	-0,04	n.s.	-1,6	
Magnolia Warbler	6965	-0,03	n.s.	2029	-0,10	n.s.	3434	0,38	*	1501	-0,05	n.s.	6,8	**
Cape May Warbler	3304	-0,04	n.s.	1884	-0,08	n.s.	859	0,07	n.s.	560	-0,05	n.s.	2,4	
Black-throated blue Warbler	3608	-0,11	**	1788	-0,19	*	1341	-0,03	n.s.	475	-0,06	n.s.	0,8	
Black-throated green Warbler	5978	-0,11	*	2274	-0,14	*	2356	0,05	n.s.	1342	-0,10	n.s.	-3,1	
Brown-headed Cowbird	21776	-0,67	***	13967	-0,79	***	4674	-0,95	***	1565	-0,54	***	-3,6	***
Purple Finch	17480	0,03	n.s.	7094	-0,10	n.s.	4816	0,03	n.s.	3227	0,42	**	3,6	*
American Goldfinch	22685	-0,18	n.s.	5735	-0,06	n.s.	7467	-0,37	n.s.	6500	-0,48	*	-1	
Neotropical migrants														
Number of species with P < 0.05			25			19			17			18		12
Number of species with P n.s.			21			27			29			28		34
Temperate migrants														
Number of species with P < 0.05			18			17			13			17		12
Number of species with P n.s.			10			11			15			11		16

Species showing a decreasing trend preferred maple forests, preferred agricultural habitats, were insectivorous in flight, or lived in edges (significant trends in all year-ÉPOQ);(Table 2A). Many icterids were also decreasing. No declining temperate migrants were found in maple forests, compared to eight neotropical species. More temperate (seven) than neotropical migrants (five) were from agricultural areas. Insectivorous and edge species were more numerous among declining neotropical species.

The pattern was very different for the group of species which showed no significant trend in all year-ÉPOQ (Table 2B). Most were increasing if anything in both summer-ÉPOQ and BBS, the trend being sometimes reversed for a different season (either spring or fall). Trends that were more consistent included species with similar significant trends from different subsets or data base. There were four such neotropical and three temperate migrants. Three neotropical and two temperate migrants showed reverse trends but not in the same season (Table 2B). Most birds showing a general significant increase belonged to boreal forest ecosystems (non-significant trends in all year-ÉPOQ) (Table 2B).

DISCUSSION

Using a checklist approach to census birds by volunteers allow the gathering of information on all species of any area, or any season, whether the bird is common or uncommon, or even only localized. Thus, any species falling into the category of neotropical migrant can be assessed to some degree with this method, because, even if it less common, the calculation involved in evaluation of long term trends is based on the ratio of total number of checklists containing this species over the total number of checklist reported. From a total sample size of

Table 2A. — Neotropical and temperate migrant birds grouped by data sets showing a significant trend in ÉPOQ-all year. Negative (-) or positive (+) trends are shown whenever they were significant in Table 1. Total number of species per habitat or guild and per data set are also given.

NEOTROPICAL MIGRANTS

Species	Habitat* or guild	ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
Significants in ÉPOQ- all year						
Red-eyed Vireo	M	-				+
Ruby-throated Hummingbird	O	-				
Chestnut-sided Warbler	E	-				
Ovenbird	M	-				
Common Yellowthroat	O	-				
Significants in ÉPOQ-all year & fall						
Yellow Warbler	A-E	-			-	
Wilson's Warbler	E	-			-	
American Redstart	In	-			-	+
Significants in ÉPOQ-all year, summer & fall						
Indigo Bunting	E	-		-	-	
Significants in ÉPOQ-all year & spring						
Veery	M	-	-			
Least Flycatcher	M	-	-			
Black-throated blue Warbler	M	-	-			
Nashville Warbler	A-E	-	-			
Black-throated green Warbler	BF	-	-			
Significants in ÉPOQ-all year, spring & fall						
Bank Swallow	In	-	-		-	
Bobolink	A-Ict	-	-		-	-
Scarlet Tanager	M	-	-		-	
Significants in all ÉPOQ subsets						
Common Nighthawk	In	-	-	-	-	-
Barn Swallow	A-In	-	-	-	-	-
Gray Catbird	A-E	-	-	-	-	-
Chimney Swift	In	-	-	-	-	
Wood Thrush	M	-	-	-	-	
Purple Martin	In	-	-	-	-	
Eastern Wood-Pewee	M-In	-	-	-	-	
Northern Oriole	Ict	-	-	-	-	
TOTAL (negative trend)		25	16	9	15	3
TOTAL (positive trend)						2

TEMPERATE MIGRANTS

Species	Habitat*	ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
Significants in ÉPOQ-all year & fall						
American Robin	O	-			-	+
Winter Wren	BF	-			-	
Significants in ÉPOQ-all year, spring & summer						
Eastern Phoebe	In	-	-	-		
White-throated Sparrow	BF	-	-	-		
Significants in ÉPOQ-all year & spring						
Ruby-crowned Kinglet	BF	-	-			
Chipping Sparrow	O	-	-			
American Crow	O	-	-			+
Significants in ÉPOQ-all year, spring & fall						
Yellow-bellied Sapsucker	O	-	-		-	
Savannah Sparrow	A	-	-		-	
European Starling	O	-	-		-	
Significants in all ÉPOQ subsets						
Brown-headed Cowbird	Ict	-	-	-	-	-
Mourning Dove	O	+	+	+	+	+
Northern Flicker	A-E	-	-	-	-	
Brown Thrasher	A	-	-	-	-	
Song Sparrow	A	-	-	-	-	
Common Grackle	A-Ict	-	-	-	-	
Eastern Meadowlark	A-Ict	-	-	-	-	-
Vesper Sparrow	A	-	-	-	-	-
TOTAL (negative trend)		17	15	9	12	3
TOTAL (positive trend)		1	1	1	1	3

SUMMARY PER GUILD AND HABITAT

NEOTROPICAL MIGRANTS

Guild or habitat	Number of species per habitat	Number species significantly decreasing (or increasing +) per habitat or guild — ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
Agricultural (A)	5	5		2	4	3
Boreal Forest (BF)	1	1	1			
Edge (E)	6	6	2	2	4	1
Icterid (Ict)	2	2	2	1	2	1
Insectivorous (In)	7	7	6	3	7	2(1+)
Maple forest (M)	8	8	6	1	3	(1+)
Regrowth (Rgr)						
Other (O)	2	2				

TEMPERATE MIGRANTS

Guild or habitat	Number of species per habitat	Number species significantly decreasing (or increasing +) per habitat or guild — ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
Agricultural (A)	7	7	7	6	7	2
Boreal Forest (BF)	3	3	2		1	
Edge (E)	1	1	1	1	1	
Icterid (Ict)	3	3	3	3	3	2
Insectivorous(In)	1	1	1	1		
Maple forest (M)						
Regrowth (Rgr)						
Other (O)	5	5(1+)	4(1+)		3(1+)	(3+)

Table 2B. — Neotropical and temperate migrant birds grouped by data sets showing a non significant trend in ÉPOQ-all year. Negative (-) or positive (+) trends are shown whenever they were significant in Table 1. Total number of species per habitat or guild and per data set are also given.

NEOTROPICAL MIGRANTS

Species	Habitat* or guild	ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
Non-significant in ÉPOQ- all year nor in other seasons						
Warbling Vireo	O					+
Broad-winged Hawk	O					
Great crested Flycatcher	In					
Eastern Kingbird	In					
Cliff Swallow	In					
Philadelphia Vireo	BF					
Cape May Warbler	BF					
Blackpoll Warbler	BF					
Mourning Warbler	O					
Rose-breasted Grosbeak	O					
Non-significant in ÉPOQ- all year but so in summer						
Blackburnian Warbler	BF			+		
Solitary Vireo	BF			+		+
Black-and-white Warbler	BF			+		+
Magnolia Warbler	BF			+		+
Lincoln Sparrow	Rgr			+		
Non-significant in ÉPOQ- all year but so in fall						
Olive-sided Flycatcher	BF				-	+
Non-significant in ÉPOQ- all year but so in summer & fall						
Yellow-bellied Flycatcher	BF			+	-	
Northern Waterthrush	BF			+	-	
Non-significant in ÉPOQ- all year but so in spring						
Swainson's Thrush	BF		-			
Parula Warbler	BF		-			
Non-significant in ÉPOQ- all year but so in spring & summer						
Alder Flycatcher	Rgr		+	+		+
TOTAL (negative trend)			2		3	
TOTAL (positive trend)			1	8		6

TEMPERATE MIGRANTS

Species	Habitat*	ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
Hermit Thrush	BF					+
Dark-eyed Junco	BF					+
Blue Jay	O					
House Wren	O					
Fox Sparrow	BF			+		+
Purple Finch	BF				+	+
Cedar Waxwing	O				-	+
American Goldfinch	O				-	
Golden-crowned Kinglet	BF			+	+	+
Yellow-rumped Warbler	BF		-	+		
TOTAL (negative trend)			1		2	
TOTAL (positive trend)				3	2	6

SUMMARY PER GUILD AND HABITAT

NEOTROPICAL MIGRANTS

Guild or habitat	Number of species per habitat	ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
		Number species significantly increasing (or decreasing -) per habitat or guild				
Agricultural (A)						
Boreal Forest (BF)	12		(2-)	6	(3-)	4
Edge (E)						
Icterid (Ict)						
Insectivorous (In)	3					
Maple forest (M)						
Regrowth (Rgr)	2			2		
Other (O)	4					1

TEMPERATE MIGRANTS

Guild or habitat	Number of species per habitat	ÉPOQ data sets: All year	Spring	Summer	Fall	BBS
		Number species significantly increasing (or decreasing -) per habitat or guild				
Agricultural (A)						
Boreal Forest (BF)	6		(1-)	3	2	5
Edge (E)						
Icterid (Ict)						
Insectivorous (In)						
Maple forest (M)						
Regrowth (Rgr)						
Other (O)	4				(2-)	1

* A=Agricultural, BF=Boreal Forest, Edge=E, Ict=Icterid, In=Insectivorous, M=Maple forest, Rgr=Regrowth, O=Other.

about 10,000 new checklists per year, any probability of finding any species can be calculated, and should be comparable between years or localities.

BBS could not be compared with other data bases up to now in Québec and very seldom elsewhere (Droege 1990 and references therein, Dunn 1991). Because most trends followed the same direction both in EPOQ and BBS, the value of both methods are reciprocally enhanced, even though very different methods were used.

General trends of many neotropical migrants showed many species might have suffered from management practices over the last 20 years, that affected at the same time many other

Table 3. — Consistency between BBS and the various ÉPOQ data sets. Trends are expressed in number of species of neotropical and temperate migrant birds per category. Highly consistent: trends are the same in both data sets. Relatively consistent: trends are in the same direction, but significance level differ. Inconsistent: trends are not in the same direction but one may be significant. Contradictory: trends are significant in opposite directions.

BBS versus		Neotropical mibrants				Temperate migrants			
	ÉPOQ	All year	Spring	Summer	Fall	All year	Spring	Summer	Fall
Highly consistent									
*+ *+		-	-	-	-	1	1	3	3
*- *-		4	5	8	4	3	3	3	3
+ +		4	6	9	1	-	-	1	1
- -		1	3	2	4	1	1	3	-
0 0									
	Total	9	14	19	9	5	5	10	7
Relatively consistent									
*+ +		3	3	5	4	3	4	4	3
*- -		9	6	4	4	5	5	3	5
+ 0		7	6	4	7	1	1	-	3
- 0		-	1	-	2	-	-	-	-
	Total	19	16	13	17	9	10	7	11
Inconsistent									
*+ 0		3	1	2	1	1	-	-	1
*- 0		-	-	-	-	-	-	-	
+ -		3	4	9	8	2	2	5	1
*+ -			3	1	2	2	3	3	-
*- +		10	8	2	7	7	7	3	6
	Total	16	16	14	18	12	12	11	8
Contradictory									
*+ *-		2	-	-	2	2	1	-	2
	Total	2	-	-	2	2	1	-	2
Consistent total		28	30	32	26	14	15	17	18
	Percent	60,87	65,22	69,57	56,52	50	53,57	60,71	64,29
Inconsistent total		18	16	14	20	14	13	11	10
	Percent	39,13	34,78	30,43	43,48	50	46,43	39,29	35,71

Total all migrants		All year	Spring	Summer	Fall
Consistent		42	45	49	44
	Percent	56,76	60,81	66,22	59,46
Inconsistent		32	29	25	30
	Percent	43,24	39,19	33,78	40,54

* = Statistically significant
*+ = Significantly positive
*- = Significantly negative
\+ = Positive, but not significant
\- = Negative, but not significant
0 = No trend

* A=Agricultural, BF=Boreal Forest, Edge=E, Ict=Icterid, In=Insectivorous, M=Maple forest, Rgr=Regrowth, O=Other.

temperate species. It is already known from trends derived from BBS that some populations of a species do not react the same way to the environment in different parts of its whole range or throughout the continent (Robbins *et al.* 1986). This might apply as well in the Québec region. When trends were not the same between ÉPOQ and BBS or between any ÉPOQ subsets, it often involved species reaching their northern distributional limit in Québec (for example Yellow-rumped Warbler, *Dendroica coronata*). Understanding these differences will require further field studies.

Obviously, species showing significant declining trend in more than one data base, and in more than one data set in ÉPOQ, should receive special attention (eight neotropical and seven temperate migrants in Table 2A).

In agricultural habitats, long term effects of pesticides on bird populations are still poorly documented. Reduction in amount of edges and hedgerows can affect many species that depend upon these for cover and feeding. Overuse of the land and reduced habitat diversity is also a problem that is more obvious in some parts of the southern portion of the Saint-Lawrence valley agricultural area. Many icterids also belong to this habitat type, and all are declining, whether neotropical or temperate migrants. Bollinger and Gavin (1992) mention that many factors contribute simultaneously to declines, especially loss of old hayfields for nesting Bobolink. Edge species are also affected by a mixture of disturbances applying both to agricultural landscapes and forest fragmentation (Freemark and Collins 1992).

Although evidence is still lacking at this point, many factors might affect the insectivorous species in flight: availability of nesting places (Chimney Swift, *Chaetura pelagica*), insect spraying with pesticides in agricultural areas, drainage in lakes and waterway, exploitation of sand banks and harassment by four wheel bikers (Bank Swallows, *Riparia riparia*), warming of climate, reduced insect diversity in agricultural landscapes, lack or reduction of natural ponds and streams for insect reproduction, and overuse of the land for agriculture without refuge area for insects to reproduce.

Boreal forest ecosystems have spread in previously forested areas of different types as a result of conversion to coniferous monocultures. This has had a positive impact on many species.

Spring-ÉPOQ or fall subsets also provide data on species that differ between seasons due to different migration routes each species follows in both seasons. With large sample sizes, trends during migration can be detected and be meaningful, especially if there are no other means to assess populations during other seasons (Dunn 1992). Our checklist program to evaluate trends during migration corroborates many trends shown by BBS and ÉPOQ during other seasons. It provides strong evidence that less standardized methods can yield very significant results for analysis of neotropical migrant bird trends on a regional or national scale during migration.

For a census program to be successful, information on all species in all habitats and seasons should be sought, because some seasons yield special information on many birds that might not otherwise be determined. One reason ÉPOQ is valuable is the huge amount of data available, with checklists being gathered at a rate of 10,000 per year containing 150,000 records gathered by volunteers. This smooths out biases related to the less standardized methods of ÉPOQ, even when different seasons are considered. Large ÉPOQ sample sizes bring further confidence in values of trends for many other species not dealt with by BBS.

ACKNOWLEDGEMENTS

This work would not have been possible without the enthusiasm of thousands of amateurs in the field reporting their sightings on checklists for a long period of time, especially during less favourable weather conditions of spring and fall. Also invaluable were hours spent by many who transcribed the data into the data base. Members of the Club des Ornithologues du Québec and the Association Québécoise des Groupes d'Ornithologues are gratefully aknowledged for providing the framework of this program. Our thanks also apply to the volunteers from the BBS program, most of whom participated in both programs. Sam Droege kindly provided the Quebec-BBS data from which comparisons were made possible. Jean-Marie Bergeron, Greg Butcher, Deborah M. Finch, William Shipley, and Peter Stangel provided helpful comments on the manuscript.

REFERENCES

Anonymous. 1970. Recommendations for an international standard for a mapping method in bird census work. Pp 49-52 *In* : Bird census work and environmental monitoring, S. Svensson (ed.). Bul. Ecol. Res. Comm. 9, Swedish Nat. Sci. Res. Counc., Stockholm.

Berthold, P. 1976. Methoden des Bestandserfassung in der Ornithologie: Übersicht und kritische Betrachtung. J. Ornithol. 117: 1-69.

Blondel, J., C. Ferry, and B. Frochot. 1981. Point counts with unlimited distance. Stud. Avian Biol. 6: 414-420.

Bollinger, E. K., and T. A. Gavin. 1992. Eastern Bobolink populations: Ecology and conservation in an agricultural landscape. Pages 497-506. *In* : J. M. Hagan, and D.W. Johnston III. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington. 609 pp.

Cyr, A. et J. Larivée. 1980. Significance of data collected on birds of Quebec, Canada, by non-standardized methods. In: H. Oelke (ed.), Bird Census Work and Nature Conservation. Dachverbandes Deutscher Avifaunisten, Göttingen, pp. 66-76.

David, N. 1978. Victor Gaboriault, Ornithologue. Cahiers d'ornithologie Victor-Gaboriault no. 1. Club des Ornithologues du Québec, Québec, 46pp.

Droege 1990. The North American Breeding Bird Survey. Pp. 1-4. *In* : J. R. Sauer, and S. Droege, eds., Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish Wildl. Ser., Biol. Rep. 90(1). 166pp.

Droege, S. et J.R. Sauer. 1988. North American breeding bird survey annual summary 1988. U.S. Fish Wildlife Serv., Biol. Rep. 89 (13), 12pp.

Dunn, E. 1991. Population trends in Canadian songbirds. Bird Trends, Can. Wildl. Serv. 1: 2-11.

Freemark, K., and B.Collins. 1992. Landscape ecology in birds breeding in temperate forest fragments. Pages 443-454. *In* : Hagan, J.M. et D.W. Johnston III. 1992. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington. 609 pp.

Hussell, D. J. T., M. H. Mather, and P. H. Sinclair. 1992. Trends in numbers of tropical- and temperate-wintering migrants landbirds in migration at Long Point, Ontario, 1961-1988. *In* : Ecology and Conservation of Neotropical Migrant Landbirds, J. M. Hagan III and D. W. Johnston (eds.), Smithsonian Institution Press, Washington, pp.101-114.

Källander, H., S. G. Nilsson, and S. Svensson. 1977. The Swedish winter bird census programme. Polish Ecol. Stud. 3(4): 77-88.

Kendeigh, C. S. 1944. Measurement of bird populations. Ecol. Monogr. 14: 67-106.

Larivée, J. 1990. Variation des observations d'oiseaux du Québec méridional de 1969 à 1988. Carnets de Zoologie 49: 83-90.

Ralph, C. J., and J. M. Scott. 1981. Estimating numbers of terrestrial birds. Studies Avian Biol. 6: 1-630.

Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. The Breeding Bird Survey: its first fifteen years, 1965-1979. U.S. Dept. of Int., Fish & Wildl. Serv., Resource Publ. 157, Washington, D.C.

Robbins, C. S., and W. T. Van Velzen. 1967. The Breeding Bird Survey, 1966. Bur. Sport Fish. Wildl., Spec. Sci. Rep. — Wildl. 102: 1-43

Temple, S. A., and J. R. Cary. 1990. Using checklist records to reveal trends in bird populations. Pp 98-104 *In* : Survey designs and statistical methods for the estimation of avian population trends., J. R. Sauer and S. Droege, eds., U. S. Fish Wildl. Serv., Biol. Report 90(1).

Verner, J. 1985. Assessment of counting techniques. Pp. 247-302 *In* : Current Ornithology, vol. 2, R. F. Johnston, ed., New York, Plenum Press.

Witham, J. W. and M. L. Hunter, Jr. 1992. Population trends of neotropical migrant landbirds in northern coastal New England. *In* : Ecology and Conservation of Neotropical Migrant Landbirds, J. M. Hagan III and D. W. Johnston (eds.), Smithsonian Institution Press, Washington, pp. 85-95.

Evaluation of Mist-netting, Nest-searching and Other Methods for Monitoring Demographic Processes in Landbird Populations

Nadav Nur and Geoffrey R. Geupel[1]

Abstract — Demographic processes (reproductive success, survival of young and adults, recruitment of young into the breeding population) are critical to monitoring and managing landbird populations. We discuss different techniques that have been used to monitor these demographic processes in landbird populations, focusing on constant-effort mist-netting (CEM). We assess whether CEM can provide valid measures of year-to-year variation in fecundity, by comparing fledgling production (determined from intensive nest-searching and -monitoring) with mist net captures of Hatching Year birds. In addition to assessing bias in capture and recapture of Wrentit adults, we consider whether estimates of adult survival obtained from mist net capture-recapture data are accurate.

Among Wrentits the number of locally-born young caught in nets mirrored the local production of fledglings, but the overall number of HY birds caught did not track local production of young. In contrast, the number of HY Song Sparrows caught reflected local production of Song Sparrow fledglings, thus demonstrating variation between species in the ability of CEM to track changes in local productivity. With regard to Wrentit adults, mist nets tended to catch mostly non-breeders (floaters), as opposed to breeders. Recapture probability (within season and between seasons) was high among breeders (71% recapture probability between years) but low among non-breeders (5% recapture probability between years). Survival was accurately estimated from capture/recapture data, provided that breeders could be distinguished from non-breeders. Breeders were very likely to be recaught, thus providing no evidence of net-avoidance. Results suggest that a low rate of recapturing adults in subsequent breeding seasons (obtained in some CEM studies) reflects inclusion of transient non-breeders with more philopatric breeders.

We recommend: 1) That the choice of monitoring techniques be tailored to match the objectives of the monitoring program. 2) That more work is needed in developing and validating different monitoring methods, especially with regard to constant-effort mist-netting. 3) That calculations of adult survivorship using mist net capture-recapture data be restricted to (presumed) breeders. 4) That monitoring programs adopt a multi-level, integrated approach, especially if species of special concern have been identified.

INTRODUCTION

Our starting point is the question: What does a manager need to know to manage a species or a set of species? In our opinion, **A manager needs to identify problems (or potential problems), to devise possible solutions, and to monitor these species to determine success of the management action.** To accomplish these objectives requires detailed information on demographic processes (Temple & Wiens 1989). Four critical components of demography are:

1) Adult survivorship

2) Reproductive success (i.e., production of young or productivity),

3) Recruitment of young into the breeding population, and

[1]*Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970*

4) Population size or density (especially breeding population size).

There is widespread consensus that monitoring population density of neotropical migrant birds is critical, but the same consensus has not been reached with regard to the first three demographic components. We focus on these three components because the change in breeding population size from year to year, representing decline or recovery of a species, can be directly attributed to a combination of the first three components and only these components (provided that immigration balances emigration). Our goal is not so much to persuade managers that measuring productivity and survivorship is critical for species of concern (see, for example, DeSante [this volume]), but to consider **how** to carry out a program of monitoring demographic processes.

The Point Reyes Bird Observatory (PRBO) has been involved in research and monitoring of migrant and resident landbird populations for over two decades (Geupel & Nur, this volume). Building on the work of L. Richard Mewaldt, C. J. Ralph, David DeSante, and others at the Observatory, PRBO has developed an integrated, four-level approach to the study of avian population processes. The levels, in order of increasing precision and/or scale of resolution, are:

1) Point counts, to assay breeding population density over a large area,

2) Constant-effort mist-netting (CEM), to provide indices of productivity (specifically, production of independent young) over a moderately large area and, potentially, to provide information on survivorship,

3) Nest-searching and -monitoring, to provide site-specific and habitat-specific information regarding success at producing young, and

4) Spot-mapping of color-banded individuals, to determine breeding status, absolute breeding density and survival of adults.

We recognize that not all managers will be able to implement all the enumerated levels of monitoring, but we wish to encourage adoption of as many as feasible. One of our goals is to provide a persuasive argument that implementing all four levels will provide superior information about the population dynamics of a species of concern and mechanisms underlying observed dynamics.

These monitoring methods can potentially provide critical data for managers, yet their accuracy, utility, and even, in some cases, validity, remain to be established. This is especially true for constant-effort mist-netting, a new monitoring technique that forms the basis of a North American monitoring program (DeSante this volume). CEM has attracted much interest because it can provide information on demographic processes, yet is not as labor-intensive as other methods, e.g., nest-searching (Martin & Geupel in press). Nevertheless, there has been little work to date to validate CEM as a monitoring technique nor to examine assumptions underlying its use - and these are our two overall objectives in this paper. Some more specific questions that we wish to address are:

1) Does the variation in number of Hatching Year birds caught during CEM accurately reflect production of young and other demographic variables? Is there variation among species?

2) Which individuals (among adults) are likely to be caught in nets? How likely are they to be recaught? Are there biases in capture and recapture of individuals?

3) Can capture-recapture data obtained from CEM provide accurate measures of annual adult survival?

We wish to emphasize that in this paper we are evaluating methods to measure year-to-year variation in demography, that is **temporal variation**. Using these methods a manager would be able to monitor trends in time. However, managers will often be interested in variation between patches - even between habitats - that is, **spatial variation**. No one, to our knowledge, has attempted to validate constant-effort mist-netting with respect to spatial variation, though we are currently collecting data that will address this point (Nur & Geupel, unpublished). It would be rash to infer that CEM is valid, or invalid, for monitoring spatial variation, on the basis of its ability, or inability, to monitor temporal variation.

STUDY SPECIES AND STUDY SITE

To evaluate CEM, we have concentrated our efforts on two species, the Song Sparrow (*Melospiza melodia*), a widespread and well-studied species (Nice 1937), and the Wrentit (*Chamaea fasciata*), a much more localized species, restricted to California, Oregon and Baja California, the subject of little study to date (Erickson 1938, Geupel & DeSante 1990).

Field work has been conducted at PRBO's Palomarin Field Station, located just within the southern boundary of Point Reyes National Seashore and adjacent to the Pacific Ocean. On our main study site, 36 ha in size, we carry out all four levels of monitoring: point counts, constant effort mist-netting, nest searches and intensive spotmapping (and behavioral observations) of color-banded bird. Spotmapping of color-banded birds allows us to establish the identity of territory holders. Here we discuss data from the last three mentioned levels only. Fourteen permanent mist net locations have been established in one portion of the 36 ha study grid (Fig. 1), and netting is conducted throughout the year, in a standardized fashion, for three to seven days per week (depending on season). The study site and methods are described in DeSante and Geupel (1987) and Geupel and DeSante (1990). Suffice it to say that we attempt to locate all nests of study species and follow the fate of those nests. Nearly all successful nests (those fledging one or more young) are found before fledging and their young individually color-banded. Additional individuals are color-banded when first caught in mist nets as hatching year (HY) or as after-hatching year (AHY) birds.

Both species are year-round residents at Palomarin. The Wrentit is particularly sedentary (Erickson 1938, Johnson 1972) and thus well suited for estimating survivorship on the basis of capture/recapture data (adults are unlikely to disperse between years). The Song Sparrow shows intraspecific variability in dispersal and migratory tendencies, though the Palomarin population appears fairly sedentary. It is precisely in sedentary populations such as these that we would expect constant-effort mist-netting to be most accurately track the local production of young.

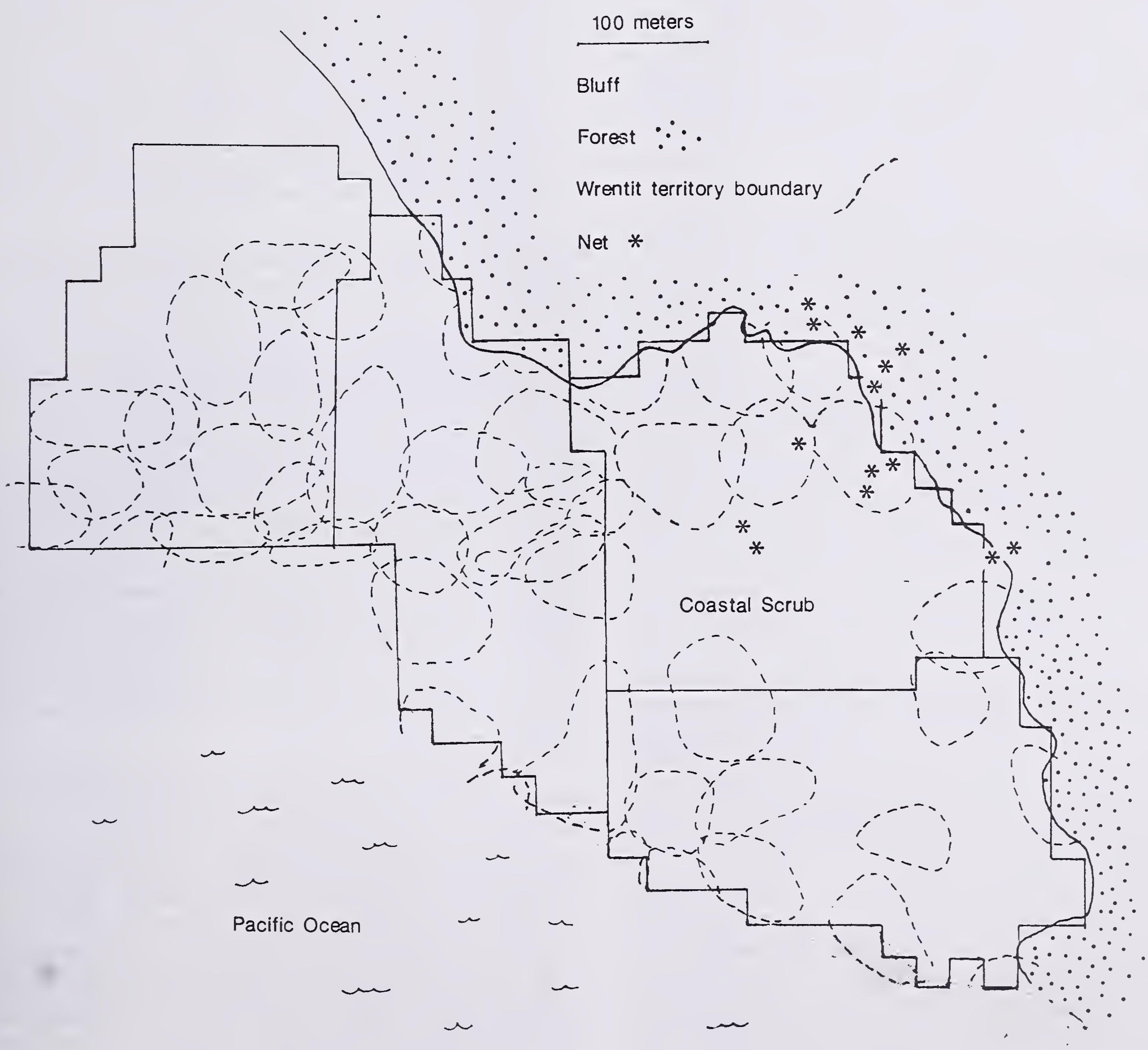


Figure 1. — Map of the study area, Palomarin Field Station, Point Reyes National Seashore. Nest-searches and spot-mapping of color-banded birds took place in the four contiguous areas marked by solid, rectilinear lines, totalling 36 ha in area. Constant effort mist-netting was conducted at nets marked with asterisks. Dotted lines enclose Wrentit territorial boundaries (1985 shown).

RESULTS

Monitoring productivity using mist nets

The more Wrentit fledglings produced on the plot, the more locally-hatched young were caught in our CEM program, conducted during the breeding season (Fig. 2). Almost fifty per-cent of year-to-year variation in number of locally-hatched young caught in nets can be accounted for by variation in number of fledglings produced. This finding confirms that mist nets are indeed measuring local production of young. Another way to view this result is to consider the proportion of fledged young which were caught in nets. Over a ten-year period, 24.2% of Wrentit fledglings were caught in nets during the summer months (n = 714). In most years, a fairly consistent percentage of Wrentit fledglings were caught, usually between 19% and 28%, but there were exceptions, especially 1983, during which only one of 57 fledged young was caught (1.8%). That year was one of unusually heavy rainfall (a record-breaking El Niño event), which may have depressed post-fledging survival of Wrentits.

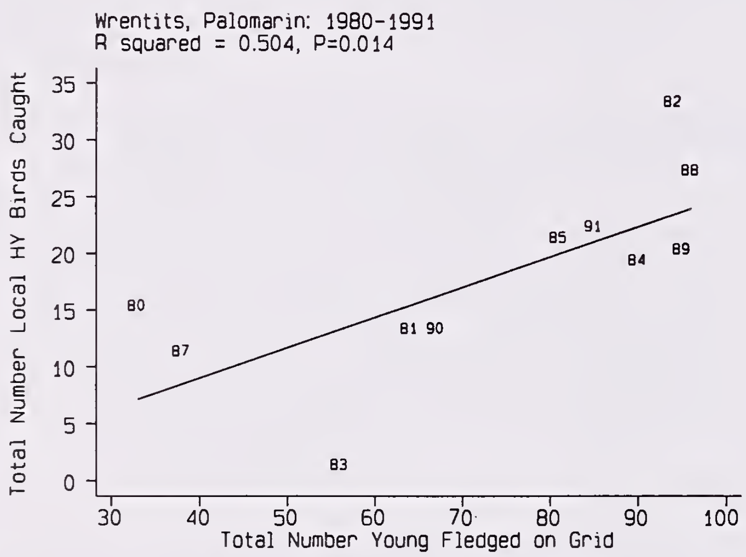


Figure 2. — Number of locally-born Hatching Year (HY) Wrentits caught in each breeding season in relation to total number of Wrentit young fledged on the study grid (see text). '80' refers to 1980 breeding season, etc. The solid line is the best least squares fit to the data; regression statistics are provided in the figure. The more young are produced in the study grid in a year, the more of these locally-hatched young are caught in the standardized array of mist nets.

Of wider interest, though, is the question, Did the **total** number of HY Wrentits caught in nets--no matter what their origin--provide a good measure of Wrentit fledgling production? This answer is disappointing. There was only a weak, non-significant relationship between production of fledglings on the 36 ha study grid and the total number of HY birds caught. The relationship is marginally improved by considering the ratio of HY birds to AHY birds caught in the nets as the dependent variable (the same measure of productivity used by the MAPS

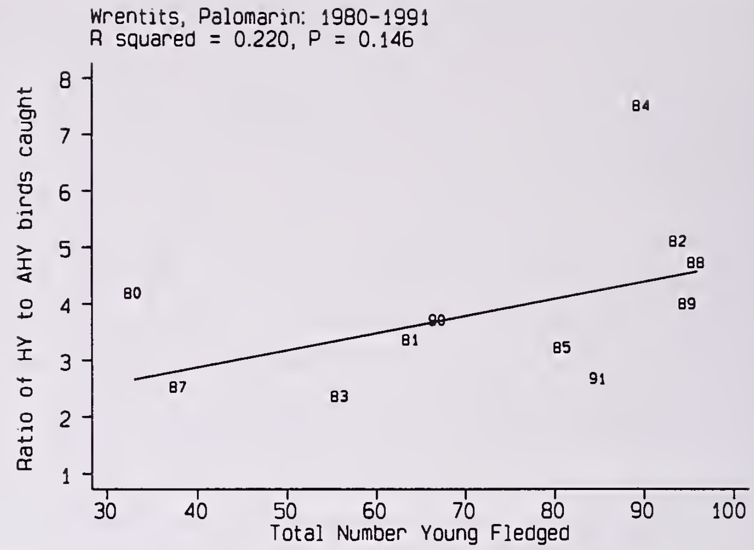


Figure 3. — Ratio of Hatching Year (HY) Wrentits to After Hatching Year Wrentits caught in each breeding season in relation to total number of Wrentit young fledged on the study grid. There is only a weak relationship between productivity as measured by the nets (shown on the Y-axis) and productivity as measured by direct observations of fledgling production (shown on the X-axis). The statistical results were similar when we substituted total HY birds caught for the ratio HY/AHY, confirming the pattern seen in this Figure. '80' refers to 1980 breeding season, etc. The solid line is the best least squares fit to the data; regression statistics are provided in the figure.

program), rather than simply the total number of HY birds, but we are still left with a result that is clearly non-significant ($P > 0.1$; Fig. 3).

This result presents a paradox. To resolve it, we note that the total number of HY birds is the sum of locally born young and those which are non-local (born outside the study grid). Above, we showed that the number of **locally** born young caught in the nets correlated with fledgling production, but it turns out that the number of **non-local** young caught in the nets had nearly nothing to do with **local** fledgling production ($r = +0.065$, $P > 0.8$). One explanation for this last result is that the production of local young is not correlated with the production of non-local young, in other words, reproductive success for Wrentits is very variable from one plot to another. An alternative explanation is that the number of non-local young caught reflects dispersal tendencies of those young more than it reflects reproductive success elsewhere.

Whereas HY captures did not predict local productivity well, they did predict a different demographic parameter, the proportion of Wrentits breeding the next year that were one year of age. This parameter is an index of success of a cohort in recruiting the following year. The greater the ratio of HY to AHY birds caught during the breeding season, the greater the proportion of one-year old birds breeding in the next year ($R^2 = 0.444$, $P = 0.035$). In fact, the mistnet-based measure of productivity did a slightly better job at predicting next year's age structure than did productivity as measured by nest-searches (that criterion being the number of fledglings reared per pair), $r = +0.666$ vs. $r = +0.608$, respectively. Why might that be? Our answer is that mist nets performed well in predicting recruitment because they sample juveniles at a later stage in life--a few weeks post-fledging, rather than at the time of fledging, as is the case for nest-searches. Thus mortality in the period soon after fledging is not reflected by data from nest-monitoring, but is reflected in CEM captures.

Turning to Song Sparrows we see a different picture: there is a **very good** relationship between fledgling production on the grid (total number of Song Sparrows fledged) and number of HY birds caught in the nets (Fig. 4A). In fact, 67% of the between year variation in HY captures can be accounted for by differences in local fledgling production and vice versa. We stress that the very same comparison for Wrentits is unambiguously not significant ($P > 0.4$) and the corresponding R^2 is only 6% (Fig. 4B). In other words, there is marked variation between species in the ability of mist nets to track year to year changes in the local production of young.

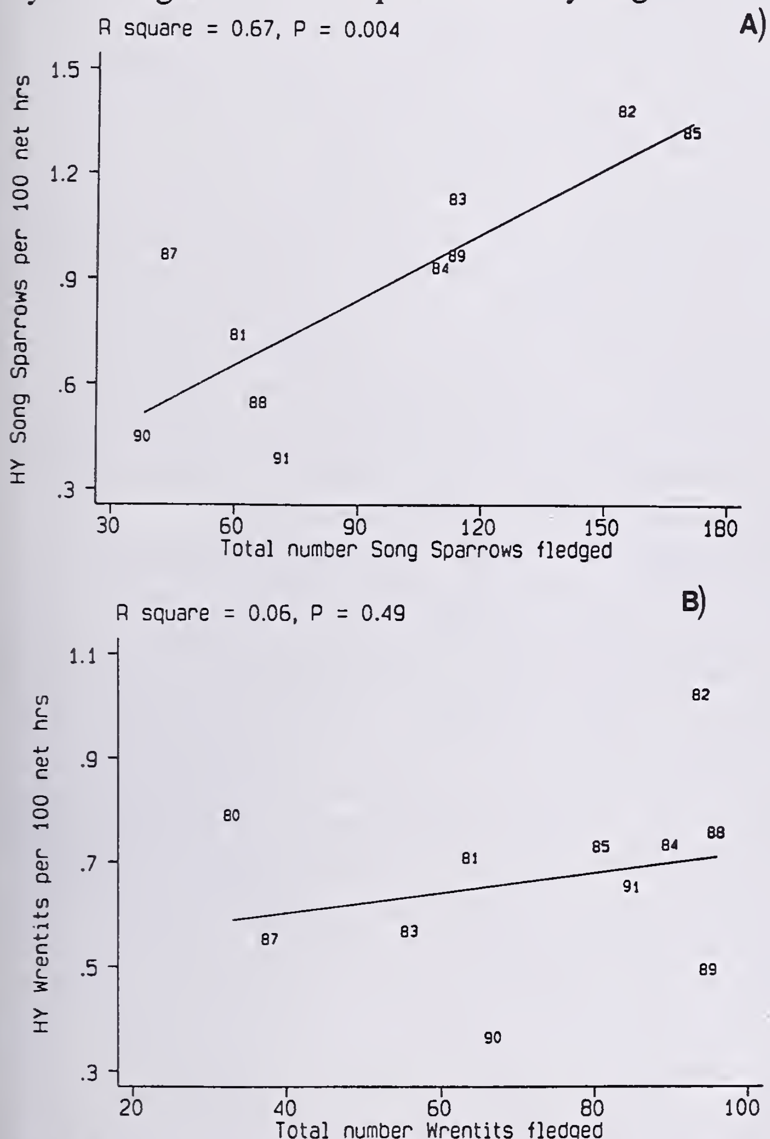


Figure 4. — A) Number of Hatching Year (HY) Song Sparrows caught in each breeding season (regardless of origin) per 100 net-hours in relation to total number of Song Sparrow young fledged on the study grid (see text). '80' refers to 1980 breeding season, etc. The solid line is the best least squares fit to the data; regression statistics are provided in the figure. B) Same variables and same years of data as in part A), but for Wrentits. The solid line is the best least squares fit to the data; regression statistics are provided in the figure. For Song Sparrows, there is a very good relationship between productivity as determined by mist nets and productivity determined from nest-monitoring. The same relationship does not hold for Wrentits.

Captures of Adults: Breeders vs. Floaters

Considering the capture and recapture of adults, we found that most Wrentits caught in mist nets were apparently non-breeders, that is, floaters (O. Williams, G. Geupel & N. Nur, unpublished; Geupel et al. 1992). Non-breeders were defined as individuals not known to hold a territory. Since all territory holders within 200 m of the mist nets were known, and since Wrentit breeders more than 200 m from the nearest net were almost never caught (<1 %, n = 389, Nur & Geupel 1993), we inferred that individuals caught who did not hold a territory were non-breeders.

On average about two floaters were caught for every breeder caught ($\bar{X} = 18.9$ non-breeders per year vs. $\bar{X} = 9.1$ breeders caught per year, n = 10 years). This difference arose not because floaters outnumbered breeders, but because breeders stayed put; only breeders with territories near mist nets--one or at most two territories away--were caught (Nur & Geupel 1993). Breeders further away were not caught. In contrast, non-breeders were very transient. Over the course of the breeding season a high number "passed through" our study site. The degree of transience is indicated, first of all, by the fact that of 188 non-breeders captured over a 10-year period, only 18 (9.6%) had been previously banded at Palomarin in their first summer or fall of life. Four individuals caught were locally-born (out of more than 700 banded fledglings) and the other 14 had been first caught as independent juveniles in their first fall. Moreover, once caught, most nonbreeders were never seen again. Only 20% of nonbreeders were caught again in the same year (n = 274; Table 1), and another 8% were seen and identified by means of their color bands (Williams, Geupel & Nur, unpublished). In contrast, most breeders were caught repeatedly during the breeding season. Seventy-eight percent of breeders were recaught in the same year (n = 78), some repeatedly (Table 1). This result implies little net-avoidance among breeding Wrentits, even though these birds had ample opportunity to learn where nets were placed.

In short, within a season, breeders were much more likely to be recaught than non-breeders. The same pattern held between seasons. Many breeders (40.6%) were recaught in the following season, whereas few non-breeders were (only 1.8%). In other words, breeders were twenty times as likely to be recaught in a subsequent season as were non-breeders (G test, $P < 0.0001$). Such a difference in recapture rates can, in theory, represent differences in survival and/or differences in recapture probability (i.e., the probability an individual is recaught the next year, given that it has survived). We have used the statistical program SURGE (Lebreton et al. 1992) to estimate these two parameters,

Table 1. — Same-Year recaptures of Wrentit breeders and non-breeders at Palomarin (1981-1991). Wrentit breeders are often recaptured in the same year, providing no evidence of net-avoidance. Non-breeders are much more transient and thus rarely recaptured.

Breeders: Number of Captures	Breeders: Frequency[1]	Breeders: Percent	Non-breeders: Number of Captures	Non-breeders: Frequency[1]	Non-breeders: Percent
1	22	29	1	196	78
2	14	18	2	37	15
3	10	13	3	9	4
4	12	16	4	3	1.2
5	5	7	5	3	1.2
6	3	4	6	1	0.4
7	6	8	7	2	0.8
8-14	4	5	-	-	-
Total	78	100	Total	251	100

[1] - The same individual is included more than once if it was caught in different years.

survival and recapture probability. Recapture probability was estimated to be 71% for breeders, vs. 5% for non-breeders (G test, $P < 0.0001$); whereas, survival probability did not differ significantly between the two groups (G test, $P > 0.3$; Nur & Geupel 1993).

SURGE analysis indicated survival probability of breeders to be 57% (95% confidence interval, 47% - 67%), similar to estimates of adult survival derived from re-sightings of color-banded birds, 59% (females) and 64% (males) ($n = 523$, Nur & Geupel, unpublished). However, had we made no distinction according to breeding status in the mist net analysis, thus pooling breeders and non-breeders, estimated survival probability would have been 31% (95% confidence interval, 22% - 41%), significantly lower than the estimate obtained from breeders alone. Thus we conclude that **capture-recapture data collected with constant effort mist-netting can provide a good index of survival--among breeders**. The difficulty is to distinguish breeders from non-breeders, which cannot be determined in Wrentits by the presence or absence of brood patch or cloacal protruberance (unpublished data). One suggestion is to calculate survival rates using only adults caught twice or more in the same breeding season, since most breeders (62%) were caught more than once, whereas most non-breeders (72%) were not.

CONCLUSIONS AND RECOMMENDATIONS

To summarize, among Wrentits the number of locally-born young caught in nets mirrored the local production of fledglings, but the overall number of HY birds caught did not track local production of young. In contrast, the number of HY Song Sparrows caught as part of a CEM regime did mirror local production of young. Thus, there is variation between species in the ability of CEM to track changes in local productivity. Our results are similar to those of Feu & McMeeking (1991) who found that in Eurasian Blackbirds (Turdus merula), the number of juveniles caught with CEM (part of the Constant Effort Sites Scheme of the British Trust for Ornithology) was correlated with local productivity, but that in Song Thrushes (Turdus philomelos) there was no such relationship.

With regard to Wrentit adults, we found that mist nets tended to catch non-breeders (floaters) rather than breeders, and that recapture probability (within season and between seasons) was strongly related to breeding status. Survival was accurately estimated from capture/recapture data, provided that breeders could be distinguished. Breeders were very likely to be recaught, thus providing no evidence of net-avoidance. Our results suggest that a low rate of recapturing adults in subsequent breeding seasons (obtained in some CEM studies) reflects inclusion of transient non-breeders with more philopatric breeders, rather than being due to avoidance of mist nets.

We recommend:

1) Before implementing a monitoring program, determine one's objectives. For example, some monitoring programs may be geared toward studying temporal trends whereas others may focus on spatial variation in demographic parameters. Our own attempt to validate mist netting and that of Feu & McMeeking (1991) have investigated temporal variation. The limited data gathered to date suggests that mist nets might provide a valid index of productivity, albeit with species-to-species variation in their efficacy. It remains to be seen, though, whether mist nets provide a good index of spatial variation. The answer would depend on degree of patchiness, extent of spatial coverage by mist nets, differences in catchability as a function of habitat, etc. With nest-searching, spatial variation presents a different sort of problem: the connection between nesting success and the patch sampled is clear, but the problem may be that nesting success in an investigated patch may not easily extrapolate to other patches, whether nearby or far away. Other objectives to be considered are the identity of the demographic parameters (all? just productivity? just survivorship?) and the spatial scale (tens of acres or thousands of acres?)

2) More work is needed in developing and validating different monitoring methods. This holds for all methods but we feel it is particularly true for mist-netting. Mist-netting has been a method for trapping birds for several decades, but has only recently been adopted and promoted as a means for monitoring bird populations. Even in England, where the British Trust for Ornithology has been conducting the Constant Effort Sites Scheme for about a decade, there has been little work on validation. This omission applies, for example, to the report by Baillie et al. (1986), which evaluates the Constant Effort Sites Scheme, but does not attempt to validate results. Other points requiring fine-tuning are, Which months to run nets in? Where best to place nets? How many days to run nets per standard, ten-day period? What is the effect of habitat on efficacy and validity of mist-netting data? What is the catchment area for juvenile and adult birds (O'Connor 1992)?

3) Calculations of adult survivorship from mist net capture-recapture data be restricted to (presumed) breeders. If non-breeders cannot be distinguished on the basis of brood patch, we recommend restricting survivorship analysis to adults caught twice or more in the same breeding season. One implication of our work is that those who wish to infer survivorship from capture-recapture data should run the same set of nets relatively often (thereby increasing the sample of birds caught twice in the same season).

4) Adoption of multi-level, integrated monitoring, especially if species of special concern have been identified. Our study at Palomarin indicated ways in which a multi-level approach to monitoring is the most powerful. Our point is that using several techniques in concert, rather than being redundant, provides information that could not otherwise be attained. In other words, the whole is greater than the sum of the individual parts. Consider these two examples from our field study. First, fledgling production of Wrentits in 1983 was fairly high but only one independent, locally-born fledgling was caught in the nets. With only nest-monitoring to go on, we would have thought productivity was reasonably good that year. With only mist-netting to go on, we would have identified low productivity of the 1983 cohort (Figure 4B) but we would have had little idea as to cause. From mist-netting data alone we could not separate poor nesting success (e.g. high nest-predation) from poor post-fledging survival.

The second example of the power of a multi-level, integrated approach is our ability to track abundance of non-breeders (floaters). Through spot-mapping or point counts we can potentially track the number of breeders, but floaters are an important component of Neotropical migrant demography, yet are hard to observe in the field due to their secretive nature. Mist-netting allowed us to track the total number of adults (whether breeding or not), but by itself could not tell us which were breeders (as mentioned above, in Wrentits, neither brood patch nor cloacal protruberance are indicators of breeding status). Putting both together (total adult abundance and breeder abundance) allows inference as to non-breeder abundance. The ability of a population to respond to disturbance might well be related to the existence and abundance of non-breeders (as exemplified by the Northern Spotted Owl (*Strix occidentalis caurina*), Verner 1992).

A multi-level monitoring program is more labor-intensive and expensive than a single-level approach (e.g., point counts), but if such a program can alert us to problems and help identify solutions *before* a species is certifiably endangered, the effort will represent an economical investment.

ACKNOWLEDGMENTS

The research presented here was partially funded by a contract with the U.S. Fish & Wildlife Service, Office of Migratory Bird Management, by Chevron Corporation and by the membership of the Point Reyes Bird Observatory. We thank the numerous intern field biologists who helped collect data reported here and thank Oriane E. Williams, Grant Ballard and B. Denise Hardesty for help in preparing and analyzing field data. We thank C. J. Ralph, W. J. Sydeman and the editors for critically reading the manuscript and thank the Point Reyes National Seashore for their continued cooperation. This is PRBO Contribution Number 573.

LITERATURE CITED

Baillie, S.R., Green, R.E., Boddy, M. and Buckland, S.T. 1986. An evaluation of the constant effort sites scheme. Unpublished report to the British Trust for Ornithology.

DeSante, D.F. This volume. The Monitoring Avian Productivity and Survivorship (MAPS) Program: Overview and Progress. Proceedings of National Conference on Neotropical Migrants, Estes Park, Colorado.

DeSante, D.F. and Geupel, G.R. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall and a reproductive failure in 1986. Condor **89**:636-653.

Erickson, M. M. 1938. Territory, annual cycle, and numbers in a population of Wrentits *Chamaea fasciata*. Univ. Calif. Publ. Zool. **42**:247-333.

Feu, C. du and McMeeking, J. 1991. Does Constant Effort Netting estimate juvenile abundance? Ringing & Migration **12**:118-123.

Geupel, G.R. and DeSante, D.F. 1990. Incidence and determinants of double brooding in Wrentits. Condor 92:67-75.

Geupel, G.R. and Nur, N. This volume. Monitoring bird populations: The role of bird observatories and other nongovernmental agencies. Proceedings of National Conference on Neotropical Migrants, Estes Park, Colorado.

Geupel, G.R., Williams, O.E., and Nur, N. 1992. Paper presented at 62nd Annual Meeting of the Cooper Ornithological Society, Seattle, WA.

Johnson, N.K. 1972. Origin and differentiation of the avifauna of the Channel Islands, California. Condor 74:295-315.

Lebreton, J.-D., Burnham, K.P., Clobert, J., and Anderson, D.R. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecological Monographs 62:67-118.

Martin, T.E. and Geupel, G.R. In press. Nest monitoring plots: Methods for locating nests and monitoring success. Journal of Field Ornithology.

Nice, M. M. 1937. Studies in the life history of the Song Sparrow. I. Trans. Linn. Soc. New York 4:1-247.

Nur, N. & Geupel, G.R. 1993. Validating the use of constant effort mist-netting to monitor avian populations. Report of the Point Reyes Bird Observatory to US Fish & Wildlife Service, Office of Migratory Bird Management.

O'Connor, R.J. 1992. The analysis of geographic scale and population processes in bird population monitoring data. Proceedings of Symposium on Ecological Indicators, Fort Lauderdale, October 1990.

Temple, S.A. and Wiens, J.A. 1989. Bird populations and environmental changes: Can birds be bio-indicators. American Birds 43:260-270.

Verner, J. 1992. Data needs for avian conservation biology: Have we avoided critical research? Condor 94:301-303.

Monitoring Goals and Programs of the U.S. Fish and Wildlife Service

John R. Sauer[1]

Abstract — The United States Fish and Wildlife Service coordinates several surveys that collect information on the population status of migratory birds in North America. The North American Breeding Bird Survey is the primary source of population information on nongame birds during the breeding season, and waterfowl surveys are conducted during breeding and wintering seasons. The surveys are international in scope, based upon research into sampling methods for birds, and used in management of migratory birds. The Service also maintains the Bird Banding Laboratory in cooperation with the Canada Wildlife Service, and supports demographic monitoring of bird populations.

INTRODUCTION

The United States Fish and Wildlife Service (Service) has a legal mandate under the Fish and Wildlife Conservation Act of 1980 to monitor population status of migratory birds. To fulfill this mandate, the Service (and its predecessor agencies such as the Bureau of Biological Survey) has developed survey methods and statistically designed surveys that provide information regarding population sizes, population trends, productivity rates, and death rates of migratory bird species. Although the Service's goal is the development of adequate survey programs for all migratory bird species, and many species are now monitored with at least population surveys, certain taxa are poorly monitored due to life-history traits or geographic ranges that make them undetectable by existing survey procedures.

The Service has several monitoring programs, each with different goals and products. For example, many surveys collect data on population size or trends in populations, while others collect data on rates of survival or reproduction. The distinction between game and nongame species has important ramifications for monitoring because game species tend to have high band recovery rates that allow for modelling of survival rates from banding and recovery data. Research into population estimation techniques has played a major role in development of surveys. Finally, most Service surveys are international in scale. In this paper, I briefly outline: (1) some fundamental principles of the design of monitoring programs; (2) variables that are monitored; and (3) underlying rationales, procedures, and uses of Service monitoring programs, with special attention to neotropical migrant bird species. Views expressed in this paper reflect my opinions about monitoring and these surveys, and should not be construed as Service policy.

There are many publications that examine Service monitoring programs. The most comprehensive recent work is Martin et al. (1979), which reviews all programs in progress up to that date. Annual reports are produced for most surveys (e.g., Droege and Sauer 1990), and periodic reviews are published in the peer-reviewed literature (e.g., Robbins et al. 1986, Sauer and Bortner 1990). Recently, the Office of Migratory Bird Management has produced a draft monitoring strategy for the lower 48 states (Droege pers. commun.).

WHAT CONSTITUTES A VALID SURVEY?

Existing bird surveys differ greatly in quality of information, varying from anecdotal, which could be defined as nonsystematic collection of data of varying quality, to statistically-designed surveys. In many cases, the population to be surveyed is poorly defined, and may change from year to year.

To have credibility as a sample survey, the population to be sampled must be divided into nonoverlapping units. All units taken together constitute what statisticians call a sampling frame, from which a subset of units is selected as a sample and all birds in each sample unit are counted. If the sampling frame is

[1] *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, laurel,. MD 20708.*

not complete in that some part of the population does not appear in the units and cannot be sampled, or if some units have a higher probability of inclusion than others, then estimates of population attributes from the sample may be biased (Cochran 1977). This form of bias may occur in surveys constrained to roads that do not sample forest interiors, wetlands, and other places where there are few roads.

Wildlife surveys usually have the additional constraint that counts within sampling units are incomplete, and a portion of the animals are missed during a survey. Much Service research has involved development of methods for estimation of the proportion of animals missed. Bias in estimation of population parameters exists due to incomplete nature of counts, as the average counts are not accurate representations of actual populations.

Surveys should be designed to estimate a population parameter with a specified level of precision. For example, for the North American Breeding Bird Survey (BBS), a reasonable goal would be estimation of trends with sufficient precision that a decline of 50 % (trend of -2.74 %/year) over a 25-year period would be detected with probability 90%. In any survey, bias in the parameter estimate must be considered, and sources of bias must be carefully examined. The particular problem of incomplete counts is often disregarded in survey design and analysis, but it can contribute significant bias and imprecision to results (Barker and Sauer 1992). Of course, as a survey progresses, evaluation of precision will provide information of whether the survey is meeting its goals.

Should We Monitor Survival and Productivity in Addition to Population Size of Bird Populations?

Temple and Weins (1989) suggested it is better to monitor survival and productivity rates than population size because the rates provide more insight into mechanisms of population change. However, they point out that population sizes are generally easier to monitor. This distinction between monitoring the vital rates and monitoring population size is extremely important, because surveys for population size of neotropical migrant birds tend to be extensive yet of low intensity. Surveys for survival and productivity tend to require much effort and are more local, but also provide better information that can be used in modelling populations. Generally, the Service has attempted to monitor both vital rates and sizes of bird populations, but success of monitoring differs greatly among bird species.

Game and Nongame Species Monitoring

Because Hunter Harvest Has Historically been a factor that influences bird populations, and the Service has legal authority to regulate hunter harvest, there has long been impetus for extensive monitoring of the population status of game species. Ironically, the harvest provides several opportunities for monitoring using methods not available for nongame species. The tradition of hunters returning bands from shot birds provides significant band-recovery information that can be used to estimate survival and recovery rates (Brownie et al. 1985) and conduct distributional analyses based on geographic patterns in band recoveries (Pendleton and Sauer 1992). Nongame birds have such low recovery rates of bands that recovery information is effectively useless for both survival rate estimation and distributional analyses (S. Droege et al., Unpublished Poster Session, Neotropical Migrant Bird Workshop, Estes Park, Colorado, 21-24 Sept. 1992).

Surveys That Provide Information on Population Sizes and Trends

In this section, I review some of the major surveys that provide population size information. Counting birds during breeding, wintering, and migration has been the focus of Service work since the earliest monitoring projects. The Bureau of Biological Survey, for example, collected observations on bird migration from lighthouse keepers and additional observers located throughout the U.S. starting in the 19th century. From this anecdotal start, other survey methods have been developed with both sampling frames and visibility adjustments to account for incomplete counts. I provide a brief review of the more extensive surveys, omitting some of lesser interest (such as goose surveys) in the context of Neotropical migrant birds.

It is critical to note that some surveys (such as the Spring Breeding-ground Survey) sponsored by the Service directly estimate population size, and are designed to provide precise and unbiased estimates of yearly size. Population changes are modelled from these yearly population sizes. Other surveys (such as the roadside surveys) are not used to estimate yearly population sizes. These surveys are known to yield biased estimators of population size because of their sampling units (a roadside route) and their unadjusted count data. For these surveys, population trends are often the quantity estimated, and yearly indices of abundance are a secondary feature.

GAME BIRD SURVEYS

Aerial Surveys

Spring Breeding-Ground Survey

Each year, the Service coordinates a survey of waterfowl in the north-central U.S., Western Canada, and Alaska. In the survey, pilots and observers in fixed-wing aircraft fly along pre-defined transects and count waterfowl. Selected portions of transects are also intensively searched from the ground, and the ratio of counts from ground to air counts is used to adjust total air counts for visibility differences due to the aerial survey. Because sexes differ greatly in their visibility, for many species age and sex of birds are noted during counts and a derived index to number of indicated pairs is computed and used as an index to abundance. This survey provides a visibility-adjusted index to population size (i.e., an estimate of population size), and results from the survey are used as a primary source of information on yearly breeding populations for setting harvest regulations. The survey has existed in its present form since 1955, and presently provides population estimates and standard errors for 10 species of ducks, including such Neotropical migrants as teal (*Anas* spp.) and Northern Pintails (*A. acuta*). In conjunction with the breeding-ground survey, habitat and pond data are collected to provide insight into causes of changes in these bird populations.

Mid-Winter Inventories

Wintering counts of waterfowl are conducted in cooperation with state wildlife agencies. These counts take many forms, including surveys from fixed-wing aircraft, helicopters, boats, and automobiles. They are all set up as roving surveys, where the survey crew is given an area to survey. As expected within this sampling framework, proportions of birds actually counted can differ greatly among areas and over time. However, this survey has been used to document changes in populations of American Black Ducks (*A. rubripes*).

Roadside surveys

Mourning Dove Call-Count Survey

Begun in 1966, the Call-count Survey is composed of over 1000 permanently-located roadside routes in the continental U.S., with 20 listening stations (stops) located about 1.6 km (1.0 mi) apart. Each May, the route is surveyed by a single observer who records all Mourning Doves (*Zenaida macroura*) heard at 3 minute counts conducted at each stop. The sum of the number of birds heard over all stops used as the yearly index of abundance on the route. Trends in dove populations are estimated each year in time for the Early Season Regulations Meeting in late June (D. D. Dolton, Office of Migratory Bird Management, U. S. Fish and Wildlife Service, Pers. commun.).

American Woodcock Singing-Ground Survey

The Singing-ground Survey is also a roadside survey, but is run at dusk each spring. This survey ranges over the northeastern and northcentral U.S. and southern Canada. Approximately 1500 survey routes are along roadsides, but each 5.79 km-long (3.6 mi) route has only 10 stops. the total number of American woodcock (*Scolopax major*) observed at all stops is used as the index to abundance in this survey, which has been run since 1968. Sauer and Bortner (1990) provide a recent analysis of Singing-ground Survey data.

NONGAME BIRD SURVEYS

North American Breeding Bird Survey

The BBS has been described in several other papers in this volume, and Robbins et al. (1986) provided an extensive summary of the methods of the survey. It is a roadside route survey in the U.S. and southern Canada, and now has over 3000 survey routes. Begun in the eastern U.S. in 1966, it is our primary source of population information for neotropical migrants (Robbins et al. 1989). Using the route-regression method (Geissler and Sauer 1990), I determined which species met the criterion of estimates with sufficient precision to detect a decline of 50 % over a 25 year period with probability 0.9. Of 137 species of neotropical migrant birds, only 13 species did not meet the criteria (Table 1). Although 124 species were estimated with sufficient precision, many of the species were either seen at low abundances on BBS routes or were seen on very few routes (Table 2). Caution is necessary in interpreting trends in species with low abundances, small sample sizes, or with ranges that extend beyond the range of the survey. Due to taxonomic changes, trends were not estimated for Alder Flycatcher (Empidonax alnorum), Willow Flycatcher (E. traillii), and Cordilleran Flycatcher (E. difficilis), and Kirtland's Warblers (Dendroica kirtlandii) did not appear in the survey due to their limited range.

Table 1. — Neotropical migrant bird species not monitored with sufficient intensity to detect a 50 % decline in the population over a 25 year period with probability 0.9. Species that were detected at low relative abundances (superscript a) or at low samples sizes (degrees of freedom < 14, superscript b) are also noted. See the AOU checklist (American Ornithologists' Union 1983) for scientific names of bird species.

BLACK SWIFT
WHITE-THROATED SWIFT[a]
COSTA'S HUMMINGBIRD[a]
GRAY FLYCATCHER[a]
GRAY-CHEEKED THRUSH[a]
BLACK-CAPPED VIREO[a,b]
GRAY VIREO[a]
TENNESSEE WARBLER
TOWNSEND'S WARBLER
GOLDEN-CHEEKED WARBLER[a,b]
GRACE'S WARBLER
BAY-BREASTED WARBLER
BLACKPOLL WARBLER

Table 2. — Neotropical migrant bird species that were monitored with sufficient intensity to detect a 50 % decline in the population over a 25 year period with probability 0.9. Note that some species were detected at low relative abundances (superscript a) or at low samples sizes (degrees of freedom < 14, superscript b), suggesting that caution be used in interpreting trend results. See the AOU checklist (American Ornithologists' Union 1983) for scientific names of bird species.

AM. SWALLOW-TAILED KITE[a]
MISSISSIPPI KITE[a]
BROAD-WINGED HAWK[a]
SWAINSON'S HAWK[a]
MERLIN[a]
PEREGRINE FALCON[a,b]
MOUNTAIN PLOVER[a]
UPLAND SANDPIPER
LONG-BILLED CURLEW
BAND-TAILED PIGEON
BLACK-BILLED CUCKOO[a]
YELLOW-BILLED CUCKOO
FLAMMULATED OWL[a,b]
BURROWING OWL[a]
LESSER NIGHTHAWK
COMMON NIGHTHAWK
CHUCK-WILL'S-WIDOW
WHIP-POOR-WILL[a]
CHIMNEY SWIFT
VAUX'S SWIFT[a]
RUBY-THR. HUMMINGBIRD[a]
BLACK-CHIN. HUMMINGBIRD[a]
CALLIOPE HUMMINGBIRD[a]
BROAD-TAIL. HUMMINGBIRD
RUFOUS HUMMINGBIRD
ALLEN'S HUMMINGBIRD[a]
OLIVE-SIDED FLYCATCHER
WESTERN WOOD-PEWEE
EASTERN WOOD-PEWEE
YELLOW-BELL. FLYCATCHER
ACADIAN FLYCATCHER
LEAST FLYCATCHER
HAMMOND'S FLYCATCHER
DUSKY FLYCATCHER
VERMILION FLYCATCHER[a]
ASH-THROATED FLYCATCHER
GRT. CRESTED FLYCATCHER
CASSIN'S KINGBIRD
WESTERN KINGBIRD
EASTERN KINGBIRD
SCISSOR-TAIL FLYCATCHER
PURPLE MARTIN
VIOLET-GREEN SWALLOW
N. ROUGH-WINGED SWALLOW
BANK SWALLOW
CLIFF SWALLOW
BARN SWALLOW
HOUSE WREN
BLUE-GRAY GNATCATCHER
VEERY
SWAINSON'S THRUSH
WOOD THRUSH
GRAY CATBIRD
PHAINOPEPLA
WHITE-EYED VIREO
BELL'S VIREO[a]
SOLITARY VIREO
YELLOW-THROATED VIREO[a]
WARBLING VIREO
PHILADELPHIA VIREO[a]
RED-EYED VIREO
BLUE-WINGED WARBLER[a]
GOLDEN-WINGED WARBLER[a]
ORANGE-CROWNED WARBLER
NASHVILLE WARBLER
VIRGINIA'S WARBLER
NORTHERN PARULA
YELLOW WARBLER
CHESTNUT-SIDED WARBLER
MAGNOLIA WARBLER
CAPE MAY WARBLER
BLACK-THR. BLUE WARBLER[a]
BLACK-THR. GRAY WARBLER
HERMIT WARBLER
BLACK-TH. GREEN WARBLER
BLACKBURNIAN WARBLER
YELLOW-THROATED WARBLER[a]
PRAIRIE WARBLER
PALM WARBLER[a]
CERULEAN WARBLER[a]
BLACK-&-WHITE WARBLER
AMERICAN REDSTART
PROTHONOTARY WARBLER
WORM-EATING WARBLER[a]
SWAINSON'S WARBLER[a]
OVENBIRD
NORTHERN WATERTHRUSH
LOUISIANA WATERTHRUSH[a]
KENTUCKY WARBLER
CONNECTICUT WARBLER[a]
MOURNING WARBLER
MACGILLIVRAY'S WARBLER
COMMON YELLOWTHROAT
HOODED WARBLER
WILSON'S WARBLER
CANADA WARBLER
YELLOW-BREASTED CHAT
HEPATIC TANAGER[a]
SUMMER TANAGER
SCARLET TANAGER
WESTERN TANAGER
ROSE-BREASTED GROSBEAK
BLACK-HEADED GROSBEAK
BLUE GROSBEAK
LAZULI BUNTING
INDIGO BUNTING
PAINTED BUNTING
DICKCISSEL
GREEN-TAILED TOWHEE
CHIPPING SPARROW
CLAY-COLORED SPARROW
BREWER'S SPARROW
LARK SPARROW
LARK BUNTING
BAIRD'S SPARROW
GRASSHOPPER SPARROW
LINCOLN'S SPARROW
BOBOLINK
YELLOW-HEAD. BLACKBIRD
ORCHARD ORIOLE
HOODED ORIOLE[a]
BULLOCK'S ORIOLE
BALTIMORE ORIOLE
SCOTT'S ORIOLE

Other Surveys

The Service has worked with many other surveys to evaluate their efficiency in estimating population trends of neotropical migrants. Christmas Bird Count and Breeding Bird Census data are presently maintained by the Office of Migratory Bird Management, and preliminary research has been conducted into the comparative efficiency of these surveys. The Service has also collaborated in studies involving International Shorebird Surveys, Hawk Migration Counts, songbird migration counts, colonial bird nest registers, and other bird surveys (See Sauer and Droege 1990 for a description of these surveys). All of these surveys tend to have either poorly defined target populations or poorly designed sampling frames.

PRIMARY DEMOGRAPHIC CHARACTERISTICS

Productivity Studies

July Waterfowl Productivity Studies

Productivity of waterfowl is assessed in July by an aerial survey to estimate brood production. Although covering generally the same area, this survey is slightly less extensive than the breeding-ground survey, and brood counts are not adjusted for visibility.

BBirds Project

A program to assess regional productivity of songbirds has been initiated by the Cooperative Research Centers (Martin, T., U. S. Fish and Wildlife Service, Pers. Comun.). In this project, study sites are established in forested areas, and nest success is monitored by Mayfield methods (Bart and Robson 1982). The program is habitat-specific, and therefore not a valid sample of overall regional nest success, but it will allow comparisons within sampled forested habitats.

Banding Studies

The North American Bird Banding Laboratory (BBL), located in Laurel, MD, houses banding and recovery records for migratory birds that breed in North America. For reasons noted below, the role of the BBL in neotropical migratory bird research and management is quite different from its role in game bird management. Banding studies are of use only when the essential feature of banding, that birds can be uniquely identified when recaptured or found dead in the future, can be used to estimate demographic features of the population. Migration banding studies do not contain this essential feature, as birds banded in migration are almost never recovered or recaptured after they leave the banding site. Hence, banding is not an essential part of migration "banding" studies, and these programs use number of birds banded as an index to yearly population sizes.

Game-Bird Banding

Banding is an important tool for management of migratory game birds. Recovery data provide information that can be used to: (1) estimate survival rates in band-recovery models (Brownie et al. 1985); (2) estimate recovery rates to index harvest rates; (3) estimate harvest rates (if reward bands are used); and (4) address distributional questions.

Non-Game Banding

Banding of nongame birds is apparently not of great use in distributional or band-recovery survival analyses due to the extremely low numbers of returns (S. Droege et al., Unpublished Poster Session, Neotropical Migrant Bird Workshop, Estes Park, Colorado, 21-24 Sept. 1992). Instead, banding is most efficiently used when birds can be recaptured at the same site and mark-recapture methods can be used to estimate survival (e.g., Pollock et al. 1990, Lebreton et al. 1992). Local banding studies using mark-recapture methods have proven to be the only appropriate way to estimate survival rates for songbirds. The MAPS program co-sponsored by the Service (DeSante 1992) uses a network of mark-recapture studies in a pilot program to monitor productivity and survival of songbirds.

THEMES IN SERVICE MONITORING

There are several themes that I note in Service monitoring programs of particular interest to neotropical migrant monitoring:

International Scope

Most Service programs are international in scope. The Canadian Wildlife Service collaborates with the Service on waterfowl surveys, breeding bird surveys and banding projects, and cooperative migratory bird studies are also conducted with Mexico. This close cooperation is essential for reasonable management of migratory species, and the North American Waterfowl Management Plan represents a major international effort to conserve waterfowl resources. Partners-in-flight will also advance international cooperation for migratory bird conservation.

Several active international FWS projects will benefit monitoring and research into populations of Neotropical migrant birds. A pilot study to assess the feasibility of extending the BBS south into northern Mexico is underway, and will begin fieldwork in 1993 (B. G. Peterjohn, Office of Migratory Bird Management, Pers. commun.). Also, FWS research has conducted cooperative banding studies in Mexico, Caribbean countries, Belize, and other Central American countries. All of these efforts emphasize the international cooperation necessary for Neotropical migrant bird conservation.

Used In Management

Service monitoring programs are used in harvest management for game bird species. Although game management procedures may not seem particularly relevant for neotropical migrant landbirds, needs for reliable survey techniques for use in the sometimes adversarial forum of harvest regulations have driven much research and development of new survey methods. For example, the American Woodcock Singing-ground Survey and the Mourning Dove Call-count Survey are roadside surveys similar in design to the North American Breeding Bird Survey used in the yearly regulations process. Because of potential for controversy that exists when survey results are used to affect political decisions regarding land-use and other practices, nongame bird surveys should also be carefully reviewed for statistical rigor.

Research-Based Methods

Statistically valid, unbiased estimation is prerequisite for population management. Because of this need for reliable information in management, the Service has traditionally supported quantitative research into survey design and analysis through Research Centers and Cooperative Wildlife Research Units. Most surveys that presently exist are conducted and analyzed using methods developed at least in part by Service biologists and statisticians, and the Service sponsors workshops on topics of interest to survey biologists (e.g., Sauer and Droege 1990).

CONCLUSIONS

The BBS provides estimates of population changes for many neotropical migrants, but clearly there are groups of species with life history characteristics or ranges that prevent the BBS from adequately covering them. For example, nocturnal birds are generally only noted on the earliest stops on BBS routes, and usually have extremely low average counts and small sample sizes. Also, species that nest to the north of the BBS survey routes tend to be poorly sampled. In 1990, we assessed the efficiency of the BBS in sampling regional populations of all North American bird species (J. R. Sauer and S. Droege, Geographic and temporal aspects of sampling in the North American Breeding Bird Survey, unpubl. manuscript), and this document is available to interested readers. Much of this material will be published in the long-term summary of BBS data (B. G. Peterjohn, C. S. Robbins, and J. R. Sauer, In prep.). For more information on the sample efficiency of Service surveys, I refer readers to the draft monitoring strategy for the lower 48 states (S. Droege, Office of Migratory Bird Management, Pers. commun.).

Service monitoring programs have benefitted from extensive interaction between field biologists motivated to study birds and statisticians interested in special problems of biological sampling. Information from Service monitoring programs are used in management, and are therefore subjected to public and professional review. Because of the use in management, survey goals are well defined, statistically defensible (or at least deficiencies are well known), and produced on schedules that maximize potential use of information. As products of a public agency, survey results are in the public domain and available to researchers and managers regardless of institutional affiliation.

Attention to methodological details has always characterized the Service approach to survey design and analysis. In Partners in Flight, there are many fledgling monitoring programs. It appears that many programs are designed to allow agencies or specific parks to participate in monitoring. The experience of the large-scale monitoring programs of the Service indicate that unless these programs are designed with specific goals and products in mind they are unlikely to succeed. A mandate to count birds without specific uses for results is doomed to produce useless results of unknown validity. To avoid wasted effort on ineffective monitoring programs I suggest that anyone designing such a program first specify the parameter of interest, with a minimal acceptable level of precision. Then, a sampling unit and frame should be carefully selected to avoid bias in the estimates of the parameter. Finally, survey results should be produced through periodic analyses and reports on the program, and the results presented in a form that is of use to managers.

ACKNOWLEDGMENTS

Work on the sampling efficiency of the BBS was conducted cooperatively with B. G. Peterjohn and S. Droege. B. G. Peterjohn, J. D. Nichols, and S. Droege commented on the manuscript.

LITERATURE CITED

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, Ka. 877pp.

Barker, R. J., and J. R. Sauer. 1992. Modelling population change from time series data. Pages 182-194 *in* Wildlife 2001: Populations, D. R. McCullough and R. Barrett, eds. Elsevier, New York.

Bart, J, and D. S. Robson. 1982. Estimating survivorship when the subjects are visited periodically. Ecology 63:1078-1090.

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1985. Statistical inference from band recovery data-A Handbook. Second Edition. U.S. Fish Wildl. Serv. Resour. Publ. 156. 305pp.

Cochran, W. G. 1977. Sampling techniques, 3rd edition. Wiley, New York. 428pp.

DeSante, D. F. 1992. Monitoring avian productivity and survivorship (MAPS): a sharp, rather than blunt, tool for monitoring and assessing landbird populations Pgs 511-521. *in* D.R. McCullough and R. H. Barrett. Wildlife 2001: populations, Elsevier, New York.

Droege, S., and J. R. Sauer 1990. North American Breeding Bird Survey annual summary 1989. U. S. Fish. Wildl. Serv., Biol. Rept. 90(8):1-22.

Geissler, P. H., and J. R. Sauer. 1990. Topics in route regression analysis. Pgs 54-57 *in* J. R. Sauer and S. Droege, eds. Survey designs and statistical methods for the estimation of avian population trends. U. S. Fish. Wildl. Serv., Biol. Rept. 90(1).

Lebreton, J-D., K. P. Burnham, J. Clobert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: A unified approach with case studies. Ecological Monographs 62:67-118.

Martin, F. W., R. S. Pospahala, and J. D. Nichols. 1979. Assessment and population management of North American migratory birds. Pages 187-239 in J. Cairns, Jr., G. P. Patil, and W. E. Waters, eds. Environmental biomonitoring, assessment, prediction, and management - certain case studies and related quantitative issues. International Cooperative Publ. House, Fairland, MD.

Pendleton, G., and J. R. Sauer. 1992. Development of population reference areas for American black ducks. Pages 182-194 in Wildlife 2001: Populations, D. R. McCullough and R. Barrett, eds. Elsevier, New York.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990, Statistical inference for capture-recapture experiments. Wildlife Monograph 107.

Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. The Breeding Bird Survey: its first fifteen years, 1965-1979. U. S. Fish Wildl. Serv., Res. Publ. 157.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proc. Natl. Acad. Sci, USA 86:7658-7662.

Sauer, J. R., and S. Droege, editors. 1990. Survey designs and statistical methods for the estimation of avian population trends. U. S. Fish. Wildl. Serv., Biol. Rept. 90(1). Sauer, J. R., and J. B. Bortner. 1990. Population trends from the American woodcock singing-ground survey, 1970-88. J. Wildl. Manage. 55:300-312.

Temple, S. A., and J. A. Wiens. 1989. Bird populations and environmental changes: can birds be bio-indicators? American Birds 43:260-270.

USDA Forest Service Goals and Programs for Monitoring Neotropical Migratory Birds

Patricia Manley[1]

Abstract — The USDA Forest Service (USFS) developed goals, objectives, and guidelines for monitoring neotropical migratory birds (NTMB) on National Forest System lands in response to the Neotropical Migratory Bird Conservation Program Partners in Flight. A USFS task group developed a hierarchical monitoring framework designed to define priorities for type of monitoring data. Three levels of monitoring were defined to provide options because funding levels typically vary from Forest to Forest, and monitoring standards were defined for each level of monitoring. In addition, responsibilities for each level of the agency were identified.

INTRODUCTION

The USDA Forest Service (USFS) has participated in the Neotropical Migratory Bird (NTMB) Conservation Program Partners in Flight from its inception. The USFS began allocating funds ($325,000 nationally) for NTMB activities in 1991. Funding grew substantially (to $2,100,000 nationally) in 1992 when the USFS began in earnest to develop NTMB programs in each of its nine Regions. Funding was targeted to support activities in three main emphasis areas: (1) establishing cooperative monitoring programs with research and non-government partners; (2) providing training for USFS biologists about NTMBs and monitoring techniques; and (3) participating fully in Partners in Flight activities and initiatives. In this paper, I describe efforts by the USFS to develop a coordinated monitoring program for NTMBs.

A national NTMB Monitoring Task Group (the Task Group) was formed within the USFS to produce a document that outlined goals, objectives, and guidelines for monitoring NTMBs on National Forest System (NFS) lands. A final draft of the monitoring document is expected in October 1992. The information presented in this paper is a synopsis of the draft document.

[1]*Regional Wildlife Ecologist, U.S. Forest Service, 630 Sansome St., San Francisco, CA 94111.*

MONITORING NEOTROPICAL MIGRATORY BIRDS

The USFS administers a large proportion of native habitats (191 million acres) in the U.S., and NTMBs comprise a large proportion of the breeding bird populations in these habitats. As a result, the USFS can make a significant contribution to conservation of NTMB populations. Conservation efforts directed toward NTMBs also fit into the new USFS policy on ecosystem management, an attempt to understand and address land management issues from an ecosystem perspective and to maintain or restore ecosystem integrity. Declines, extirpations, or extinctions of NTMBs would likely have major impacts on ecosystem functions.

The USFS typically monitors trends in habitat as a surrogate for the status of associated wildlife species. However, it is insufficient to monitor trends in habitat and assume that population levels are proportional to habitat quality (Van Horne 1983). Many factors other than habitat affect populations, such as human disturbance, predation, competition, prey abundance, parasitism, adverse weather, disease, and, for migratory species, the status of wintering habitat. The number and distribution of reproductive individuals and their productivity and survivorship are key measures of an area's ability to support viable populations. These population parameters cannot be measured directly from habitat data, but must be determined through monitoring and research. Only through monitoring and research can we quantitatively assess population parameters to ensure that land-management activities are in compliance with governing laws, regulations, and policies.

A list of goals was developed for monitoring on NFS lands. The goals reflect information needs within the agency and those identified in the Monitoring Work Group's Needs Assessment for Partners in Flight (Butcher 1992): (1) build an understanding of the influence of habitat changes resulting from USFS management activities on NTMBs; (2) provide insights into temporal dynamics and trends of local and regional populations of target NTMB species; (3) provide some clues as to cause(s) of trends; and (4) contribute to national and international Partners in Flight monitoring efforts.

The monitoring framework outlined in this document was motivated by concerns for NTMBs, but it will serve to monitor both resident and neotropical migratory birds. As a result, the NTMB program has potential to serve as a vehicle by which the USFS can obtain valuable information on status of bird species and bird communities on NFS lands. Bird communities provide a valuable barometer of ecosystem condition (Morrison 1986). Monitoring all birds will provide a context for interpreting changes in NTMB populations and further our understanding of the role NTMBs play on NFS lands.

MONITORING FRAMEWORK

The Task Group developed a hierarchical monitoring framework designed to define priorities for various types of information. The hierarchical framework defines monitoring options that build on one another. Monitoring options range from extensive surveys of population trends, requiring a minimum investment of time and funding, to intensive monitoring of population demographics requiring more time and effort per unit area. The framework consists of monitoring standards and three levels of monitoring effort: (1) level 1 entails monitoring population trends; (2) level 2 evaluates habitat relationships or management impacts; and (3) level 3 monitors factors affecting species' demographics. In addition, the framework defines roles and responsibilities at each level of the agency. The hierarchy is intended to encourage each National Forest or Grassland to participate in at least one and hopefully multiple levels of monitoring

A cadre of standardized protocols for a variety of avian survey and monitoring methods now exist. Field methods are not discussed in detail in this document because they are already well described in other documents. Standardized roadside point counts have been employed for the Breeding Bird Survey (BBS) since 1965 (Robbins et al. 1989). A number of other standardized protocols have recently been developed. Standardized protocols for point counts were developed at the Point Count Workshop held in Patuxent, Maryland, on November 6-7, 1991 (Ralph et al. in press). In addition, methods for obtaining demographic data have been detailed in protocols by DeSante (1991) and Martin and Geupel (in press). The following monitoring guidelines simply reference these standardized protocols, and emphasize some aspects of implementation where they are critical to success of the monitoring effort.

Monitoring Standards for All Hierarchical Levels

Monitoring activities at each level in the hierarchy should comply with set standards listed below.

1. Monitoring proposals should be prepared and then undergo review by a research scientist (or other qualified individual) and a biometrician for sound design and statistical validity before monitoring begins.
2. All monitoring efforts should have trigger points identified which quantify one or more resource conditions that, if reached, will launch some described research or management action. Resource conditions for which trigger points could be developed include population trends, habitat conditions, threats to special habitat requirements, changes in reproductive success or survival, etc.
3. All point counts should be at least 5 minutes in duration. The first three minutes of each count should be indicated on data sheets so the data can be compared to BBS data. Any counts conducted for longer than 5 minutes will mark the 5 minute point in the count so the first 5 minutes can be extracted from the data.
4. The point count standards call for recording all birds seen and heard inside and outside a 50m radius of the counting station. In narrow habitats such as riparian areas, a smaller radius band of perhaps 25m may be added to the 50m radius band to identify birds occurring within the habitat of interest.
5. Point counts should be conducted by multiple observers. The number of observers required should be determined using local or habitat specific information on potential observer bias. Habitats will vary in the relative difficulty they present in accurately counting birds. Differences between observers will also vary, depending upon criteria used to select observers. If local data on biases associated with habitats and observers is not available, they should be pursued through research. In lieu of local data, a minimum of 3 highly skilled observers should be used on each monitoring effort each year. Using three observers each year will help to average out individual biases within a year and reduce the likelihood that between-year differences are attributable to biases of an individual observer (Verner 1987). If possible, each observer should collect data at each point, thereby spreading the bias of each observer equally across all data points.

6. The number of counting stations required to meet Forest or Regional objectives should be evaluated with pilot or first year data to determine sample sizes that will yield the desired level of confidence. If preliminary data are unavailable to estimate minimum sample sizes, local researchers should be consulted to estimate an appropriate sample size. If data are unavailable, establish at least the minimum number of counting stations suggested for each level of the hierarchy. As soon as preliminary data become available, minimum sample size requirements should be calculated. A biometrician should be consulted when calculating minimum sample sizes or when making inferences about minimum sample sizes using local data sources.
7. Counting stations should be marked permanently and the same stations used each year.

Level 1 Monitoring

Level 1 monitoring is the most basic of monitoring efforts. Level 1 monitoring includes two distinct efforts.

1. Cooperating with U.S. Fish and Wildlife Service to ensure that the USFS is doing all it can to see that states, regions, and physiographic provinces each have enough BBS routes surveyed annually to characterize population trends.
2. Monitoring population trends of NTMBs at a Regional or Forest level via off-road (and possibly on-road) point counts. BBS methodology is well documented (Robbins et al. 1986). NFS could contribute by proposing new BBS routes, recruiting volunteers to survey the routes, and providing support services for volunteers.

The task group designed the second component of level 1 monitoring to provide population trend data for a Forest without stratifying counting stations by environmental parameters (e.g., vegetation types). This design will provide information to Forests on NTMB population trends, but will not yield information on trend interpretation since sampling is not stratified by environmental parameters. Stratifying by environmental parameters would require larger sample sizes and may not be achievable on all Forests. Level 1 monitoring should be achievable on all NFS lands within the next 3 years. Guidelines for implementing level 1 monitoring are outlined below.

1. Establishing counting stations:
   (a) counting stations should be located a set distance apart (see Ralph et al. in press) on transects, and the number of counting stations on each transect should be limited to the number that could be counted in one morning; and
   (b) transects should be distributed randomly across the Forest to obtain a representative sample of habitats and ecotones.
2. Sample size requirements:
   (a) minimum sample sizes required to detect trends should be calculated for each Forest, and should be adequate to detect approximately a 20% increase or decrease in population levels between consecutive years;
   (b) if absolutely no local or applicable sample size information is available, establish a minimum of 200 counting stations per Forest (Verner and Kie 1988, Thompson and Schwalbach in press); and
   (c) after the first and second year, the minimum sample size should be calculated and adjusted accordingly.
3. Count duration and visitation frequency:
   (a) counting stations should be visited once during the breeding season for a 5 minute count; and
   (b) the number of visits and count length is limited for level 1 monitoring to increase the number of stations that could be surveyed.
4. Observers:
   (a) each observer should be randomly assigned an equal proportion of the transects to be visited.
5. Habitat measurements:
   (a) habitat at each counting station should be classified using an ecological classification system that is applied throughout the Region; and
   (b) habitat measurements are not crucial in level 1 monitoring because the objective and sample design are not intended to yield information on habitat associations or causes for trends.

Level 2 Monitoring

Level 2 monitoring relates species presence/absence or abundance trends to habitat conditions representing natural conditions and/or land-use practices. Level 2 monitoring encompasses a range of options, some requiring minimal additional effort over level 1, and some requiring much more effort. Options for level 2 monitoring range from a scheme that investigates the impact of a management action on a local population of one or more bird species to a scheme that monitors a variety of habitat types throughout a Region or a Forest. Guidelines for implementing level 2 monitoring are outlined below.

1. Establishing counting stations:
   (a) counting stations should be randomly located throughout as many representative areas as possible for each habitat condition.
2. Sample size:

(a) describing the species associated with a particular habitat condition requires that adequate sample sizes are achieved within each habitat condition;
(b) minimum sample sizes should be calculated based on preliminary data and desired levels of confidence (a set level of confidence can not be established here because level 2 monitoring encompasses such a wide range of monitoring objectives); and
(c) if preliminary or locally applicable data are unavailable to estimate sample size, an absolute minimum of 30 counting stations should be established within each habitat condition for the first sample season.

3. Count duration and visitation frequency:
   (a) count duration and visitation frequency affect the number of counting stations that can be sampled per unit effort, with the ultimate goal being to provide an accurate estimate of the presence/absence or abundance trends of bird species occurring in specific habitat conditions;
   (b) if local data are unavailable, a pilot sample should be developed with the help of a biometrician; and
   (c) species accumulation curves should be calculated for each counting station to determine how much time is required to detect the majority of species at each point and if the greatest variability occurs between points or at a point over the counting period.
4. Habitat measurements:
   (a) habitat characteristics should be measured at and around each counting station;
   (b) each monitoring project should carefully consider the type of habitat information required to address the specific questions being posed;
   (c) at a minimum, habitat variables such as plant species composition, canopy closure, vegetation structure, slope, aspect, and elevation should be quantified using standardized techniques (Block et al. 1987); and
   (d) standardized measuring techniques should be used to ensure precise estimates of variables (Block et al. 1987), and visual estimates should be avoided.

Level 3 Monitoring

Level 3 monitoring obtains information on species demographics. Monitoring population demographics is recognized as an important element in the conservation of species. Monitoring the relative abundance of species over time may not be adequate to address cause and effect relationships of management activities or habitat quality (Southwood 1977, Van Horne 1983, and Hobbs and Hanley 1990). Demographic data will provide information needed to assess population viability and for interpreting population trends.

Two generalized procedures are currently being evaluated for their ability to yield demographic data: constant effort mist netting procedures and nest search and monitoring procedures. Demographic data consists of two components: (1) survivorship - the probability of survival from birth to age x; and (2) reproduction - the expected number of female offspring for each female of age x per unit time. The monitoring methods described here provide proxies to one or both components of demography. Both approaches have inherent advantages and limitations that should be considered before use.

Constant-effort mist net procedures provide information on productivity and survivorship. As with the population trends obtained from point counts, the data do not provide information on environmental factors that might be affecting productivity and survivorship. Productivity data is obtained by comparing the adult/young ratio, and is only a general indication of productivity in that once the young fledge, many species move great distances (often moving up in elevation). Birds captured in the nets could be from the local area and/or from areas miles away. Productivity data provided by the mist net technique appears to be most useful in providing large-scale trend data that are best complemented by habitat or area-specific monitoring to contribute to a monitoring scheme that can affect land management in a timely fashion.

Nest search and monitoring provide information on productivity via nest success, in addition to information on habitat associations. The strengths of nest search are that: (1) productivity data can be directly associated with habitat conditions; and (2) factors affecting productivity, such as predation and brood parasitism, can be quantified. The nest search procedure can not provide information on survivorship, and it is labor intensive so study areas are typically small and few in number.

Most level 3 efforts typically should be conducted in conjunction with level 2 efforts. Additional methods of obtaining population parameters need to be explored as a large-scale monitoring tools to provide information where existing methods fall short.

ROLES AND RESPONSIBILITIES

Involvement in data collection, analysis, storage, and exchange will extend across all levels of the USFS. A scheme for assigning areas of responsibility to each level of the agency are outlined below.

1. Washington Office responsibilities:
   (a) conduct periodic reviews of the national NTMB program within the NFS and research to determine if adjustments in program direction are needed;

(b) store data and conduct analyses necessary to describe multi-regional and national population trends; and
(c) distribute analysis results throughout the USFS and to other agencies and non-governmental organizations.

2. Regional Office responsibilities:
   (a) develop a monitoring plan for each Region that, (1) spans a five year time frame, (2) meets local, regional, and national information needs, (3) clearly defines and documents monitoring objectives in detail, (4) establishes a NTMB monitoring program on every Forest that accomplishes at least level 1 monitoring objectives, and (5) is rigorously reviewed for technical soundness;
   (b) provide the services of a Regional data center that serves as a repository for all monitoring data, provides standardized field and data entry forms and procedures, and conducts data analysis and interpretation of data collected within the Region;
   (c) provide high quality, consistent training throughout the Region on data collection, data entry, and data analysis; and
   (d) establish a Regional steering committee that is comprised of representatives from Forests, Districts, and research to help develop Regional direction for the NTMB monitoring program.
3. National Forest responsibilities:
   (a) develop proposals that will meet Forest needs for level 2 and 3 monitoring;
   (b) provide Forest-wide coordination of data collection, storage, and analysis;
   (c) conduct all data entry and proofing;
   (d) for data sets that are unique to a Forest, the Forest will be responsible for structuring a data base format and analyzing the data through cooperation with research; and
   (e) incorporate monitoring results into Forest direction, particularly when monitoring data indicate that a trigger point has been reached, and a change in management actions is indicated.
4. Research Responsibilities
   (a) conduct studies and experiments that investigate probable causes of troublesome population trends occurring within the Region;
   (b) investigate the habitat relationships, productivity, and survivorship of populations of NTMBs; and
   (c) design and test protocols for data collection, storage, and analysis to insure the desired quality and quantity of data are obtained.

THE IMPACT OF NTMB MONITORING IN THE USFS

The NTMB Program has the potential to have a significant effect within the NFS. The focus on monitoring species and habitats, and manipulating scientific data is unique within NFS, and the need exists for improved technical skills at all levels of the agency. The NTMB Program has enabled NFS to focus on improving technical skill levels within the agency, which will positively affect all USFS programs.

By far the most beneficial aspect of a successful monitoring program will be an increase in the quality of information upon which we base resource management decisions. It is clear that information about wildlife on NFS lands is inadequate for the kinds of land management decisions being made today. The NTMB program provides the NFS with an opportunity to develop information bases that are site-specific, current, and long-term.

LITERATURE CITED

Block, W.M., K.A. With, and M.L. Morrison. 1987. On measuring bird habitat influence of observer variability and sample size. Condor 89:241-251.

Butcher, G.S., ed. 1992. Needs Assessment: Monitoring Neotropical Migrant Birds. Unpubl. Rpt. Partners in Flight, Monitoring Working Group.

DeSante, D.F. 1991. The Monitoring Avian Productivity and Survivorship (MAPS) Program first annual report. Unpubl. rpt. Institute for Bird Populations, P.O. Box 554, Inverness, CA.

Hobbs, N.T. and T.A. Hanley. 1990. Habitat evaluation: do use/availability data reflect carrying capacity? J. Wildl. Manage. 54:515-522.

Martin, T.E. and G.R. Geupel. In press. Protocols for nest monitoring plots: locating nests, monitoring success and measuring vegetation. J. Wildl. Manage.

Morrison, M.L. 1986. Bird populations as indicators of environmental change. Pp. 429-451 in Current Ornithology, vol 3. R.J. Johnston, ed. Plenum Press, New York, NY.

Ralph, C.J., J.R. Sauer, and S. Droege. in press. Proc. of the Point Count Workshop in Patuxent, Maryland. USDA For. Serv. Gen. Tech. Rpt. PSW. Pacific Southwest Station, Albany, CA.

Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The breeding bird survey: its first fifteen years, 1975-1979. USDI Fish and Wildl. Serv. Res. Publ. 157. Washington, D.C.

Robbins, C.S., J.R. Sauer, R. Greenburg, and S. Droege. 1989. Population decline North American birds that migrate to the neotropics. Proc. Natl. Acad. Sci. 86:7658-7662.

Southwood, T.R.E. 1977. Habitat, the template for ecological strategies. J. Anim. Ecol. 46:337-365.

Thompson, F.R., III, and M.J. Schwalbach. in press. Analysis of sample size, counting time, and plot size from an avian point count survey on Hoosier National Forest, Indiana. in Proc. of the Point Count Workshop in Patuxent, Maryland. Ralph, C.J., J.R. Sauer, and S. Droege. USDA For. Serv. Gen Tech. Rpt. PSW. Pacific Southwest Station, Albany, Ca.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893-901.

Verner, J. 1987. Preliminary results from a system for monitoring trends in bird populations in oak-pine woodlands. Pp. 214-222 in Proc. of Symposia on Multiple Use Management of California Hardwood Resources. Plumb, T.R. and N.H. Pillsbury, tech. coords. USDA For. Serv. Gen. Tech. Rpt. PSW-100. Pacific Southwest Station, Albany, CA.

Verner, J. and J.G. Kie. 1988. Population monitoring: an essential link between theoretical and applied conservation biology. Trans. W. Sec. Wildl. Soc. 24:18-25.

Integrated Natural Resource Monitoring on Army Lands and Its Application to Conservation of Neotropical Birds

Timothy J. Hayden and David J. Tazik[1]

Abstract — The U.S. Army is responsible for managing 5.0 million ha (12.4 million acres) of land on 186 major installations world-wide. The Land Condition Trend Analysis (LCTA) Program is the Army's integrated monitoring and data collection program designed to fulfill the Army's natural resource information and management needs. Implementation of this program was initiated in 1987, and over 50 installations nationwide have begun or plan to implement LCTA. This paper describes the LCTA approach to natural resource monitoring and provides examples of LCTA applications for monitoring neotropical migratory birds and their habitats on Army installations. Activities on other Department of Defense lands related to conservation and monitoring of neotropical birds are also described.

INTRODUCTION

The United States military faces the unique challenge of being a public land steward while fulfilling its primary mission of maintaining a well-trained, combat-ready fighting force. The Department of Defense (DOD) recognizes the need to be a leader in environmental compliance and natural resource management if it is to maintain the land base necessary to meet its mission requirements (Cheney 1989).

Conservation of neotropical migratory birds is directly relevant to the military's ability to complete its mission requirements. Military installations often are protected from increased urbanization and agricultural development, sometimes becoming inadvertent refuges for wildlife and plant populations in a surrounding landscape of increasingly degraded habitats. Once a species requires legal protection at the state or Federal level, its presence on an installation can result in loss of training time and access to areas of endangered species habitat. This can result in both a monetary impact as well as a reduction in military readiness.

A significant percent of the known populations of four of the five Federally endangered bird species that are category A neotropical migrants (preliminary neotropical migratory bird list, Research Working Group 1992) breed on DOD installations. These include the golden-cheeked warbler (*Dendroica chrysoparia*), black-capped vireo (*Vireo atricapillus*), Kirtland's warbler (*Dendroica kirtlandii*), and California's least Bell's vireo (*Vireo bellii pusillus*). The fifth Federally endangered species, the peregrine falcon (*Falco peregrinus*) may occur as a transient on several installations.

Aside from its responsibility as a public land steward, it is in the military's self-interest to participate in programs such as Partners in Flight that have the goal of conserving species before they require legal protection.

Conservation and management of neotropical migratory birds requires information on current status of and trends in populations and habitats. Partners in Flight emphasizes comprehensive monitoring programs to meet these information needs.

This paper focuses on the U.S. Army's approach to natural resource inventory and monitoring and its application to monitoring of neotropical migrants and their habitats. The Army faces a significant challenge, managing approximately 5.0 million ha (12.4 million acres) of land on 186 major installations world-wide (Diersing et al. 1988). To meet this challenge, the Land Condition Trend Analysis (LCTA) Program was developed at the U.S. Army Engineering Construction Engineering Research Laboratory (USACERL) as the Army's standardized natural resource inventory and monitoring program. LCTA is currently implemented or scheduled for implementation at over 50 Army installations nationwide (fig. 1).

[1]*US Army Construction Engineering Research Labs, Natural Resources Management Team, PO Box 9005, Champaign, IL 61826.*

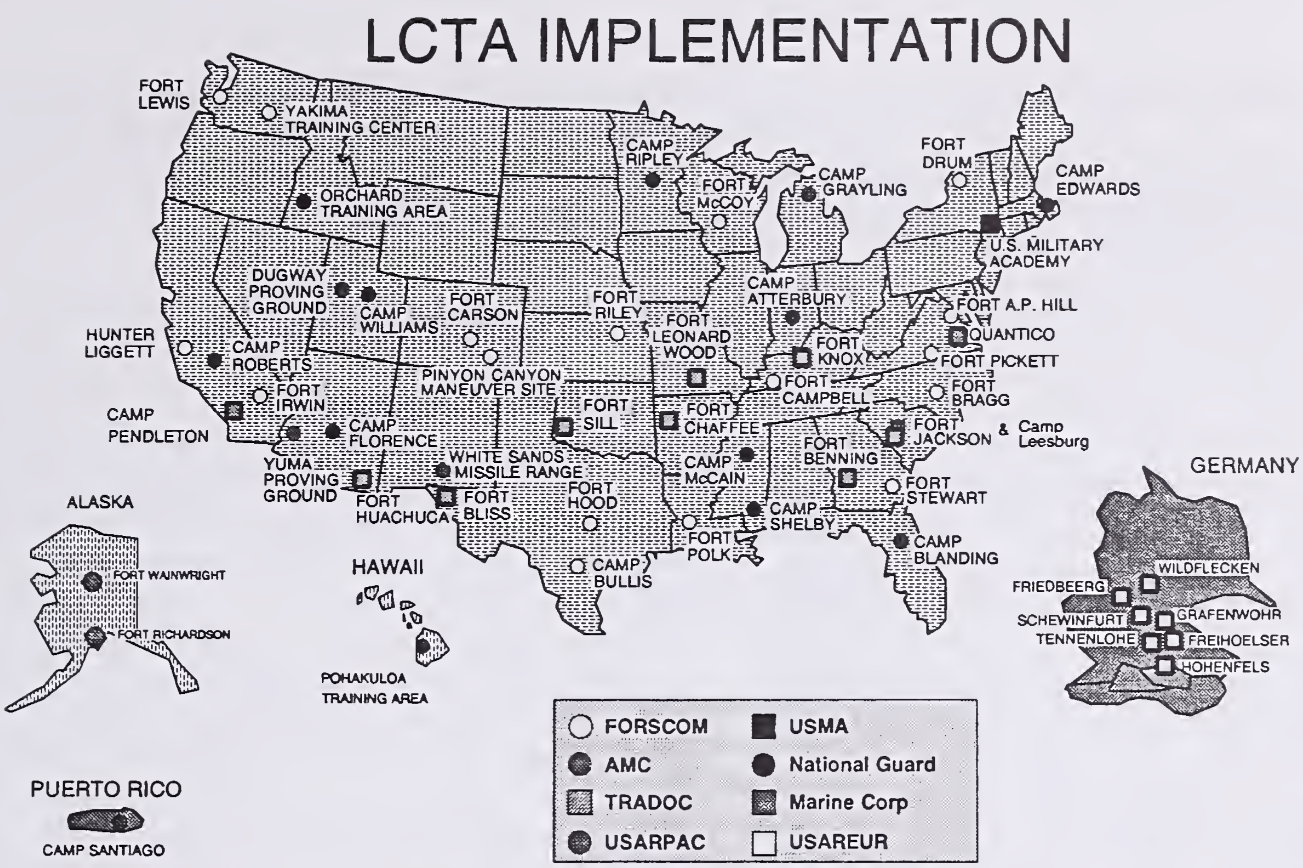


Figure 1. — Installations that have implemented or are scheduled to implement the Land Condition-Trend Analysis (LCTA) Program. Does not include some Natural Guard installations scheduled for implementation in 1993.

LAND CONDITION TREND ANALYSIS (LCTA) PROGRAM

Background and Objectives

In spring of 1984 an independent expert review panel reviewed natural resource management programs on selected military installations and civil works projects (Jahn et al. 1984). Their recommendations catalyzed development of a standardized natural resource inventory and monitoring program on Army lands. The LCTA program was recommended for Army-wide implementation in 1987.

LCTA's goals are: 1) evaluate capability of land to meet multiple-use demands of the U.S. Army on a sustained basis, (2) monitor and evaluate changes in natural resources relative to current land uses, (3) delineate biophysical and regulatory constraints to land use, (4) serve as a basis for amending land management plans to ensure long-term resource availability, (5) implement standardized data collection, analysis, and reporting procedures that enable compilation and evaluation of data and other information on an army-wide basis, and (6) characterize flora and fauna on army installations (Diersing et al. 1992).

Methods

The LCTA approach is to integrate field data collection, GIS and remote sensing technologies, and data analysis and retrieval capabilities into a comprehensive natural resource inventory and monitoring program.

Data collection on permanent field plots is the basis for natural resource monitoring in LCTA (Tazik et al. 1992). The standard LCTA field plot is 100 x 6 m with a 100-m line transect forming the longitudinal axis.

Allocation of permanent core plots is based on a stratified, random design. Stratified allocation of core plots is accomplished by integrating an unsupervised classification of satellite imagery with digitized soil surveys using the Geographic Resources Analysis Support System (GRASS) developed at USACERL (Warren et al. 1990). The number of core plots allocated to each reflectance category-soil mapping unit combination is proportional to the amount of total area the combination covers on an installation.

These permanent plots are monitored on an annual basis and data are collected on soils, slope, aspect, land use, surface disturbance, ground cover, canopy cover, and woody plants (Tazik et al. 1992). Collection of bird and small mammal data on a subsample of plots is the standard requirement for wildlife data, although other auxiliary wildlife data may be collected depending on installation requirements. Additional special use plots may be monitored to meet installation-specific information needs.

A plant community classification (PCC) for each plot is derived from an algorithm of cover type and percent of top-most aerial hits on the transect. The algorithm is based on a modification of Unesco (1973) and Driscoll et al. (1984) vegetation classifications. The LCTA plant community classification is a broad-based, generalized classification. Cluster analysis and other techniques are being evaluated to enhance the utility of plant community classifications at the individual installation level (D. Kowalski, USACERL, pers. communication).

LCTA Avian Census Methods

Birds are censused annually at a subsample of approximately one-third of permanent core plots up to a total of about 60 plots using a modified point-count transect technique (Blondel et al. 1981). Each plot is censused once each morning and evening by slowly walking the length of the LCTA plot in 6 minutes, recording all birds seen or heard within 100 m of the plot (Line Out). Upon reaching the end of the plot, the observer stops for 8 minutes and again records all birds seen or heard within 100 m (End Point). Finally, the observer walks back to the starting point in a period of 6 minutes, again recording any birds detected within 100 m of the plot (Line In). All morning censuses are conducted between 0.5 hour before and 4 hours after sunrise on relatively calm, rainless days. The evening census is conducted during the 4 hours prior to sunset. The inventory is conducted within a 2- 4-week period corresponding to the seasonal peak in breeding bird activity.

Data currently entered into the LCTA database include installation and plot ID, date, species, total number of pairs and individuals observed (largest of the 3 counts), whether it was a morning or evening count, flyovers observed during counts, and incidental sightings between plots.

APPLICATIONS FOR NEOTROPICAL MIGRATORY BIRDS

Because LCTA implementation is being phased in on Army installations over a period of several years, multi-year data sets currently are available for only a few installations. However, the available data is currently being reviewed and analyzed by the Natural Resources Management Team at USACERL in order to realize its full utility for natural resource management. The examples below show how LCTA data can be applied to monitoring and management of neotropical migratory birds.

Data Summary

The LCTA database and reporting capabilities allow quick retrieval of information for reporting summary statistics and species lists by installation and by year. Examples of summary statistics include relative frequency, number of observations, relative abundance, and importance values. Measures of species diversity, evenness, and richness can also be calculated. These summary statistics can compiled and reported in table or graph formats for use by managers to characterize and describe the installations avifauna in management plans and other environmental reporting requirements.

The LCTA database can also be referenced to auxiliary databases. In the case of neotropical migrants an auxiliary database was created listing North American species and their migratory status based on a preliminary list compiled by the research working group (RWG) of Partners in Flight (RWG 1992). This auxiliary database has been cross-referenced with LCTA avian census data for several military installations to compile species lists of neotropical migrants occurring on those installations (Tazik 1991).

Species/Habitat Relationships

Land managers need to know how land use and their management actions affect wildlife occurrence and abundance. Since LCTA data for vegetation, land use, and wildlife are collected on the same plots on annual basis, species/habitat relationships can be examined and related to patterns and trends in land use and condition.

As an example, suppose an Army resource manager wants to know which plant communities on the installation are preferred by a neotropical bird species. Using LCTA data, the relative abundance of each species in each plant community classification (PCC) can be compared with the expected abundance based on the relative frequency of plots in each PCC. Table 1 shows the relative abundance of each category A neotropical migratory species in each PCC and the relative frequency of plots in each PCC for a single year of LCTA data from Fort Drum, New York. Figure 2 represents this data graphically for an individual species. Although there are 15 plant community classifications for Fort Drum, they are grouped into five categories in Table 1 for clarity. These data can help focus a manager's attention on those habitats most important to an individual species or group of species.

Once a resource manager identifies habitats of interest or concern, the next step would be to determine where those habitats occur on the installation. One way to accomplish this is through costly and time-consuming ground surveys; however, vegetation cover maps developed from remote sensing applications are potentially more cost-effective and have the advantage of being replicated relatively easily over time. Researchers at USACERL are working to create supervised classifications of satellite imagery based on the LCTA plant community classifications with defined confidence estimates. This includes efforts to improve image processing and conduct accuracy assessments on selected installations (C. Bagley, USACERL, pers. communication).

The annual collection of avian census and vegetation, and satellite imagery for each installation potentially will allow resource managers in the future to monitor changes in habitats and their use by neotropical migratory birds over time.

Monitoring Trends

Partners in Flight recognizes that land managers need timely, quantifiable data on current or predicted trends in populations, land use, and habitat in order to assess the effects of natural resource plans and management prescriptions on neotropical migratory birds. Multi-year field data are now

Table 1. — Relative abundance (row frequency) of category A neotropical migratory bird species on 1990 LCTA plots on Fort Drum, New York. Relative frequency of plots is shown below PCC heading (n = 60).

				Broadleaf Woodland		
		Grassland	Shrubland	Open[1]	Closed[2]	Dense[3]
	n =[4]	0.400	0.083	0.167	0.283	0.067
Bobolink	44	1.000				
Bunting, Indigo	4	0.750		0.250		
Catbird, Gray	16	0.563	0.250	0.125	0.063	
Cuckoo, Black-billed	5	0.600	0.200	0.200		
Cuckoo, Yellow-billed	2	0.500			0.500	
Flycatcher, Alder	21	0.524	0.333	0.048	0.095	
Flycatcher, Great Crested	15	0.333		0.200	0.467	
Flycatcher, Least	25	0.320		0.120	0.520	0.040
Flycatcher, Willow	8	1.000				
Gnatcatcher, Blue-gray	1				1.000	
Grosbeak, Rose-breasted	18	0.111	0.222	0.111	0.389	0.167
Hummingbird, Ruby-throated	1				1.000	
Kingbird, Eastern	16	0.938			0.063	
Kinglet, Ruby-crowned	1			1.000		
Oriole, Northern	18	0.500	0.167	0.167	0.167	
Ovenbird	17	0.150		0.500	0.050	0.300
Redstart, American	29	0.069	0.069	0.138	0.690	0.034
Sparrow, Chipping	27	0.481	0.185	0.222	0.074	0.037
Sparrow, Clay-colored	1	1.000				
Sparrow, Grasshopper	1	1.000				
Sparrow, Savannah	41	1.000				
Swallow, American Tree	11	0.818	0.182			
Swallow, Barn	5	1.000				
Swallow, Northern Rough-winged	1	1.000				
Swift, Chimney	1				1.000	
Tanager, Scarlet	14		0.071	0.214	0.714	
Thrush, Hermit	20	0.050	0.050	0.350	0.500	0.050
Thrush, Wood	26	0.115	0.115	0.154	0.500	0.115
Veery	56	0.143	0.125	0.250	0.393	0.089
Vireo, Red-eyed	49	0.061	0.020	0.306	0.531	0.082
Vireo, Solitary	7	0.143		0.286	0.571	
Vireo, Warbling	8	0.750	0.125		0.125	
Vireo, Yellow-throated	5				1.000	
Warbler, Blackburnian	11	0.273		0.182	0.364	0.182
Warbler, Black-and-white	11		0.091	0.364	0.364	0.182
Warbler, Black-throated Blue	5				1.000	
Warbler, Black-throated Green	12			0.250	0.583	0.167
Warbler, Canada	4			0.500		0.500
Warbler, Chestnut-sided	23	0.435	0.261	0.174	0.043	0.087
Warbler, Golden-winged	3	0.333	0.667			
Warbler, Mourning	2				0.500	0.500
Warbler, Prairie	1				1.000	
Warbler, Yellow	21	0.524	0.429		0.048	
Warbler, Yellow-throated	5	1.000				
Warbler, Nashville	1			1.000		
Waterthrush, Northern	1			1.000		
Wood-Pewee, Eastern	17	0.176		0.235	0.588	
Wren, House	7	0.714		0.143		0.143
Yellowthroat, Common	40	0.375	0.300	0.150	0.100	0.075

[1] *Tree canopy cover >25 percent <=50 percent.*

[2] *Tree canopy cover >50 percent <=75 percent.*

[3] *Tree canopy cover >75 percent.*

[4] *Total number of individuals observed on plots.*

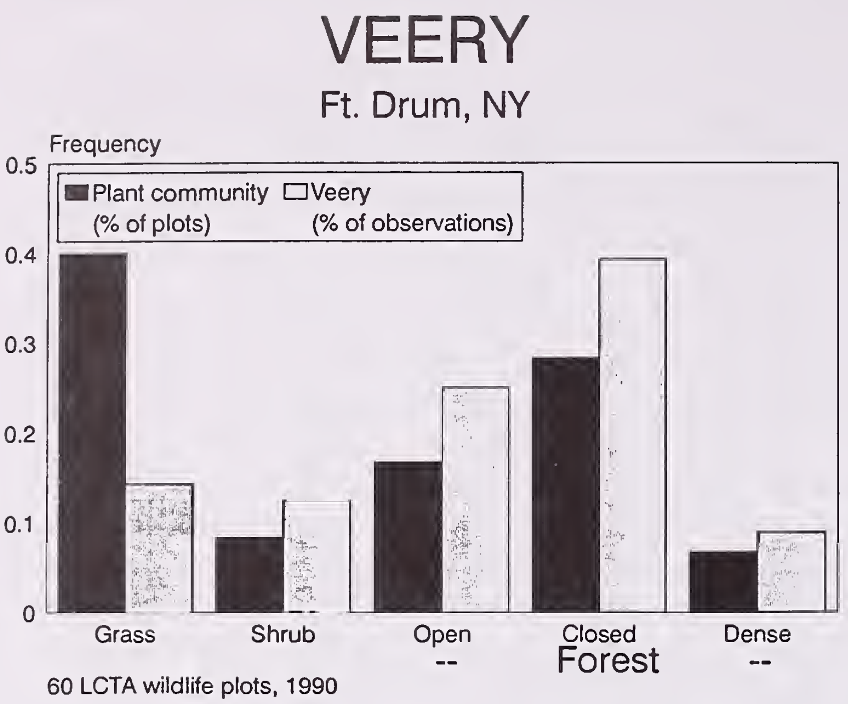


Figure 2. — Relative abundance of the Veery, a common neotropical migrant occurring on Fort Drum, New York, by vegetation classification (1990 data). Graph compares relative abundance to relative frequency of plots in each vegetation class.

available for some installations which is allowing USACERL researchers to assess some key parameters of trend analysis such as sample size adequacy for detecting population trends on installations.

As an example, two years of avian census data from Fort Sill, Oklahoma were used to explore sample size adequacy (A. Anderson and B. Sprouse, unpub. data). Data from 60 census plots were analyzed to determine sample size required to detect a 25 percent change in populations at = α 0.1 and = β 0.2 (Snedecor and Cochran 1980:102). Sample size requirements were determined for detecting change in populations of individual species as well as for various groupings such as by foraging guild, and migratory status.

Typically, sample size requirements for individual species were high. Sample requirements required to detect a 25% change in populations ranged from 94.7 to > 10,000 plots for the 62 species observed on Fort Sill. The sample size required for 51 of the species was >1,000. Obviously, this preliminary analysis indicates that current sampling is inadequate to detect a population change of 25% for individual avian species on Fort Sill. Various groupings of the data by species (e.g. by foraging guilds, nest substrate, migratory status) and by plots (e.g. plant community classification) reduced sample requirements. However, the number of plots required remained high relative to the number of plots actually censused. Grouping by migratory status of bird species on Fort Sill resulted in the most reasonable sample size requirements (Table 2). Sample requirements for category A neotropical migrants in 1989 and 1990 were 85.3 and 98.7 plots, respectively.

Table 2. — Sample size requirements to detect a 25 percent change in populations of avian species grouped by migratory status at = α 0.1 and = β 0.2. Calculations based on 1989 and 1990 LCTA data collected on Fort Sill, Oklahoma. Migratory category based on preliminary list of North American neotropical migratory terrestrial bird species (Research Working Group 1992).

Year	Migr. Cat.	mean (#/plot)	N	cv	Required sample size
1989	A	6.467	60	65.57	85.3
1989	B	7.367	60	53.66	57.1
1989	R[1]	8.467	60	106.01	223.0
1990	A	5.117	60	70.52	98.7
1990	B	4.717	60	58.82	68.7
1990	R	6.200	60	100.26	199.4

[1] *Resident species.*

The large sample size requirements were related in part to the statistical distribution of the data, variance in plots between years and variance among plots, the relative rarity of many species, and habitat heterogeneity among plots. The latter is due to the necessity of representing all habitat types within the installation boundary rather than focusing on a single, more homogenous habitat type. Factors which may help enhance the robustness of trend analysis include statistical techniques for transforming non-normally distributed data or for non-parametric analysis, determining reasonable *a priori* assumptions for clumping data in order to reduce variance, increased sample size, improved methodology to reduce variance in the data, and determination of what amount of change over what period of time is biologically significant.

Through LCTA, the Army is beginning to collect a large body of data throughout a broad geographic region and across ecologically diverse areas. These data are a significant resource for addressing questions regarding trend analysis in neotropical migratory birds. Guidance and suggestions from the Partners in Flight monitoring working group will be invaluable in efforts to enhance the utility of this data in detecting avian population trends not only at the installation level but also on a continental scale.

Related Army and Department of Defense Programs and Projects

Several research projects are currently underway on Army and DoD lands nationwide that directly or indirectly relate to conservation and monitoring of neotropical migratory birds.

Monitoring programs for Federally endangered neotropical migratory species are ongoing on several Army and Department of Defense installations. These programs emphasize monitoring of population trends and productivity of the Kirtland's warbler, (Camp Grayling, Michigan; National Guard), the black-capped vireo (Fort Hood and Camp Bullis, Texas, and Fort Sill, Oklahoma; Army), the golden-cheeked warbler (Fort Hood and Camp Bullis, Texas), and the least Bell's vireo (Camp Pendleton, California; Marine Corps).

Some of these species-specific research efforts may have broader applications to monitoring efforts for neotropical migrants. For example, golden-cheeked warbler field data, LCTA vegetation plot data, and satellite imagery were used to create a preliminary map of golden-cheeked warbler habitat on Fort Hood, Texas (Fig. 3). This process could be used to track changes in the abundance and distribution of golden-cheeked warbler habitat. The techniques will require further refinement and accuracy assessment but, in conjunction with other research efforts previously described, could have application for monitoring landscape scale changes in habitats of other neotropical migratory species.

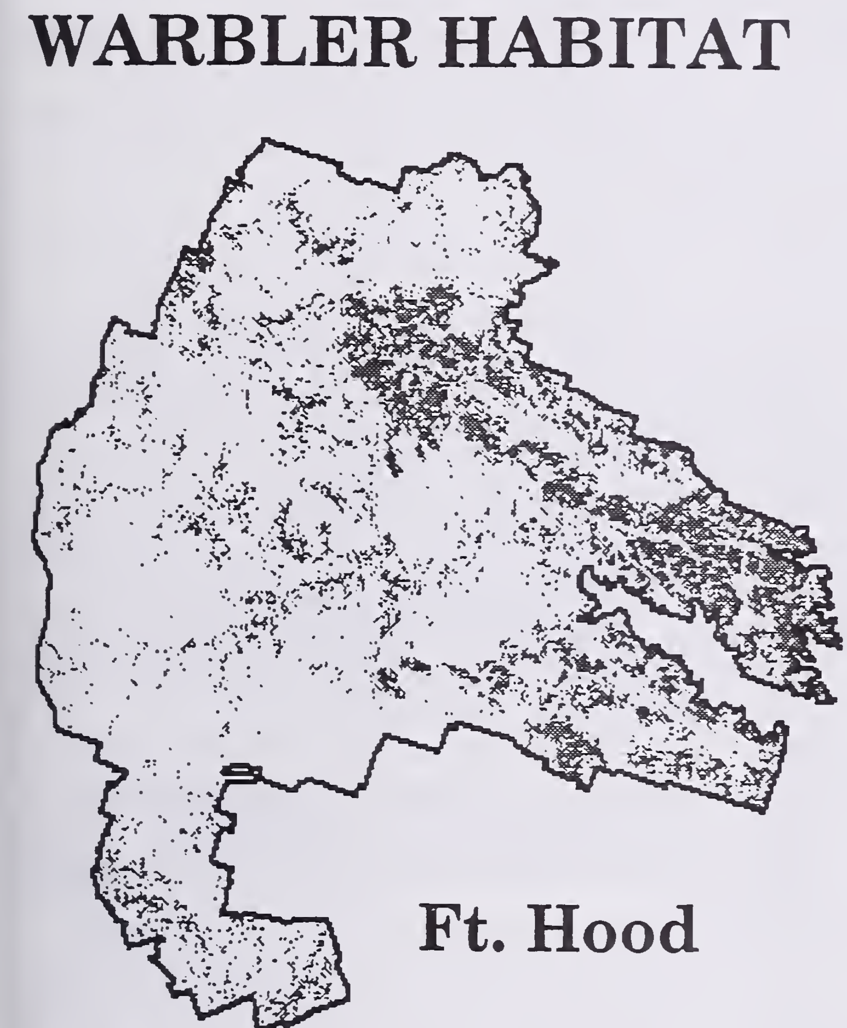


Figure 3. — Preliminary habitat map of the endangered golden-cheek warbler on Fort Hood, Texas. Map is derived from a supervised classification of satellite imagery using LCTA and warbler location ground data.

A related project is underway at Fort Sill, Oklahoma to create a species diversity map for neotropical migrants on the installation based on LCTA plot data and a vegetation cover map derived from aerial photography.

The army is also initiating studies related to monitoring and managing for biodiversity at a landscape scale, including projects related to monitoring riparian and wetland habitats and conserving biodiversity in southeastern U.S. long-leaf pine/wire grass ecosystems. All these projects may have direct or indirect applications in conservation of neotropical migratory bird species.

Interagency Cooperation

Populations and ecosystems do not stop at installation boundaries. Truly effective monitoring and management of populations or ecosystems must be accomplished across the landscape in which they exist. Becoming an active cooperator in Partners in Flight is an example of how the Army and other service branches are seeking to reach beyond installation boundaries to effectively manage their natural resources.

Several potential avenues exist for cooperating with Partners in Flight national monitoring efforts. One proposal under consideration is to develop a military migratory bird conservation network in cooperation with the National Fish and Wildlife Foundation. This proposal would emphasize cooperation within the military and with non-military organizations and agencies.

Once the Monitoring Committee establishes guidelines for a national monitoring based on point count methodology, LCTA data currently collected could be fed into the national database. This may require some modification or addition in data collection and database formats to conform to a national standard. However, the logistical base for such and effort is already in place. Also, a monitoring program for the endangered golden-cheeked warbler on Fort Hood has been initiated based on preliminary recommendations of the Partners in Flight monitoring working group.

Another example, is the establishment of constant effort mist-net stations on Department of Navy lands in cooperation with the Monitoring Avian Productivity and Survivorship (MAPS) Program. MAPS stations were established on three Navy installations in 1992, including the Naval Surface Warfare Center, Indian Head, Maryland; the Naval Surface Warfare Center, Dahlgren, Virginia; and the Naval Air Warfare Center, Patuxent River, Maryland in 1992 (J. Hautzenroder, U.S. Navy, pers. communication).

Two MAPS stations were also started on Fort Drum, an Army installation in New York, in 1992 (R. Leclerc, Fort Drum, pers. communication). At this installation, LCTA special use plots were established at each mist-net station so that vegetation and land-use data at the stations could be compared with data for the rest of the installation.

Most current biodiversity and ecosystem monitoring and management research on Army lands has or will have some element of interagency cooperation at a variety of administrative levels, and include state, Federal, and non-governmental agencies.

CONCLUSION

Monitoring programs that track trends in both habitats and their associated populations are crucial for providing natural resource managers the information they require to conserve and manage neotropical migratory birds. The Army through its integrated natural resource inventory and monitoring program (LCTA) is addressing many of the issues that the Partners in Flight Program has recognized as important to neotropical migratory bird conservation.

Data currently collected on Army installations are providing managers with basic information on species occurrence and distribution on their installations. Refinements in methodology and data analysis promise to increase the utility of these data to monitor trends in populations and habitats. The fact that avian data collection is integrated with other resource and land use data collection activities is one of the strengths of the LCTA approach to natural resource monitoring. Other Army research efforts related to monitoring biodiversity and ecosystems will have both direct and indirect applications to the conservation of neotropical migrants.

Programs with a continental perspective such as Partners in Flight recognize that close cooperation among government and non-government agencies is essential. The Army and other service branches realize this cooperative effort is key to achieving conservation goals, and look forward to working with other Partners in Flight cooperators to enhance conservation of neotropical migratory birds.

LITERATURE CITED

Blondel, J., C. Feery, and B. Frochet. 1981. Point counts with unlimited distance. Pages 414-420 *in* C. J. Ralph and J. M. Scott, eds. Estimating numbers of terrestrial birds. Studies in aviation biology, No. 6. Cooper Ornithological Society.

Cheney, R. 1989. Memorandum for Secretaries of the military departments. Subject: Environmental management policy. Unpublished.

Diersing, V. E., R. B. Shaw, S. D. Warren, and E. w. Novak. 1988. User's guide for estimating allowable use of tracked vehicles on non-wooded military training lands. Journal of Soil and Water Conservation 43:191-195.

Diersing, V. E., R. B. Shaw, and D. J. Tazik. 1992. U.S. Army Land Condition-Trend Analysis (LCTA) Program. Environmental Management 16:405-414.

Driscoll, R. S., D. L. Merkel, D. L. Radloff, D. E. Snyder, J. S. Hagihara. 1984. An ecological land classification framework for the United States. USDA Forest Service. Misc. Publ. No. 1439.

Research Working Group. 1992. Preliminary lists of migrants for neotropical migrant bird conservation program. Workplans and reports, Research Working Group, Neotropical Migratory Bird Conservation Program. Partners in Flight Newsletter 2(1):30.

Jahn, L. R., C. W. Cook, and J. D. Hughes. 1984. An evaluation of U.S. Army natural resource management programs on selected military installations and civil works projects. Report to the Secretary of the Army, U.S. Department of the Army. Unpublished.

Snedecor, G. W., and W. G. Cochran. 1980. Statistical Methods, 7th ed. The Iowa State University Press, Ames Iowa.

Tazik, D. J. 1991. Neotropical migratory birds recorded on selected U.S. Army installations. Report to Natural and Cultural Resources Division, U.S. Army Engineering and Housing Support Center. Unpublished.

Tazik, D. J., S. D. Warren, V. E. Diersing, R. B. Shaw, R. J. Brozka, C. F. Bagley, W. R. Whitworth. 1992. U.S. Army Land Condition-Trend Analysis (LCTA) Plot Inventory Field Methods. USACERL Technical Report N-92/03.

Unesco. 1973. International classification and mapping of vegetation. United Nations Educational Scientific and Cultural Organization. Paris France.

Warren, S.D., M.O. Johnson, W.D. Goran, and V.E. Diersing. 1990. An automated, objective procedure for selecting representative field sample sites. Photogrammetric Engineering and Remote Sensing. 56:333-335.

Monitoring Goals and Programs of the Bureau of Land Management

Terrell D. Rich[1]

Abstract — In 1991, the Bureau of Land Management wrote its *Nongame Migratory Bird Habitat Conservation Plan* to guide implementation of *Partners In Flight* objectives on 270 million acres of public land in the U.S. Inventory and monitoring of neotropical migrants are the most important program goals because few bird data are available over large expanses of sparsely populated western lands. Nongame bird activities will mesh nicely with ongoing initiatives such as the Riparian-Wetlands, Watchable Wildlife, and Ecosystem Management. Impediments to success are the remoteness of many important habitats and the shortage of skilled birders in those areas.

The Bureau of Land Management (BLM) manages over 270 million acres of public land in the 11 western states and Alaska. Under the Bureau's *Fish and Wildlife 2000* initiative, the *Nongame Migratory Bird Habitat Conservation Plan* was written in 1991 as a strategy for future management of nongame birds on these lands. Focal species include not only those of consensus in *Partners In Flight* but also most other nongame species that either breed or winter on BLM-administered lands. Separate strategic plans for Raptors, Waterfowl, and Upland Game Birds address habitat management for those groups.

NONGAME MIGRATORY BIRD HABITAT CONSERVATION PLAN GOALS

Goals in six general categories of action structure the Nongame Bird Strategy Plan: 1) Inventory and Monitoring, 2) Habitat Management, 3) Research and Studies, 4) Training, Education, Outreach and Communication, 5) Domestic Partnerships, and 6) International Partnerships.

Positioning *Inventory and Monitoring* as the first goal reflects its importance. *Partners In Flight* was engendered by concern over species' population trends in the eastern United States where there are relatively many amateur birders and ornithologists. However, over much of the West, there are few long-term monitoring data for most nongame species, largely a consequence of a sparse human population. Additionally, the condition of habitats on public lands traditionally has been evaluated from a livestock or big game perspective, for example, and condition as breeding habitat for neotropical migrants has been considered only in a few special cases. Thus, both bird and habitat monitoring are widely needed.

Baseline Nongame Bird and Habitat Inventories

The first of four major objectives under the monitoring goal is to *Develop and implement standardized baseline inventories of nongame birds and their habitats.* "Inventory" simply means a collection of basic data on what species are present in certain habitats during different periods of the year. Current nongame bird inventory data are inadequate in most geographic areas. The numbers of species involved, the difficulty in identifying them and the lack of time for field biologists to devote to only this one aspect of multiple use management contribute to this undersampling situation. Where special management areas are in place, such as the Birds of Prey Area in Idaho and the San Pedro Riparian National Conservation Area in southern Arizona, nongame bird inventories are complete.

The Bureau intends to rely on recommendations of the *Partners In Flight* Monitoring Working Group for bird monitoring techniques that will be used to establish formal, systematic baseline inventories. In many areas, inventories may be more casual, consisting of observations, for example, of volunteer birders who may spend time in the field during the breeding season on a less predictable basis. Following the *Partners In Flight* lead, emphasis will be placed on neotropical migrant land birds and species that are declining.

[1] *Nongame Bird Program Manager, Bureau of Land Management, 3380 Americana Terrace, Boise, ID 83706.*

A priority list of species will greatly aid the effectiveness of any inventory where experts are not available. It should be possible to train field personnel to identify general habitat requirements, field marks and, most importantly, vocalizations of a limited number of species of particular concern. Although this type of inventory is less valuable from the standpoint of ecosystem management and conservation of biodiversity, it may be a practical alternative that is much better than nothing at all.

For habitats, existing vegetation inventory data must be evaluated for applicability to nongame bird management. It seems likely that these data will be useful and that it will not be necessary to go back to the field for expensive, time consuming, large-scale data gathering. Fortunately, the Bureau's ongoing *Riparian-Wetlands Initiative* has focused attention for years on assessing species composition, structure, condition, and potential of riparian vegetation. This will provide a platform for assessment of the most critical nongame bird habitat in the arid West. Refinements in vegetation evaluation undoubtedly will be necessary as we focus more clearly on particular species or problems in the near future.

Long-term Monitoring

Our second objective is to *Develop and implement a monitoring scheme to determine long-term changes of nongame bird populations and habitat and their responses to management activities and to natural phenomena such as fire and flood.* The ultimate objective will be to understand the biological cause-effect relationships between bird populations and vegetative changes. The latter are caused not only by conscious management actions but also by natural phenomena such as wildfires, floods, disease outbreaks, and invasion by exotic plants.

Long-term monitoring methodology for birds will follow the recommendations of the Monitoring Working Group as far as possible. We intend to participate fully in existing systems such as the Breeding Bird Survey and will explore the possibility of creating new routes where necessary.

As in the inventory stage, the challenge will be to get qualified birders on the ground year after year to collect population data. Remoteness of potentially important areas and the narrow window available for monitoring breeding birds will be an impediment. Further prioritization following inventory should allow us to focus on a smaller set of species and geographic locations. This is essential to reliable data collection.

Habitat monitoring techniques already in place in the Bureau should be sufficient to provide data linking bird populations and plants. The interdisciplinary nature of our Riparian-Wetlands Initiative has specialists from a variety of resource programs, e.g., wildlife, range and water quality, involved in vegetation monitoring. If cause-effect relationships emerge that are not being properly followed, new techniques can be readily put into place.

Coordination and Communication With Partners

Third, the Bureau intends to *Coordinate with other land managers to ensure that inventory and monitoring schemes are compatible and completed in all necessary areas.* Through good communication with the many *Partners In Flight* cooperators, particularly the U.S. Forest Service and U.S. Fish and Wildlife Service in the West, we will strive to conduct efficient inventories and monitoring by sharing information on species, similar habitat types and geographic areas. Participation in the West Working Group and in state working groups will be critical to this end.

Data Base and Geographic Information System

Our final major objective is to *Develop and implement an automated data base with Geographic Information System (GIS) capability.* Unlike many of our partners in this conservation program, BLM has a mandate for multiple use management. Thus, we must manage a forbidding amount of information on a huge array of resources and their uses. From the data perspective, one benefit of this mandate is that information useful to nongame bird conservation may have already been collected and analyzed for entirely different purposes. The use of satellite imagery to study landscape-level vegetation for fire management is an example. Ultimately, a GIS system may be the only way to make large amounts of information useful in land use planning and in daily management activities.

In a related effort, the Information Resources Management branch of the Bureau is standardizing data elements for automated data base systems. This has been accomplished with full involvement of other agencies and groups who manage natural resource data. Hopefully, this will lead to a steady improvement in the ability of diverse organizations to exchange data.

SELECTED EXAMPLES OF NEOTROPICAL MIGRANT MONITORING

San Pedro Riparian National Conservation Area

Selected examples of ongoing neotropical migrant monitoring in BLM are highlighted by the San Pedro Riparian National Conservation Area in Arizona's Safford District (see Krueper 1992). The San Pedro story shows what can be accomplished when various resource programs, e.g., wildlife, lands, range, archaeology and recreation, work together with management support toward a common goal.

Over 45,000 acres of riparian habitat along the San Pedro River in southeastern Arizona were acquired in 1986. This is a 40-mile long north-south corridor with headwaters in Mexico. A 15-year grazing moratorium was initiated to allow vegetation to recover while line transects were established in 21 different plant communities. Transects were then read for 60 continuous months.

To date, 379 species of birds have been recorded in the area including 210 species of neotropical migrants. Preliminary data analysis show avian densities reaching 50 individuals/ha during spring migration and 38 individuals/ha during the breeding season. In response to the improved vegetation under rest from grazing, understory specialists such as the yellow-breasted chat (*Icteria virens*), common yellowthroat (*Geothlypis trichas*) and song sparrow (*Melospiza melodia*) have significantly increased. Yellow warbler (*Dendroica petechia*) and western wood-pewee (*Contopus sordidulus*) populations have increased 400 percent while summer tanager populations have doubled. Given the probable lags in species' responses to habitat changes (Wiens et al. 1986), further increases are likely.

Responses of vegetation and then of birds to improved management is not particularly surprising. But the unequivocal demonstration of these responses is extremely important. For it shows that we can directly and rather quickly improve critical riparian habitats in arid landscapes, increase neotropical migrant populations and enrich biological diversity if we want to.

Marys River

In Nevada's Elko District, another important riparian area has been put under special management. In May 1991, an exchange was completed that increased the total stream miles on BLM-administered land from 31.6 miles to 86.2 miles and increased total acreage by 46,969 acres in the Marys River drainage. This includes 8,600 acres of wet meadows, 60 springs and 6,700 acre-feet of water rights.

The primary objective of the acquisition and management plan is to restore Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) habitat and allow for eventual delisting of the subspecies. However, vegetation monitoring will be useful for all riparian resources. Bird monitoring will be carried out by the Nevada Department of wildlife. The Marys River project provides a significant opportunity in the Great Basin to better understand neotropical migrant responses to vegetation changes.

Montana Riparian Association Vegetation Classification

In Montana, the Montana Riparian Association, a coalition of agencies, groups and academic institutions, has cooperated to evaluate and classify over 1000 miles of riparian habitat. Seral stage, potential vegetative community, responses to grazing and management recommendations are among the many subjects considered (Hansen 1991, Hansen et al. 1991).

A pilot study in 1992 investigated how to link breeding bird community composition to the defined habitat types. Long-term monitoring of selected sites is planned with the objective of refining our ability to predict both vegetative and avian responses to management actions.

Snake River Birds of Prey Area

Biologists in the Snake River Birds of Prey Area in the Boise District in southwestern Idaho have monitored nest productivity and populations of several species of raptors since as early as 1970. Northern harriers (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicencis*), ferruginous hawks (*B. regalis*), golden eagles (*Aquila chrysaetos*), American kestrels (*Falco sparverius*), prairie falcons (*F. mexicanus*), burrowing owls (*Athene cunicularia*) and short-eared owls (*Asio flammeus*) have been studied while other aspects of their ecology, e.g., prey populations, have been explored (e.g., Steenhof 1991). This research has led to a number of specific management recommendations for raptors and the vegetative communities that support their prey base.

The value of research at the Birds of Prey Area has led to an extension of their responsibilities through creation of the Raptor Research and Technical Assistance Center (RRTAC) in conjunction with Boise State University, University of Idaho, Idaho State University, U.S. Fish and Wildlife Service, Idaho Department of Fish and Game and the Peregrine Fund. RRTAC expertise is available to help with research, monitoring or other aspects of raptor management on BLM lands.

Although livestock grazing is ubiquitous in the western U.S., few data are available on the effects of grazing on neotropical migrants of shrubsteppe habitats (see Bock et al., this volume). Monitoring of shrubsteppe birds in areas of different management and different degrees of fragmentation also has been initiated in the Birds of Prey Area (Rotenberry and Knick 1991). Similar monitoring to evaluate islands of shrubsteppe habitat in an agricultural landscape is being established in Washington state. Although fragmentation and area sensitivity have been popular and valuable lines of investigation in forested landscapes, nothing is known about their relation to bird populations in shrubsteppe.

CONCLUSIONS

The Bureau has several initiatives where monitoring of neotropical migrants will be an important component, particularly Riparian-Wetlands, Bring Back the Natives (fish), Watchable Wildlife and Ecosystem Management. Emergence of *Partners In Flight* is especially timely and has been well received by BLM personnel. However, it is unrealistic to expect instant and widespread implementation of management for neotropical migrants. The very initiatives that have focused attention on the critical conservation issues of our time have placed additional workloads on field biologists who, on the average, each have about 1,000,000 acres of public land to manage and about 12 cents per acre to accomplish needed work. This situation demonstrates the necessity of establishing species, habitat and geographic priorities and, most importantly, cooperating with our partners at every possible turn.

LITERATURE CITED

Bock, C.E., V.A. Saab, T.D. Rich, and D.S. Dobkin. Effects of livestock grazing on neotropical migratory landbirds in western North America. *in press.*

Hansen, P.L. 1991. Classification and management of riparian-wetland shrub sites in Montana. Pages 68-78 *in* Proceedings-symposium on ecology and management of riparian shrub communities (W.P. Clary, E.D. McArthur, D. Bedunah and C.L. Wambolt, Eds.). USDA For. Ser. Gen. Tech. Rep. INT-289. Ogden, UT.

Hansen, P.L., K. Boggs, R. Pfister, and J. Joy. 1991. Classification and management of riparian and wetland sites in Montana. Draft version 1. Univ. Montana, Montana Riparian Assoc., Montana For. and Cons. Exper. Sta., School of For. Missoula, MT.

Krueper, D. 1992. Birds and habitat on the San Pedro Riparian National Conservation Area. Partners In Flight Newsletter 2(1):10.

Rotenberry, J.T. and S.T. Knick. 1991. Passerine surveys on the Snake River Birds of Prey Area. Pages 220-228 *in* Snake River Birds of Prey Area 1991 Annual Report, (K. Steenhof, Ed.). USDI Bur. Land Manage. Boise, ID.

Steenhof, K. (Ed.). 1991. Snake River Birds of Prey Area 1991 Annual Report. USDI Bur. Land Manage. Boise, ID.

Wiens, J.A., J.T. Rotenberry, and B. Van Horne. 1986. A lesson in the limitations of field experiments: shrubsteppe birds and habitat alteration. Ecology 67:365-376.

A Western State Perspective on Monitoring and Managing Neotropical Migratory Birds

Frank Howe[1]

Abstract — Neotropical migratory bird monitoring programs can contribute greatly to a more holistic and proactive management approach for state agencies. It is, however, imperative that these monitoring programs be scientifically designed and clearly communicated to managers. Information from monitoring programs can be used to develop multiple-species habitat management strategies, and declining populations can be detected before threatened and endangered species management is required.

State agency perspectives on wildlife values and management are evolving, and many are seeking to develop more holistic management plans. Such plans focus not only on traditional values and single species management, but also include emerging wildlife values and multiple-species management based on principles of community and ecosystems ecology. This is, in part, in response to public pressure for greater efforts at conservation; however, this is also because of changes in state agencies themselves.

Unfortunately, information on which to base holistic management decisions is scarce. And, few managers or administrators are willing to change management strategies without sufficient evidence of need. Monitoring and inventory of neotropical migratory birds, in combination with increased biological research on neotropical migrants, will provide managers and administrators with information needed to justify and guide more progressive management actions.

THE INFORMATION NEEDED

Agencies will benefit most from monitoring programs that provide sound and applicable information about population trends. Programs must be carried out in a scientific fashion, using principles of experimental design and statistical sampling. While most state programs will not include manipulative research, proper scientific protocol and design should, nonetheless, be incorporated.

[1] *Utah Division of Wildlife Resources, 1596 W. North Temple, Salt Lake City, UT 84116-3195.*

It is vital that information collected through monitoring programs be applicable. Also, academic research designed to fill basic information gaps on life history and habitat requirements should compliment monitoring and inventory programs; such information is required before management decisions can be made. Inventory, monitoring, and research efforts should all be conducted with consideration for management, and results must be communicated in a form useful to managers. A well communicated and balanced monitoring program will allow state agencies to approach breeding bird management with more information and less apprehension than in the past.

BENEFITS

Ultimately, the state's goal is to manage neotropical migrants as part of an ecosystem. A neotropical migrant monitoring program provides a means to detect declining breeding bird populations and changes in their habitats. However, a monitoring program may be used as an end unto itself. In Utah, the information collected under the neotropical migrant monitoring program is used to inventory birds in riparian habitats. The program provides species diversity, relative abundance, and distribution information. And, population and vegetation data can be used to develop species/habitat associations.

By monitoring population trends, agencies will detect declines before populations become endangered or threatened. That is, trend information will allow states to be more proactive in their management. Frequently, by the time a species is recognized as threatened or endangered, management options are severely limited, not to mention politically sensitive. It is desirable to have a method of early detection which allows agencies manage before the "triage" approach of endangered species management is required.

Despite political baggage, threatened and endangered species do have legal protection. This is not be the case with declining populations of neotropical migrants. Here again the need for scientifically sound, understandable information and effective communication becomes apparent. In order for state agencies to justify conservation actions aimed at preserving declining breeding bird populations, evidence must be scientifically sound and effectively communicated.

Information collected through monitoring programs can contribute to ongoing or anticipated state projects. In Utah, monitoring information is collected in a way that it can be incorporated into GAP analysis and electronic database projects. Coordinates are recorded with Global Positioning Devices for each monitoring point. Vegetation information from these points is used to ground truth coverages derived from Landsat imagery. And, breeding bird data in association with vegetation data can be used either to construct or validate potential species range models.

Monitoring data also gives information on species presence (inventory), species diversity, relative abundance, and distribution. This information becomes available before any trends can be determined. However, the quality of information grows with each additional year of monitoring.

HOW INFORMATION IS COLLECTED

Prior to our neotropical migratory bird initiative, almost all collection of breeding bird data in Utah can be attributed to a few dedicated individuals. Early academic works and a Utah latilong bird study contributed much to our knowledge of distribution and life history. However, monitoring of neotropical migrants was limited to the Breeding Bird Survey (BBS), and coverage of Utah was poor (13 routes from 1965-1979).

Coverage of Utah has increased to 61 routes with 8 new routes scheduled for 1993. While BBS does provide suitable information about several neotropical migrant species, coverage of many species is inadequate. Also, since no habitat data is collected on BBS routes, managers find the information hard to apply.

While addition of more BBS routes and habitat evaluation of these routes is a worthwhile endeavor, there are other problems with BBS in Utah. In addition to the problem of bias in road-side counts, many of Utah's important habitat features are roadless. Also, availability of qualified surveyors is a bottleneck in sparsely populated, rural states like Utah. Thus, addition of routes may be a moot gesture.

Since much of Utah cannot be accessed by road, Utah Division of Wildlife Resources (UDWR) and the U. S. Fish and Wildlife Service initiated an off-road program to monitor neotropical migrant populations in key habitat types, beginning with riparian areas. The program includes extensive monitoring in over 30 riparian sites and intensive monitoring and constant effort mist netting at 8 sites statewide. Riparian habitats were chosen because of their high relative importance and because various factors continue to threaten their existence in the West.

MAKING USE OF THE INFORMATION

How can managers best use information provided by monitoring programs? First, inventories provided by monitoring programs are of immediate use to managers in evaluating species presence. Monitoring programs also provide basic information on species richness, breeding bird distributions, and habitat associations. This information is important to those struggling with management-for-biodiversity issues.

Perhaps the most important information provided by monitoring programs is on population trends of breeding birds and their habitats. This can serve as an early indicator of species and/or habitat instability. By using this information, managers can be proactive in their decisions. Also, managers can use species/habitat correlations developed through monitoring and research to direct management actions.

MAKING INFORMATION USEFUL

To date, much of the information available is insufficient to address most management problems. Most monitoring programs resulting from Partners in Flight are too new to provide any current trend information, and even well established programs like the BBS do not provide adequate information on many species. And, as mentioned above, no habitat data is collected in association with the BBS.

The perception of monitoring information as unscientific is a serious problem. For example, criticisms of the BBS have been so widespread that recognition of its biases seem to overshadow recognition of its usefulness. While it is necessary to point out shortcomings of data collected under various monitoring methods, it is also crucial to understand and point out where the data are strongest and most applicable. And, it is equally important to improve methods to address biases, if possible, or augment them with other methods.

Since no one monitoring technique provides sufficient information for all breeding bird species, combinations of monitoring techniques are required. Some techniques may need to be developed for single species which, because of unique habits or habitats, are not addressed by any standardized methods. Research into habitat requirements and life history prerequisites may also be needed for some species or guilds. States will need to tailor their monitoring programs to provide information required to develop sound management strategies.

Communication of available information is crucial. Development of communication links and a central clearinghouse would be of great use to state agencies. Many such links have already been established through Partners in Flight.

THE FUTURE

The future of neotropical migratory bird monitoring programs in state agencies like Utah's is bright but hazy. The desire of state agencies to monitor neotropical migrants is real; however, funding and training are two formidable obstacles faced by states. While challenge grants and cooperative matching-fund programs allow states to gather more information per dollar, states often cannot afford to match federal money even at a 1:1 ratio. Also, several states are cutting non-game wildlife programs and/or requiring traditional consumptive users to foot the bill for all wildlife programs. Non-game checkoffs are facing increased competition on tax forms and few politicians are willing to consider an increase in sales or income tax. However, efforts to identify other sources of money have met with some success. Conservation stamps, lottery of wildlife viewing opportunities and other non-consumptive-user contributions have been discussed. Private partners are another source of funding. However, private partners must be chosen carefully, because while they can be a good source of money, they can also be a source of political problems. The UDWR was fortunate to have solicited a good private sponsor for its neotropical migrant/riparian monitoring project.

Most state personnel are not currently trained in bird identification or monitoring techniques. While training workshops are available in out-of-state locations, out-of-state travel is severely limited in most state agencies. Permanent state employees cannot dedicate all their time to monitoring programs, so frequently seasonal or temporary employees need to be hired for most monitoring programs. Since trained seasonal personnel are difficult to find, states need to organize their own training sessions on an annual basis. But to do this, states will need to import experts in neotropical migrant identification and monitoring techniques, at least initially.

Monitoring neotropical migrants presents unprecedented need for interagency cooperation. Coordination of state and federal wildlife and land management agencies, universities and interest groups will be required. This will be no small feat, but Partners in Flight has already brought many key players together. Maintaining these ties, especially at the state level, will be a key to the success of Partners in Flight.

Much coordination of agencies and management of neotropical migrants will depend on state agencies. The states' developing interest in holistic and proactive management strategies could be well served by neotropical migratory bird monitoring programs but is threatened by training and funding shortages. States can tailor programs to their individual needs, but should do so while adhering, when possible, to standardized techniques. Standardized techniques are being developed so information can be compared across state and national lines--an important consideration for management of migratory birds. The techniques being developed must, in turn, provide information that is scientifically sound and suitable for on-the-ground application by wildlife managers.

Virginia's Monitoring Goals and Programs: An Eastern State Perspective

Dana Bradshaw[1]

Abstract — Unlike the federal ownership patterns of the western United States, the eastern states are still largely in the hands of the private landowner. As a result, the implementation of the Partners in Flight program in the East will depend a great deal on the motivation and dedication of individual states. Monitoring programs in particular are in a position to benefit from the relationships that state agencies maintain with private landowners and non-governmental organizations, as well as their federal counterparts. The activities of Virginia's Department of Game and Inland Fisheries serve as an example of one state's approach to implementing the monitoring objectives of Partners in Flight.

Virginia is unique in many respects. By virtue of its east-west orientation it enjoys a geography that incorporates five different physiographic regions: coastal plain, piedmont plateau, blue ridge province, ridge and valley province, and the Appalachian plateaus province. For its size, it has the greatest diversity of living forms of any temperate area (Woodward and Hoffman 1991). Virginia's latitude coincides with the southern boundary for many boreal species expanding southward, and also the northern boundary for many austral species expanding northward. As such, its avifauna consists of 390 recorded species, 209 of which are documented breeders in the state (Kain 1987).

Among forest dwelling birds, some 60 species in Virginia are neotropical migrants and over half of these species have shown declines since 1980 (S. Droege, pers. comm.) Unfortunately, there is a paucity of trend data, demographic data, and habitat modification data from which to understand the causative elements of these species' declines. At three independent long-term monitoring stations in or near Virginia, results showed increasing, declining, and stable populations respectively, of neotropical migrants all during roughly the same time periods (Byrd and Johnston 1991). Factors that were not adequately monitored however were habitat changes and other man-induced disturbances at a landscape level. Despite this lack of direct knowledge of human impacts, it is widely accepted that the declines in neotropical migratory bird species are associated primarily with the effects of human activity.

Prior to 1992, Virginians censused approximately 45 Breeding Bird Survey (BBS) routes each year. However, given the clumped nature of randomly distributed routes, there were many gaps across the state that received no survey coverage. And prior to the implementation of the Neotropical Migratory Bird Conservation Program (Partners in Flight), there were several routes that were not run each year due to lack of interest or to time constraints. Therefore much of the BBS data generated in Virginia lacks completeness or consistency of coverage. However, for data that was available, results have shown declines in a large percentage of neotropical migrants since 1980. Unfortunately, it is also known that many neotropical migrant species are not sampled adequately by roadside point counts, a problem that is characteristic of species that are endemic to unique habitat types or those that inhabit inaccessible areas like forest interiors.

In addition to the BBS routes, a Breeding Bird Atlas project was conducted in the state for the five year period 1985-1989 inclusive. This effort generated long needed information on much of the avifauna of the state including the breeding distribution of many neotropical migrants. A project publication is still pending.

And finally, in terms of pre-Partners in Flight activities, there has been a long-term mist netting operation ongoing on the Eastern Shore of Virginia near the southern tip of the Delmarva peninsula. This banding station has been in operation since 1963, and is operated during the fall migration period.

[1] *Wildlife Biologist, Department of Game and Inland Fisheries, P.O. Box 11104, Richmond, Virginia 23230.*

With the inception of the Partners in Flight Program there was generated an opportunity for state agencies to take a lead role in implementing the objectives of a multi-national endeavor. Through academic contractors, volunteer conservation groups, and daily interaction with other resource agencies as well as local citizens, state agencies are in an ideal position to organize local, statewide, or even regional efforts toward a common goal.

As the regulatory wildlife resource agency in Virginia, the Department of Game and Inland Fisheries (DGIF) serves as the lead agency for the Partners in Flight effort. Virginia shares the status with both Maryland and West Virginia of being a border state represented in both the Southeast and Northeast Associations of Fish and Wildlife Agencies. As such, DGIF is active in both regional working groups of Partners in Flight. Although we are just now becoming active participants, DGIF has subscribed to the methodology adopted in the Southeast whereby multi-state programs will be coordinated regionally according to physiographic province. This technique will no doubt prove effective in making use of local expertise and in partitioning regional effects in bird population fluctuations. Among the products of the Southeast working group are lists of breeding species and their priority ranking scores within each physiographic area, in addition to a list of monitoring needs to be addressed by all participants.

As regards the Northeast, DGIF was fortunate to be involved in a four-state migration corridor study in 1991 that was sponsored by The Nature Conservancy. With National Oceanic and Atmospheric Administration (NOAA) and National Fish and Wildlife Foundation funding, Virginia's Division of Natural Heritage lead the state's efforts in monitoring fall migrant movements down the Atlantic coast from Cape May, New Jersey to Cape Charles, Virginia. Data was collected on locations and habitats selected by migrants for resting and foraging to better understand the critical characteristics of this migratory pathway. Of central importance to this effort, was the fact that data collected was to be used in helping to evaluate future land planning decisions along this four-state coastal corridor. This project also made use of over 100 birding volunteers in Virginia alone, a milestone effort for citizen involvement in a field project.

This year, with additional NOAA funding, the Virginia Game Department joined forces with the Division of Natural Heritage and the College of William and Mary to refine the previous study for specific application along the southern tip of the Delmarva Peninsula on Virginia's Eastern Shore. Paid observers are monitoring habitat patches throughout the study area to record migrant bird use in terms of species diversity, abundance, and distribution relative to patch characteristics and location. The county planning office is an active supporter of the study, which should provide a useful guide to land planning as it relates to migratory bird habitat conservation.

As the Partners in Flight program has taken shape, it seems that monitoring programs have been the biggest benefactor of the early organizational efforts. As a result DGIF has sought to refine its needs with respect to monitoring programs and to target resources toward the most essential data. A hierarchy of goals was established whose objectives we felt would accommodate the needs of our agency and our cooperators as well as complement the national objectives.

To capitalize on this early emphasis on monitoring, the Department of Game and Inland Fisheries held two regional meetings to organize cooperators. These meetings were extremely successful enabling the recruitment of personnel and property from both National Forests in the state, three National Park Service properties, two National Wildlife Refuges, and two military bases. The Virginia Society of Ornithology (VSO) with its 25 chapters and over 1000 members volunteered its services, as did interested members of the academic community and other state resource agency personnel.

Our first objective was an effort to fill in the gaps across sections of the state that had not received adequate monitoring coverage, putting an initial emphasis on adding new BBS routes. Toward that end, Game Department staff coordinated the layout of 20 additional routes across the state. This effort was facilitated by the interest of the federal landholders in the state who saw BBS routes as a viable long term monitoring tool to aid in evaluating future landuse decisions. As a result, fourteen of the new routes were located on federal lands and they initially served to provide baseline information on the presence and distribution of neotropical migrants and other species of concern. In a departure from standard BBS methodology, the newly established routes were not randomly distributed, but rather were placed within target habitat areas. Target areas in this case were grasslands or large tracts of mature forest, with an emphasis on deciduous forests. The rationale behind this effort stemmed from an attempt to more effectively monitor species that were typically under-sampled on randomized, non-habitat specific routes. This procedure was agreed to by all cooperators and sanctioned by the BBS office in Laurel, Maryland.

Our second thrust in implementing new monitoring programs was directed at customizing specific programs for a particular land area or habitat type. The principal strategy for this effort was the establishment of mini-BBS routes or off-road routes. There was particular interest in this program from many of the landowner cooperators who wished to establish a monitoring program on specific tracts of land that was entirely under their management control. This was especially true of some of the National Forest Service properties and the National Wildlife Refuges. Although there was substantial interest, this program was only partially implemented this year due to a lack of qualified personnel to assist with the establishment of the routes and the associated surveys. This was not recognized as a setback however, in view of the information that was generated by the national monitoring committee this summer regarding recommended survey techniques for off-road routes. More attention can now be devoted to getting this program in place next year with a standardized methodology that should ensure data compatibility with other studies.

Apart from addressing the needs of our federal cooperators, an additional pilot project that was brought on line made use of canoes to establish monitoring routes along narrow coastal rivers. This effort was undertaken by DGIF staff to evaluate methodologies for establishing long term surveys to monitor trends in species associated with riverine forests. These forests represent one of the few habitat types that are relatively free from disturbance in the coastal plain. Once again the need for this type of project was generated by the paucity of trend information in Virginia on species that are associated with mature deciduous forests and forested wetlands. A total of six 30-stop routes were run on three coastal rivers generating the first data ever on species presence and distribution in these areas. Additional survey methodologies will be attempted next summer to refine a technique best suited for data collection by canoe.

One other ancillary project that has been modified to fill in additional information gaps is called the Rare Bird Monitoring Program. This effort seeks to involve interested citizens and local birders to help in locating and monitoring species of concern. Originally started as a threatened and endangered species monitoring effort, this project makes principal use of post-Atlas birders who locate, map, and monitor the nesting success of priority species. With the interest in the Partners in Flight program, this effort has grown to include data collection efforts on many of the neotropical migrants experiencing declines in the state. The program has served another vital purpose in terms of creating an additional opportunity for public involvement in a high profile program like Partners in Flight, and in fostering a valuable rapport between private citizens and government agencies.

Our third monitoring emphasis was targeted at facilitating the management decisions of our staff land managers by providing them with monitoring information from properties that were under their control. DGIF owns 30 wildlife management areas (WMAs) comprising some 180,000 acres. These areas are managed primarily for game species and to a lesser extent for timber production. As a result of the Partners in Flight initiative, we contracted out a breeding bird survey to be done on each WMA, making use of a standardized methodology that could be repeated on an annual basis. Our initial goal was to provide each WMA manager with a list of neotropical migrants and the habitats in which they occurred on that particular WMA. Over time however, we intend to continue these surveys and monitor changes in bird populations relative to habitat changes as initiated by the land manager. Through this approach we make our land managers a part of the neotropical program by first cultivating their interest with a list of migrants pertinent to their area. Then we establish a program to monitor these birds thereby providing the managers with a "yardstick" to measure the benefits or impacts to these species based on their management strategies. Ultimately, we hope that our wildlife management areas can serve as a model for our land managers to better understand the demands of managing habitat for a broader spectrum of wildlife.

Finally, there is an aspect of monitoring programs that can serve a useful function apart from just providing data. For most studies, monitoring is thought of as a means to an end; the end usually being some type of trend information. However, in view of the magnitude and momentum of the Neotropical Migratory Bird Conservation Program, the Department of Game and Inland Fisheries decided to dedicate some of its efforts to promoting monitoring as a product in itself, an educational product. Our first client was a statewide coordinator for the Girl Scouts. As part of an educational program we introduced the Girl Scouts to a project in which they would monitor two or three target species each year at summer camp. We have selected several vocally distinct species such as wood thrushes and ovenbirds, and are encouraging Girl Scouts to identify and map singing males during the course of their summer camp stay. We anticipate bringing the Boy Scouts on board next summer to participate in a similar effort.

Apart from the local information these efforts can generate, we believe that the future success of the Partners in Flight program will rest largely on the degree to which it can interest and involve the general public. Large scale conservation decisions will invariably involve large scale political decisions. So as a public wildlife resource agency, we believe that an informed and involved public will ultimately be the most instrumental tool in bringing about successful wildlife conservation.

LITERATURE CITED

Byrd, M.A. and D.W. Johnston. 1991. Birds. Pages 477-537 in Virginia's endangered species (K. Terwilliger, Coord.) The McDonald and Woodward Publishing Company, Blacksburg, Virginia.

Kain, T. 1987. Virginia's birdlife: an annotated checklist. Virginia Society of Ornithology.

Woodward, S.L. and R.L. Hoffman. 1991. The Nature of Virginia. Pages 23-48 in Virginia's endangered species (K. Terwilliger, Coord.) The McDonald and Woodward Publishing Company, Blacksburg, Virginia.

Monitoring Bird Populations: The Role of Bird Observatories and Nongovernmental Organizations

Geoffrey R. Geupel and Nadav Nur[1]

Abstract — Nongovernmental organizations (NGOs) currently participating in Partners in Flight have been monitoring bird populations in North America for decades. These regional organization have strong grass roots and private sector support and are able to conduct truly long term studies by using nontraditional funding sources and staffing with dedicated volunteers and personnel. NGOs are well positioned to provide the expertise needed to implement and maintain long term monitoring programs that are required to document normal and anthropogenic fluctuations in neotropical bird populations. An integrated monitoring scheme that samples both population trends and demographic parameters of populations across both broad geographical regions and local microhabitats is needed. We recommend NGO sponsor monitoring programs that are intensive and localized; habitat or land-use based; employ standardized protocols; utilizes volunteers as well as professionals; attracts grass root support; and provide regular results that can direct management. Specific recommendations and examples on implementing such a program are presented.

INTRODUCTION

A fundamental goal of the Partners In Flight (PIF) initiative is to maintain populations of bird species while they are still relatively common (Senner this volume). This will enable cost effective responses before a species undergoes serious population decline. Ideally we would develop a comprehensive management plan for every species based on the latest scientific research. Unfortunately for a vast majority of nongame bird species little to no data exist on such basic information as density, productivity, survival, dispersal, or even habitat preferences (Martin and Nur, this volume). To collect this type of data requires long term studies of bird populations (Wiens 1984). However, in North America long term studies focused on population biology of species are few (O'Connor 1991). To implement long term monitoring studies of neotropical migrants, a cooperative approach between Nongovernmental organizations (NGOs) and state and federal agencies is required. In this paper we outline how NGO's may help in such a program and present suggestions for implementing a coordinated standardized effort.

Examples provided by Spotted Owl, Golden-cheeked Warbler, and numerous other species have shown that collecting baseline data after a species is declared threatened or endangered ("T and E") is cost prohibitive (O'Connor 1992). Out of necessity, many current management plans for "T and E" species are based on population data from different species in a different habitat. An important and key component of PIF is to develop and maintain baseline monitoring programs that trigger cost effective management responses before species show serious decline. Baseline monitoring also provides the documentation to convince land managers and the public that habitat preservation may be required.

THE ROLE OF NON-GOVERNMENTAL ORGANIZATIONS

Many NGOs are actively participating in PIF. They represent a diverse group ranging from private agricultural organizations to regional, national, international educational and

[1] *Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970.*

research organizations. Their missions and interests are far too diverse to summarize here, but, in general they offer a wide range of experience and expertise in science, education, management and/or public policy (Senner this volume).

The most common type of NGOs active in PIF are "regional bird organizations" (Table 1). The mission of these organizations is conservation of bird populations and their habitats through research, monitoring and education. For many their primary goal is to provide credible science-based information for policy formation.

Table 1. — North American Bird Observatories currently active in the Partners In Flight Initiative. [1]

Organization	Location	Contact	Phone
Alaska Bird Observatory	Fairbanks AK	Tom Pogson	907 456 5156
Cape May Bird Observatory	Cape May Point NJ	Paul Kerlinger	609 884 2736
Colorado Bird Observatory	Denver CO	Mike Carter	303 659 4348
Hawk Mountain Sanctuary	Kempton PA	Laurie Goodrich	215 756 6961
Long Point Bird Observatory	Port Rowan ON	Michael Bradstreet	519 586 3531
Manomet Bird Observatory	Manomet MA	Linda Leddy	617 224 6521
Point Reyes Bird Observatory	Stinson Beach CA	Geoff Geupel	415 868 1221

[1] This list was complied from the PIF newsletter (Vol. 2, No. 1),and ICBP NGO mailing list (George Schillinger, personal communication). The list is not intended to be comprehensive and excludes many bird oriented organizations that may be active in the PIF initiative. Bird oriented NGO's with more national and international scope were also excluded.

Regional bird organizations are in a unique position to play a critical role implementing most of the PIF's objectives. Typically they are membership based nonprofit organizations that have strong regional and grass roots support. They garner regional support by actively involving members in data collection and education programs, and interpret scientific results through publications and outreach programs. Most also conduct long term studies on nongame bird populations.

Monitoring and longterm studies of bird populations have typically been avoided by U.S. biologists for a variety of reasons and are relatively scarce in North America (for review see O'Connor 1991). Our current understanding of nongame bird population biology has come from a few long term studies (e.g. Holmes et al. 1986, Wiens and Rotenberry 1981). With the exception of a few volunteer-oriented projects (e.g. US. Fish and Wildlife Service's (USFWS,) "Breeding Bird Survey" (BBS), National Audubon's "Christmas Bird Counts", and Cornell Laboratory Of Ornithology's' "Nest Record Scheme" and "Resident Bird counts") and a few universities that focus on concept oriented research, regional bird organizations are the only entities in North America conducting long term (greater than 3 year) monitoring studies on bird populations.

Point Reyes, Hawk Mountain, Long Point, Manomet, and Cape May Bird Observatories all have ongoing landbird monitoring programs that have been in existence for 20 years or longer. Many monitoring methodologies currently being recommended and employed by various PIF working groups have been based on NGO long term studies. (e.g. DeSante and Geupel 1987, Hussell et al. 1992, Ralph et al. in press, Martin and Geupel in press)

These programs survive over the long term by using a combination of: 1) Non-traditional research funding sources (e.g. membership) not tied to specific personnel, initiatives, or specific grants. 2) Staffing with students, interns, amateurs, and professional volunteers at relatively low costs. These people are willing to participate because of the unique hands-on, intensive training they receive and the satisfaction of participating in meaningful data collection. 3) Low turnover of staff biologists allowing project continuity. For example PRBO scientific staff currently averages over 15 years.

These programs provide the long term data vital to understanding bird population dynamics. They provide critical information on natural fluctuations and allow proper evaluation of effects of human caused environmental disturbances (Wiens 1984). Monitoring bird populations over time, in conjunction with other interdisciplinary monitoring or research, can yield results that reveal important causal relationships (Temple and Wiens 1989, for examples see DeSante and Geupel 1987, Sherry and Holmes 1992, Nur and Geupel this volume).

At present, long term monitoring programs sponsored by regional NGOs are widely dispersed across North America. The recent fledging of new organizations such as the Alaska, Colorado, Missouri, and Gulf Island Bird Observatories, to name a few, are beginning to fill some geographic gaps. They now provide regional expertise and, in the future, valuable results from longterm data bases. Clearly there is a need for many more such organizations as efforts to maintain vitally important data bases increase.

For the past 27 years Point Reyes Bird Observatory (PRBO) has been monitoring nongame bird populations throughout California, and now Mexico and many Western states. A current monitoring program that may serve as model for PIF is PRBO's Pacific Flyway Project (Page et al. 1992). The project utilizes hundreds of volunteers and collaborates with a variety of private companies, governmental agencies, international biologists, and land mangers. The objectives of the program is to monitor shorebird density and usage of most wetland habitats west of the Rocky Mountains. The project provides training workshops for volunteer censusers, and scientifically credible information for land managers. Now in its fifth year, it represents the only long term data base on seasonal populations of shorebirds in the west.

Another example of the value of long term monitoring is provided by PRBO's Landbird monitoring program (Nur and Geupel this volume). Results have shown a strong correlation of landbird productivity with rainfall and unprecedented reproductive failure in 1986 (Fig. 1, DeSante and Geupel 1987). If other monitoring programs were in existence the geographical extent of the problems in 1986 would be known. This program, now in its 18th year, has survived by using hundreds of volunteers to collect data and limited financial support from the

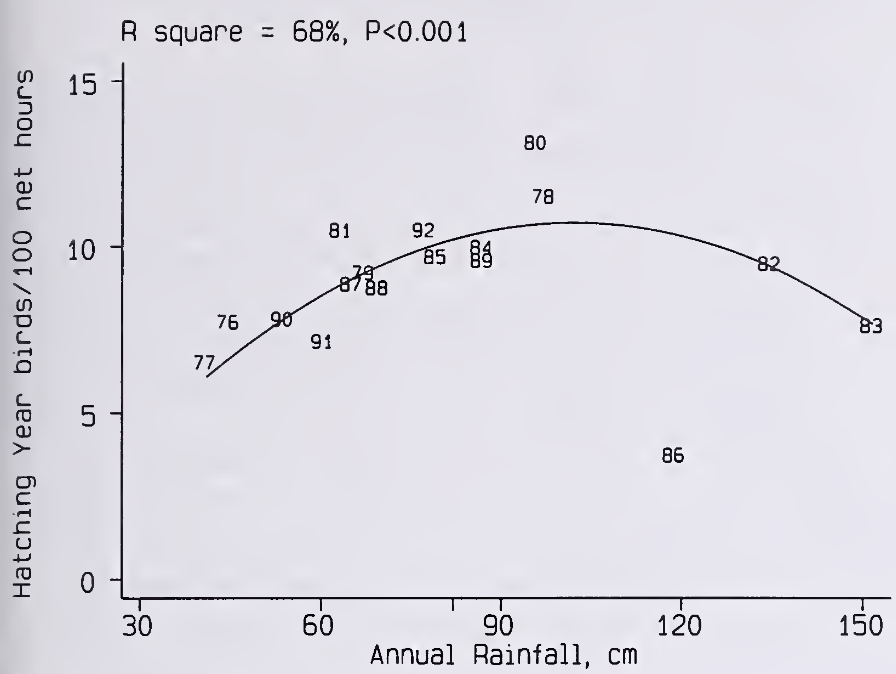


Figure 1. — The number of new, hatching year birds (representing 51 locally breeding species) banded per 100 net hours as a function of total annual rainfall (1 July to 30 June) from 1976 through 1992 at the Palomarin Research Station (see DeSante and Geupel 1987 for methods of standardized mist netting) .

membership of PRBO. The protocols from this program are now being adapted for use in nationwide monitoring programs (DeSante, this volume, Martin and Geupel, in press)

Regional NGOs are instrumental in implementing and, more importantly, maintaining long term monitoring programs. In summary they offer the following:

1. Regional expertise in methods, site selection, habitat and/or species focus.
2. A pool of well trained volunteers and professional biologists to collect data and collaborate.
3. Training to university, state, federal, and international agency personnel.
4. Institutional sponsorship at relatively low costs with long term commitments.
5. Intensive monitoring of primary population parameters.
6. Coordination of monitoring programs, both regionally and internationally, without political agendas.

RECOMMENDATIONS FOR IMPLEMENTING A MONITORING PROGRAM

An integrated monitoring scheme that samples both population trends and demographic parameters of populations across both broad geographical regions and local microhabitats is needed (Temple and Wiens 1989, Ballie 1990, Nur and Geupel this volume).

The USFWS' Breeding Bird Survey (BBS) is a model program and has provided sound evidence of broad scale declines in population size in many populations of Neotropical migrants across North America (Robbins et al. 1989). However, other studies have demonstrated substantial geographic variation in population trends of individual species and these broad-scale declines inferred from BBS data are not reflected regionally (James et al. 1992) or locally (Hagen et al. 1992). Thus broad scale programs such as the BBS, that are not habitat based or integrated with other studies, are unable to provide the resolution needed to identify causes of population decline. More importantly these programs do not identify specific management practices or habitat conditions that a land manager can modify to enhance bird populations

In order to produce meaningful results that can trigger a management response we suggest that NGO sponsored monitoring concentrate on long term data bases that monitor demographic and habitat association patterns locally. These program should be targeted at specific habitat types or land uses typically associated with smaller administrative units such as forest districts, preserves, parks, or refuges. Larger units, such as forest service regions, bioregions, states, or even continents should focus instead on population trend data from roadside point counts.

Localized monitoring data bases that are widely dispersed may have a problem with interpretation due to spatial variation and scale. Because bird populations may vary substantially between sites, even within the same habitat type, results may differ from site specific biases. In other words, changes observed locally may not be representative of changes on a broader scale. (O'Connor 1991).

The standardization of protocols among sites may significantly reduce this problem. Therefore biologists participating in monitoring programs must be willing to foster, coordinate and accept common methodologies and protocols. Forthcoming, comprehensive training programs for wildlife managers and workshops conducted in cooperation with NGOs, universities, and PIF Working groups may help significantly in this regard.

NGO sponsored programs should also integrate with other biological studies whenever possible and provide usable information on a regular basis. It is unlikely that any program can survive beyond a few years without yielding some results on annual basis. Even simple presence/absence data tied to a particular habitat or management practice may provide valuable information they will justify a program's existence.

The methods of monitoring employed are dependent on the objectives of the land holder, funding, and skills of the personnel involved. It is important that a fairly simple procedure (e.g. Area search) be used in any program in order to attract and recruit new observers and lay persons. The use of amateurs in a program may also provide the grass roots support that ensure a program survives over the long term.

The following recommendations for implementing a monitoring program reflect the objectives discussed above and have been discussed by the monitoring working group of PIF (Butcher 1992). All are outlined in more detail in Ralph et al. (in press), Bibby et al. 1992 and elsewhere as noted.

1) Select and register a site that fits current land use definitions or habitat criteria (e.g. grazing, controlled burning, recreational park land, preserve or mixed riparian woodland etc.). Define plots within a site that are at a minimum of 3 ha in size and over 100 meters from the edge of the defined habitat/land use. Exact plot size is dependent on bird density (see Robbins 1970). If sites, plots or census stations are not definable, a habitat assessment procedure should be employed at each plot and/or census station (see Ralph et al. (in press) for methodology).
2) Determine annual species presence or absence, density index (population size), and species richness using one of the following standardized methods:
   a) Area search: Recently adopted for the Australian Bird Count, this method is a time constraint census, similar to a "Christmas Bird Count"(Ambrose 1989). Conducted a minimum of once a year, this is an ideal method for volunteers in that it requires little observer training and mimics the method that a group of birders would use for "birding" a given area.
   b) Spot mapping: This method is used by hundreds of volunteers annually that participate in the Cornell Laboratory's Resident Bird Counts (Hall 1964, Robbins 1970). It is considered to be labor intensive (8 visits per year required), subject to considerable analyst and observer variability (Verner and Milne 1990), and not applicable to non-territorial or wide ranging species. However unlike other methods provides an absolute measure of density.
   c) Point counts: The cornerstone of the BBS census this method is considered to be the most cost effective and scientifically reliable. National standards have recently been adopted (Ralph, personal communication). This method requires skilled observers who have had considerable training at the census sites.
3) Monitor primary population parameters, as suggested by Temple and Wiens (1989) and Pienkowski (1991), using one or ideally both of the following standardized methods (Nur and Geupel this volume).
   a) Nest monitoring: Allows determination of breeding productivity by locating nests and monitoring outcome. Unlike nest record schemes, nest should be monitored in specific plots or study areas. This allows breeding productivity to be correlated with habitat conditions and/or management practices. Methods for locating, monitoring, and determining outcome and preventing human caused depredation of nests are described in Martin and Geupel (in press). Nest monitoring while relatively labor intensive requires limited training and is an activity well-suited for volunteers.
   b) Constant effort mist netting: Provides an index of productivity and adult survivorship by banding and aging birds captured in a standardized array of mist nets. Nets must be operated a minimum of once every ten days throughout the breeding season (May through August). The proper handling of migratory birds requires intensive training and permits from the USFWS Bird Banding laboratory.

Both nest monitoring and constant effort mist netting have recently been adopted in North America by two national monitoring programs; Martin's "BBIRD" (Martin and Nur this volume) and DeSante's "MAPS" (this volume), respectively. Both programs pool local demographic data across regional and national scales. While long term results of these studies are forthcoming, preliminary indications are promising. Participation in these programs will provide land managers with the best data that may be linked to local habitat conditions and at the same time provide collaborative data on regional and national trends.

In conclusion: the need for habitat specific long term monitoring is clear. Current funding and logistical support is not adequate for most agencies to implement such a program. Fortunately PIF fosters a cooperative network of NGOs private, and governmental agencies. With minimal funding and using the approach outlined in this paper, working partnerships may be formed. With a cooperative and coordinated monitoring effort we have good chance of achieving the goals of the PIF.

While these monitoring programs may not provide a management plan for every species, they will put us a major step forward in understanding nongame bird populations and educating the public on the utility and need for maintaining and restoring habitats for birds as well as humans.

ACKNOWLEDGMENTS

We would like to thank the staff, members, and volunteers of the Point Reyes Bird Observatory for their continued support of longterm studies. Dan Evans, Deborah Finch, George Schillinger, Peter Stangel, and Laurie Wayburn provided valuable comments on earlier drafts of this manuscript. This is PRBO contribution number 575.

LITERATURE CITED

Ambrose, S. 1989. The Australian bird count -Have we got your numbers? RAOU Newsletter, Published by the Royal Australasian Ornithologists Union, Moonee Ponds, Vic. 3039, Australia. 80: 1-2. Ballie, S. R. 1990. Integrated population monitoring of breeding birds in Britain and Ireland. Ibis 132: 151-166.

Butcher, G. 1992. Needs Assessment: monitoring neotropical birds. Report of the PIF Monitoring Working Group. Cornell Ornithological Laboratory, Ithaca, NY.

Bibby, C. J., N. D. Burgess, & D. A. Hill. 1992. Bird Census Techniques. Academic Press Inc. San Diego, CA.

DeSante, D. F. this volume. The Monitoring Avian Productivity and Survivorship (MAPS) Program: Overview and progress. Proceedings of the Estes Park Partners in Flight Conference.

DeSante, D. F., & G. R. Geupel. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall and a reproductive failure in 1986. Condor 89: 636-653.

Hall, G. A. 1964. Breeding Bird Census--why and how. Aud. Field Notes 18:413-416.

Hagen, J. M., T. L. Lloyd-Evans, J. L. Atwood, & D. S. Wood. 1992. Long term changes in the north-eastern United States: Evidence from migration capture data. Pp.115-130. in J. M. Hagan and D. W. Johnston (editors) Ecology and Conservation of Neotropical Migrant Birds. Smithson. Inst. Press, Washington, D.C.

Holmes, R. T., T. W. Sherry, & F. W. Sturgis. 1986. Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Brook. Ecol. Monogr. 56:201-220.

Hussel, D. J. T., M. H. Mather, & P. H. Sinclar. 1992. Pp. 101-114. in J.M.Hagan and D. W. Johnston (editors) Ecology and Conservation of Neotropical Migrant Birds. Smithson. Inst. Press, Washington, D.C.

James, F. C., D. A. Wiedenfield, & C. E. McCulloch. 1992. Trends in breeding populations of warblers: Declines in the southern highlands and increases in the lowlands. Pp. 43-56. in J. M. Hagan and D. W. Johnston (editors) Ecology and Conservation of Neotropical Migrant Birds. Smithson. Inst. Press, Washington, D.C.

Martin, T .E. & G. R. Geupel. in press. Nest monitoring plots: Methods for locating nests and monitoring success. Journal of Field Ornithology.

Martin, T. E. & N. Nur. this volume. Population dynamics and their implications for vulnerability. Proceedings of the Estes Park Partners in Flight Conference.

Nur, N & G .R. Geupel. this volume . Evaluations of mist-netting nest searching, and other methods for monitoring demographic processes in landbird populations. Proceedings of the Estes Park Partners in Flight Conference.

O'Connor, R. J.1991. Long-term bird population studies in the United States. Ibis 133 suppl.I:36-48.

O'Connor, R. J. 1992. Trends in Population: Introduction. Pp. 23-25 in J. M. Hagan and D. W. Johnston (editors) Ecology and Conservation of Neotropical Migrant Birds. Smithson. Inst. Press, Washington, D.C.

Page, G. W., W. D. Shuford, J. E. Kjelmyr, & L. E. Stenzel. 1992. Shorebird numbers in wetlands of the Pacific Flyway: A summary of counts from April 1988 to January 1992. PRBO Report. PRBO, Stinson Beach, CA.

Pienkowski, M. W. 1991. Using long-term ornithological studies in setting targets for conservation in Britain. Ibis 133 suppl.:62-75.

Ralph, C. J., G. R. Geupel, P Pyle, T. E. Martin, & D. F. DeSante. in press. Field Methods for Monitoring Landbirds. USFS publication, Arcata, CA.

Robbins C. S. 1970. Recommendations for an international standard for a mapping method in bird census work. Audubon Field Notes 24: 723-726.

Robbins, C. S., J. R. Sauer, R.S. Greenberg, & S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proc.Natl. Acad. Sci., USA 86: 7658-7662.

Senner, S. this volume. Partners in flight: past, present, and future II. Nongovernment Organization Presentation. Proceedings of the Estes Park Partners in Flight Conference.

Sherry, T. W. & R. T. Holmes. 1992. Population fluctuations in a long-distance Neotropical migrant: Demographic evidence of the importance of the breeding season events in the American Redstart. Pp. 431-442. in J. M. Hagan and D. W. Johnston (editors) Ecology and Conservation of Neotropical Migrant Birds. Smithson. Inst. Press, Washington, D.C.

Temple, S. A., & J. A. Wiens. 1989. Bird Populations and environmental changes: can birds be bio-indicators? Amer. Birds 43: 260-270.

Verner, J. & K. A. Milne. 1990. Analyst and observer variability in density estimates from spot mapping. Condor 92: 313-325.

Wiens, J. A. 1984. The place of long-term studies in ornithology. Auk 101:202-203.

Wiens, J. W. & J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecol. Mongr. 51:21-41.

Effects of Temperate Agriculture on Neotropical Migrant Landbirds

Nicholas L. Rodenhouse[1], Louis B. Best[2]
Raymond J. O'Connor[3], and Eric K. Bollinger[4]

Abstract — The ecology of Neotropical migrant landbirds in temperate farmland is reviewed to develop management recommendations for the conservation of migrants. Migrants constitute about 71% of bird species using farmland and 86% of bird species nesting there. The number and abundances of Neotropical migrants using farmland are greatest in uncultivated edges with trees and shrubless in uncultivated, grassed areas (grassed fencerows, waterways, terrace berms, road verges, and land set aside in the Conservation Reserve Program); and least in rowcrops. Causes of recent declines in abundance of farmland migrants are not clear, but recent decades also saw increasing agricultural mechanization and chemical use that probably lowered breeding productivity of migrants. Major nesting losses of migrants in farmland are from predation, agricultural field operations, and brood parasitism by Brown-headed Cowbirds (*Molothrus ater*), but few migrants in farmland have been studied. Farmland also has become more homogeneous as farm size increased, uncultivated areas have been removed, and farms have specialized on one or a few commodities. These changes probably have created farmland that often lacks the food, shelter, safe nesting sites, or appropriate interspersion of these needed to attract and sustain Neotropical migrants. Agricultural practices that promote breeding productivity and survival of Neotropical migrants include reduced tillage and inorganic fertilizer inputs and use of integrated pest management programs. The importance of farmland heterogeneity and uncultivated areas with shrubs and trees for enhancing populations of Neotropical migrants is emphasized.

Introduction

The ecology of Neotropical migrant landbirds in temperate farmland is reviewed in this paper to develop management recommendations for their conservation. We focus on migrants during the breeding season and migration because research on impacts of agriculture on migrants in winter, although potentially of great importance to migrant conservation (Greenberg 1992, Petit et al. this proceedings), is very limited. Neotropical migrants using temperate farmland can be classified as field or edge species. Fields are areas worked for crop production, and migrants found in fields often were formerly grassland species. Edges include field borders but also uncultivated areas within fields, such as grassed waterways or terrace berms. Edges with woody vegetation often are used by forest edge species. The distinction between fields and edges, although simple, is important because these areas receive very different agricultural treatment, and hence, migrants using these areas are affected differently.

Effects of agricultural activities on Neotropical migrants merit consideration because a large proportion of North America is farmed (about 52% of the land area of the contiguous 48

[1] Department of Biological Sciences, Wellesley College, Wellesley, MA 02181

[2] Department of Animal Ecology, 124 Science 11, Iowa State University, Ames, IA 50011

[3] Department of Wildlife Biology, 240 Nutting Hall, University of Maine, Orono, ME 04460

[4] Department of Zoology, Eastern Illinois University, Charleston, IL 61920

Table 1. — Factors influenced by agriculture that are contributing to the decline of the Neotropical migrant landbirds that are listed as threaten or endangered or are candidates for these lists (listed species taken from Finch [1991]).

Migrant species	Habitat use	Factors contributing the to decline in abundance	References
Swainson's Hawk (Buteo swainsoni)	savannahs, prairies shelterbelts	habitat loss to agriculture pesticide contamination	Risebrough et al. 1989. Houston et al. 1991 Schmutz 1987
Yellow-billed Cuckoo (Coccyzus americanus)	open woodlands thickets	habitat loss to agriculture	Gaines and Laymon 1984
Willow Flycatcher (Empidonax traillii)	swamps, thickets	cowbird parasitism range and cattle management	Taylor and Littlefield 1986; Harris 1991
Bell's Vireo (Vireo bellii)	riparian thickets fencerows	habitat loss to agriculture cowbird parasitism	Goldwasser et al. 1986 Franzreb 1990
Black-capped Vireo (Vireo atricapillus)	riparian woodlands	habitat loss to agriculture	Grzybowski et al. 1986
Golden-cheeked Warbler (Dendroica chrysoparia)	mature oak-juniper woodlands	cowbird parasitism	Pulich 1976
Bachman's Warbler (Vermivora bachmanii)	palmetto and cypress swamps	habitat loss to agriculture	Terborgh 1989 Hamel 1986
Kirtland's Warbler (Dendroica kirtlandii)	jack pine stands	cowbird parasitism	Walkinshaw 1983
Peregrine Falcon (Falco peregrinus)	cosmopolitan	pesticide contamination	Cade et al. 1988

states, USDA 1992: and 11% of Canada, Freemark and Boutin 1992), and because agriculture is implicated in the decline of all nine Neotropical migrants currently listed as threatened or endangered or that are candidates for listing (Table 1). Abundances of some field migrants have declined over 80% in agricultural areas during the past 20 years (Robbins 1982, Graber and Graber 1983, Castrale 1985, Zaletel and Dinsmore 1985, Bollinger et al. 1990, Bollinger and Gavin 1992), and some edge migrants also are declining (e.g., Black-billed Cuckoo, *Coccyzus erythropthalmus*, Northern Baltimore Oriole, *Icterus glabula*, White-eyed Vireo: see Sauer and Droege 1992, James et al. 1992: scientific names are listed in the Appendix except if given). How agriculture has contributed to declines is often not clear, but recent decades also saw rapid change in agricultural practices (methods used in crop production including type of crop grown) and farmland structure (types, relative coverage, and spatial distribution of habitat features in farmland including uncultivated areas).

Recent changes in agricultural practices and farmland structure may have reduced favorability of agricultural fields for foraging and nesting by migrants (Castrale 1985, Best 1986, O'Connor and Shrubb 1986). Potentially harmful changes in agricultural practices include agricultural mechanization (Rasmussen 1982) and chemical use (Gard et al. this proceedings), whereas farmland structure has become more homogeneous as farm size increased and farms specialized on producing one or a few commodities (Barrett et al. 1990). Of particular importance to Neotropical migrants, the percentage of farmland in hay or pasture (USDA 1990), or in uncultivated, semi-natural habitats such as fencerows (Best 1983, Warner 1992a), has decreased in proportion to increases in the area of intensively cultivated rowcrops.

To understand how agricultural practices or farmland structure may affect populations of Neotropical migrants, we reviewed field and farm-scale studies of migrants, as well as broad-scale, long-term studies. Studies at different spatial and temporal scales provided complementary information. Field and farm-level studies were particularly useful in identifying how agricultural practices may be affecting reproduction and survival of migrants, and they documented migrant use of farmland habitat features such as fields, fencerows or grassed waterways (e.g., Rodenhouse and Best 1983, Basore et al. 1986, Bollinger et al. 1990, Best et al. 1990). Long-term, broad-scale studies contributed to assessing the ability of farmland dominated by different crop types to sustain migrant populations. Because agriculture is rapidly changing, we consider prospects for migrants in agriculture of the future, and we conclude by proposing general management recommendations for the conservation of Neotropical migrants in farmland.

USE OF FARMLAND BY NEOTROPICAL MIGRANTS

Results of Field and Farm-scale Studies

Results of studies at the level of the field or farm clearly identify three major patterns. First, Neotropical migrants constitute the majority of bird species using farmland (Table 2). In northcentral and northeastern North America, migrants make up 71% of bird species reported to use farmland and 86% of bird species identified as nesting there. The number of migrant species nesting in crop fields, however, is low relative to

Table 2. — The percentage of Neotropical migrant landbird species observed using farmland or reported nesting in different crops or uncropped areas of northcentral and northeastern North America (from species lists compiled by Freemark et al. [1991] except where noted). "List A" species breed in North America and spend the nonbreeding season primarily south of the United States border; "list B" species breed and winter extensively in North America, but some populations winter south of the United States (Gauthreaux 1992). Unlisted species are residents and migrants whose winter ranges do not extend south of the United States border.

	Species observed (%)			Total number of species		% of nesting species that
	Migrants					
Category	List A	List A & B	Unlisted	Observed	Nesting	are migrants
Crops						
Red Clover	37	74	26	35	6	100
Oats[1]	34	72	28	29	9	89
Alfalfa	33	70	30	27	6	100
Grapes	32	76	24	25	0	
Hay	31	74	26	39	12	75
Corn (tilled)	30	75	25	44	17	88
Wheat[2]	27	68	32	22	10	70
Blueberries	23	65	35	26	0	
Pasture	22	70	30	37	9	89
Cherries	22	56	44	18	0	
Soybean (tilled)[3]	21	73	27	33	10	80
Means	29.1	70.5	29.5	30.5	7.2	86.4
Uncropped						
Fencerow[4]	35	70	30	54	26	73
Grassed waterway[5]	31	69	31	39	11	82
Shelterbelt[6]	51	76	24	45	18	67

[1] Includes species from Frawley (unpublished data).
[2] Includes species from Rodgers (1983).
[3] Includes species from Best (1986).
[4] Includes species from Shalaway (1985), and the classification "strip cover" in Basore et al. (1986).
[5] Includes species from Bryan and Best (1991).
[6] Includes species from Martin and Vohs (1978), Cassel and Weihe (1980), Yahner (1982).

uncultivated areas (Freemark et al. 1991). The proportion of migrants differs somewhat among crops, but migrants are strongly represented in widely divergent crop types such as corn, hay and vineyards (Table 2). Furthermore, migrants constitute the majority of bird species using field or edge areas (Table 2).

Second, species richness and abundances of Neotropical migrants in farmland are greatest in uncultivated edge with trees and shrubs, less in uncultivated grassed edge and least in rowcrops (Table 3). Furthermore, migrant richness and abundances are greater in wider strips of uncultivated edge

Table 3. — The number of species and abundance of Neotropical migrant landbirds in edge versus field vegetation types. Values are numbers per 100 ha, except for Best (1983) and Shalaway (1985) that are per 10 km of fencerow.

Edge						
Wooded		Grassed		Field		
Species	Abundance	Species	Abundance	Species	Abundance	Reference
31	2,193	18	365	15	18	Best et al. 1990
45	2,600			11	136	Graber & Graber 1963[1]
		19	1596	14	42	Camp 1990[2]
		24	1952	12	638	Bryan & Best 1991[3]
20	128	9	75			Best 1983[4]
5	73	4	106			Shalaway 1985[5]

[1] Graber and Graber's (1963) "edge shrub" habitat corresponds with the wooded edge category in this table, but their study only provides total bird abundances for this habitat. To identify migrants, we used species lists provided by Graber and Graber for "shrub-grown" habitat of northern, central and southern zones combined. Number of species given here for wooded edge is, therefore, based on the number of migrant species in summer "shrub-grown" habitat of all zones combined. Abundance for the wooded edge category in this table was calculated using total abundance of all species in "edge shrub" habitat times the proportion of total abundance that migrants composed in "shrub-grown" habitat of all zones combined.
[2] Average of results from 1990 and 1991.
[3] Average of results from 1987 and 1988.
[4] Number of species and individuals per 10 km of "herbaceous" or "continuous shrubs and trees" fencerow.
[5] Only nesting species are included for "grass" and "wooded" fencerows. Abundances = abundances of nests/10 km of fencerow. The study only included 4.6 km of fencerow.

vegetation (Best 1983, Shalaway 1985, Johnson and Beck 1988), Uncultivated wooded areas include wooded fencerows or edges of fields bordering woodland; grassed edge includes some fencerows, waterways, terrace berms, road verges and most land set aside in the Conservation Reserve Program (92% of CRP land is enrolled as perennial grassland; Agricultural Stabilization and Conservation Service, Washington, D. C., unpublished data). This pattern of migrant abundances also occurs in Europe (O'Connor and Shrubb 1986).

Third, breeding productivity of migrants nesting in farmland is often low relative to the number of offspring estimated to balance adult and juvenile mortality (Table 4). Breeding productivity is particularly low in hayfields and rowcrops, but it can also be low in edge including road verges (DeGeus 1990, Camp 1990, Warner 1992b), grassed waterways (Bryan 1990) and edge strip cover in general (Basore et al. 1986). Unfortunately, breeding productivity information is available only for few migrant species nesting in farmland, and few migrants have been studied in more than one crop type.

County-level Associations between Crops and Migrants

To assess the ability of farmland to sustain populations of Neotropical migrants, we reviewed long-term studies conducted by O'Connor and coworkers (see Lauber 1991, Boone 1991, O'Connor and Boone 1990, O'Connor et al. 1992) of associations by county between bird species abundances (N = 105 bird species) and coverage of 23 major crop categories. These associations were determined by using decision tree analysis (described in detail by Lauber [1991]) of Breeding Bird Survey abundances and USDA agricultural statistics over a 17-year period (1973-89). Because associations were tested on a county-by-county basis, results reflect large-scale associations rather than field-scale use of individual crops.

After examining county-level species-crop associations for 52 migrant species (listed in the Appendix) and 23 crop categories, six observations are noteworthy. First, 11 of 23 crop categories (including CRP) were associated with significantly

Table 4. — The productivity (fledglings per breeding pair per season) of Neotropical migrant landbirds breeding in farmland. The level needed to balance mortality of adults and juveniles is about three or greater fledglings/pair/year (e.g., Rodenhouse and Best 1983, Probst 1986, Sullivan 1989) except for Loggerhead Shrikes which is 5.5 (Brooks and Temple 1990).

Migrant species	Number of nests	Fledglings/ breeding pair/year	Nesting losses (%)[1] Predation	Agriculture	Parasitism	Nesting habitat	Reference
Vesper Sparrow	45	2.8	29	27	11	Corn/soybean	Rodenhouse & Best 1983
	74	2.9[2]				Corn/soybean	Perritt & Best 1989
	10	2.4	50	10	0	Alfalfa	Frawley 1989
	35	1.4[3]	54	0	9	No-till/strip cover[4]	Basore & Best unpubl. data
Grasshopper Sparrow	41	0.8[3]	80	2	2	No-till/strip cover	Basore & Best unpubl. data
Loggerhead Shrike	222	2.2	86	0	0	Roadside[5]	DeGeus 1990
	100	3.3				Pasture	Tyler 1992
Bobolink	33	0.3	9	85	0	Hayfield	Bollinger et al. 1990
Dickcissel	34	0.2	18	50	21	Alfalfa	Frawley 1989
	69	1.7[3]	28	23	3	Oat field	Frawley & Best unpubl. data
	27	2.2	44	7	19	Waterway[6]	Bryan 1990
Red-winged Blackbird	41	0.4	29	41	10	Alfalfa	Frawley 1989
	133	1.2[3]	50	1	20	No-till/strip cover	Basore & Best unpubl. data
	65	0.9[3]	20	42	5	Oat field	Frawley & Best unpubl. data
	63	1.0	27	33	16	Waterway	Bryan 1990
	73		55	1	4	Roadside[5]	Camp 1990
Western Meadowlark	9	0.1	56	1	0	Alfalfa	Frawley 1989
	15	0.7[3]	47	20	0	No-till/strip cover	Basore & Best unpubl data
Killdeer	12	6.9[3]	8	0	0	No-till/strip cover	Basore & Best unpubl data
Mourning Dove	13	0.4[3]	31	8	0	Oat field	Frawley & Best unpubl. data
	12	1.5[3]	33	17	0	No-till/strip cover	Basore & Best unpubl. data

[1] Losses as a percentage of all nests to predation, agricultural activity or brood parasitism. Nests considered lost to parasitism were deserted due to this cause or fledged only cowbird young.

[2] Calculated as the mean number of successful nests per female for 1984 and 1985 (mean = 0.77) times mean clutch size (3.8) from Rodenhouse and Best (unpubl. data). Missing values indicate data either not gathered or reported.

[3] Breeding productivity calculated as (number of fledgings per successful nest) * (nesting success) * (two nesting attempts). Each female was assumed to make two nesting attempts.

[4] Includes nests in no-till corn and soybeans and adjacent strip cover.

[5] Roadsides adjacent to corn and soybeans.

[6] Grassed waterways within corn and soybean fields.

more migrant than resident bird species (Table 5). Second, up to 65% of the bird species significantly associated with a crop were Neotropical migrants. Soybeans and sorghum had the highest number of significant associations, but many of those associations were negative. High proportions of negative associations may indicate that these crops are grown using management practices unfavorable to migrants, or that farmland structure in these areas is altered in ways that are inimical to migrants. Third, 50 of 52 migrants tested were significantly associated with one or more crop categories, and fourteen migrant species were associated with 10 or more crop categories (Appendix). Positive associations between migrant abundances and crop coverages (N = 216) greatly outnumbered negative ones (N = 91). Because positive associations indicated that these migrants were more abundant where crop coverage was greater, this result suggests that agriculture or factors associated with agriculture in some way enhanced their populations. Irrespective of the processes involved, these results imply a surprising level of positive associations between migrants and agriculture.

Fourth, the percentage of county area in the Conservation Reserve Program was positively associated with the abundance of 19 migrant species (Table 5), 12 of which were field species. Interpretation of this result, however, is not clear because Lauber (1991) found that many of the associations with CRP-enrolled land were manifest before the advent of the CRP. Probably some basic features of land in these areas, e.g., amounts or types of edge, are key to sustaining populations of migrants. Fifth, the strongest positive associations were usually found for bird species that consume the crop before harvest or as waste grain. Twenty-four of 50 migrants associated with a crop consumed one or more of the crops (these species are identified in the Appendix), and values of the positive associations for consumers of grains were about four times those for non-consumers (Rodenhouse et al. 1993). Last, 44% of the significant associations (including positive and negative associations) occurred between crops and Neotropical migrants that neither nest in nor consume the crops involved, e.g., Eastern Kingbird. Many

Table 5. — Proportion of Neotropical migrants (N = 52 species) and residents (N = 53) significantly associated with major crops. Association was determined using Breeding Bird Survey abundances and USDA agricultural statistics by county for 1973 - 1989. For Neotropical migrant species the number of positive and negative associations are also listed.

Crop category	Percent of species associated with crop: Migrants	Residents	Chi-square[1]	Fisher exact probability	Number of significant associations: Positive	Negative
Soybean	65.4	32.1	11.66	<0.01	17	13
Sorghum	63.5	26.4	14.57	<0.01	16	15
Oats	61.5	22.6	16.3	<0.01	18	6
Corn for grain	57.7	37.7	4.19	0.05	21	8
Barley	57.7	35.9	5.03	0.03	14	3
Winter wheat	53.9	22.6	10.84	<0.01	20	5
Alfalfa	32.7	11.3	7.01	0.01	7	2
All hay[2]	32.7	13.2	5.65	0.02	9	4
All wheat[3]	32.7	13.2	5.65	0.02	14	2
Corn for silage	28.9	15.1	2.90	0.10	4	5
Spring wheat	28.9	26.4	0.08	0.83	11	4
Durum wheat	26.9	20.8	0.55	0.50	8	5
Other hay[4]	23.1	7.6	4.90	0.03	5	3
Sunflower seed	21.2	17.0	0.30	0.63	9	1
Peanuts	19.2	17.0	0.09	0.80	0	5
Cotton	15.4	11.3	0.38	0.58	3	3
Flaxseed	15.4	17.0	0.05	1.00	5	0
Rice	13.5	15.1	0.06	1.00	4	1
Sugar beets	13.5	17.0	0.25	0.79	3	3
Dry beans	9.6	3.8	1.44	0.27	3	0
Tobacco	9.6	7.6	0.14	0.74	5	0
Potatoes	7.7	11.3	0.40	0.74	1	2
CRP[5]	40.4	15.1	8.40	<0.01	19	2
				Totals	216	91

[1] Chi-square value for a test of equal percentage of migrants and residents associated with each crop category.
[2] Includes the categories alfalfa and other hay.
[3] Includes winter wheat, spring wheat and durum wheat.
[4] Includes all types of hay excluding alfalfa.
[5] Conservation Reserve Program.

migrants, therefore, probably are primarily affected by either uncultivated edge within farmland, or by combinations of cultivated and uncultivated areas.

Results of large-scale, long-term studies, therefore, provide new insights and emphasize some of the same patterns identified by field and farm-scale studies. Migrants strongly dominate the bird communities of farmland, and numerous major crops are positively associated with some migrant species. These positive crop-migrant associations are strongest for species that consume foods provided by the crop. But positive associations between migrants that neither nest in crop nor consume the crop emphasize the importance of uncultivated edge, CRP-enrolled lands, and possibly other as yet unidentified habitat features of farmland in sustaining populations of some migrants.

ECOLOGY OF NEOTROPICAL MIGRANTS IN FARMLAND

The patterns of migrant abundances identified above probably reflect ecological conditions and resources available to Neotropical migrants in farmland. In this section, we review how agricultural practices and farmland structure may affect those conditions and resources needed by migrants.

Food Availability and Diets of Migrants

Many Neotropical migrants are wholly or partly insectivorous (Freemark et al. 1991), and agricultural practices often reduce arthropod abundances in croplands. Each field operation buries some crop residue (Sloneker and Moldenhauer 1977), thereby reducing habitat for litter arthropods or killing overwintering individuals. Abundance of litter-dwelling arthropods is greater in fields where plant litter on the soil surface is more dense (Edwards and Lofty 1969, Culin and Yeargan 1983, House and Stinner 1983). In contrast, abundance of foliage-dwelling arthropods in fields is dependent on crop development and may be little influenced by amount of surface-litter (Basore et al. 1987). Among other practices that reduce arthropod abundance, inorganic fertilizers can lead to reductions in the soil organic matter that sustains soil fauna (Hendrix et al. 1990). Herbicides also reduce within-field plant species diversity that is correlated with arthropod diversity (Chiverton and Sotherton 1991), and insecticides directly reduce arthropod abundance (reviewed by Gard et al. this proceedings).

The field and edge structure of farmland often both creates cultivated areas with low food abundance and retains uncultivated areas with high food abundance. Areas with permanent vegetation, even if only grasses, and no-till cropland often support higher arthropod abundances than conventionally tilled crop fields (Dambach 1948; Lewis 1965, 1969; House and All 1981; Warbuton and Klimstra 1984; House and Parmelee 1985; Hokkanen and Holopinen 1986; Brust and House 1988), but differences among arthropod species may be large and the trend reverses during pest outbreaks in the crop (Duelli et al. 1990). Arthropod abundance is also greater near permanently vegetated field edges than in field centers (Price 1976, Mayse and Price 1978, Kemp and Barrett 1989) and greater in fields surrounded by complex habitats (e.g., old fields and woodland) than by simple ones (e.g., rowcrops) (Altieri and Whitcomb 1980). Weed seeds consumed by omnivorous and granivorous migrants are also usually most abundant in and near uncultivated areas, both because seeds disperse from uncultivated areas receiving little or no weed control and because permanent vegetation concentrates wind dispersed arthropods and seeds (Pasek 1988). Homogenization of farmland structure, by draining moist-soil areas within cropland or removing uncultivated areas to consolidate fields, therefore, likely lowers diversity and abundances of plants, seeds and arthropods within fields and landscapes. Whether reductions in food abundance or patchy food distributions limit reproductive success or survival of migrants using farmland is unknown.

Foraging by Neotropical migrants in farmland may contribute to crop production by reducing abundances of pest insects and weed seeds. Although populations of beneficial insects also might be reduced, it seems rarer for birds to consume beneficial insects in agricultural habitats (Woronecki and Dolbeer 1980, Bollinger and Caslick 1985, Rodenhouse and Best, unpubl. data). Unfortunately, the quantitative contribution by avian communities to pest control is rarely known. Bendell et al. (1981), however, found that the economic benefit of pest control by Red-winged Blackbirds only compensated for 20% of crop damage caused by this species. Thus, Neotropical migrants may also reduce crop yields by feeding on crops.

A variety of crops are damaged by migrant birds, but few species are responsible. In fact, fewer than 10 of the 215 Neotropical migrants are currently reported to cause significant damage to agricultural crops over wide geographic areas. The principal migrants involved are the Red-winged Blackbird, Brown-headed Cowbird, American Robin, Bobolink, Dickcissel, Gray Catbird, Northern Oriole, and Yellow-headed Blackbird. Of these, Red-winged Blackbirds cause by far the most economic loss. When bird damage to agricultural crops occurs, total yield on a state or nationwide basis is typically reduced by less than 1-2% (e.g., Dolbeer 1990), but economic losses to individual farmers may be severe. Bird damage to crops, however, is minor relative to damage by insects, weeds, and diseases which combine to reduce potential yields by over 20% (Boyer 1982).

The migrants most frequently mentioned as damaging fruit crops in North America are American Robins, Gray Catbirds, and Northern Orioles. Crops eaten include cherries, grapes, blueberries, and strawberries (e.g., Seamans and Caslick 1983; Tobin et al. 1988, 1991). Bobolinks and Dickcissels are considered pests on wintering grounds in South America because of their rice-eating habits (Dyer and Ward 1977). Migrant birds visiting feedlots (primarily Brown-headed Cowbirds) may also reduce "yield" of livestock by consuming livestock feed and by fouling food or transmitting diseases (Glahn 1983).

Crop damage by Neotropical migrants is probably influenced by farmland structure. Damage to corn by Red-winged Blackbirds increased in North America from the late 1960's to the early 1980's due perhaps to increases in the area producing grain (White et al. 1985, Clark et al. 1986), and to decreased acreages of small grain stubbles, hayfields, and uncultivated lands which, in turn, led to increased reliance on corn for food by red-wings (Besser and Brady 1986). Crop damage is also usually concentrated in space and time. Most fields receive little or no damage, but those located near roosting concentrations of birds (e.g., cornfields near marshes) can be heavily damaged, and most crop damage occurs near the time of crop maturation (Bollinger and Caslick 1985). Crop damage also tends to be highest where crop and landscape diversity is lowest (Stone and Danner 1980).

Sheltering Vegetation, Perching and Nesting Sites

The presence of sheltering vegetation may be needed for some migrants, particularly edge species, to use farmland during breeding or migration (Castrale 1985). For example, foraging sites may only become suitable when they include, in addition to food, refuges for escape from predators or adverse weather and safe perching sites for preening, resting, or sunbathing (Lima et al. 1987, Nakamura and Matsuoka 1987, Johnson and Beck 1988). The availability of such sites for edge migrants is positively associated with vertical vegetation complexity created by shrubs and trees and with farmland heterogeneity (Johnson and Beck 1988, O'Connor and Boone 1990). Complex vegetation structure, however, also provides nesting sites (e.g., Yahner 1982, 1983) and song perches (e.g., Rodenhouse and Best 1983), conceals bird movements from predators or brood parasites (Schneider 1984, Lima et al. 1987) and creates favorable microclimatic conditions for nesting or other activities (McNaughton 1988).

Farmland complexity, which is determined by the number and spatial locations of crop types and types of uncropped areas (e.g., grassy waterways, wooded fencerows, shelterbelts) is currently declining in most agricultural areas. Causes include increased use of large equipment, enlarged field sizes, trends toward producing and rotating fewer crops (e.g., Barrett et al. 1990), and consolidation of farms, thus increasing average farm size (USDA 1990) and correspondingly reducing spatial diversity. Consequently, availability of protective shelter in farmland has declined as uncropped habitats, such as fencerows, are removed. From 30 to 80% of fencerows in midwestern agricultural regions have been removed since the 1930's (Mohlis 1974, Vance 1976, Taylor et al. 1978, Baltensperger 1987), and those that remain often contain only herbaceous vegetation (Rodenhouse and Best 1983).

Reproductive Success

The absence of safe nesting sites may be the factor most limiting reproduction and survival of migrants ln cropland. Agricultural practices that can destroy nests, fledglings, or adults in fields include primary tillage, disking, cultivation, rotary hoeing. (e.g., Rodenhouse and Best 1983, Rodgers 1983), chemical applications (reviewed by Gard et al. this proceedings) and mowing (e.g., Bollinger et al. 1990, Frawley and Best 1991). Mowing hayfields at night is particularly destructive to adult birds that are attending nests or roosting in hayfields at night (Frawley, pers. comm.). Predation, however, usually causes most nesting losses in rowcrop fields and edge (Table 4). Agriculture may indirectly imperil birds by increasing the spatial concentration of predators that feed on adults, juveniles or nest contents (Gates and Gysel 1978). Edge created by agriculture can serve as travel lanes for predators (Fritzell 1978, Johnson and Adkisson 1985, Glueck et al. 1988), and birds nesting in or near these lanes often have low nesting success (Gates and Gysel 1978, Basore et al. 1986, Bryan 1990, DeGeus 1990, Johnson and Temple 1990, Camp 1990). However, Shalaway (1985) reported high nesting success (58% of nests fledged at least one young) in a wooded fencerow, but he noted that this fencerow lacked small mammalian predators that often destroy bird nests. Nesting success in rowcrops (e.g., Rodenhouse and Best 1983, Basore et al. 1986) and hayfields is also often low (e.g., Frawley 1989, Bollinger et al. 1990). Nest predation in or near farmland is probably proportional to predator abundance, and predation rates in farmland can be equal to or higher than those in uncropped habitats (O'Connor and Shrubb 1986, Angelstam 1986). But, the causes of high rates of nest predation in farmland have not been clearly identified, because predator densities in farmland seldom have been quantified.

Shifts in agricultural practices and farmland structure probably have also enhanced brood parasitism of Neotropical migrants by Brown-headed Cowbirds (Brittingham and Temple 1983). More than 200 bird species are parasitized by Brown-headed Cowbirds, and most hosts are Neotropical migrants (Robinson 1992a). Brood parasitism by cowbirds often severely reduces reproductive success of Neotropical migrants in farmland (Table 4). The effect of farmland structure on brood parasitism (i.e., fragmentation of native vegetation by agriculture and creation of edge) is manifested by higher rates of brood parasitism near field edges with elevated perches for cowbirds than away from field edges and elevated perches (Best 1978, Johnson and Temple 1990). Present rates of brood parasitism, nest predation, and destruction of nests by agricultural operations are probably novel conditions for most migrants breeding in farmland, because agricultural mechanization and rapid increases in cowbird abundances have occurred during mostly the past 45 years. Whether migrants that evolved to use fields and/or edges created by agriculture are also capable of adjusting to high nesting losses caused by agriculture is unknown (Best and Rodenhouse 1984).

Population Sources and Sinks

The impacts of agricultural activities on vegetation structure, food abundance, and nesting success described above may create population sources and sinks. Population sources are characterized by local reproduction that exceeds that needed to balance local mortality of adults and juveniles, but replacement level reproduction is not achieved in population sinks (Wiens and Rotenberry 1981). Locations of sources and sinks in farmland may vary in space and time because agricultural activities and environmental conditions (e.g., weather) also vary.

If source and sink areas occur for Neotropical migrants in farmland, identification of these areas will be important for bird conservation (Howe and Davis 1991), because it could lead to management that mitigates sinks and protects sources. Identification of sources and sinks should be possible by documenting reproductive success in farmland features receiving different agricultural practices or by comparing reproductive success among farmlands of different structure. Few studies of this kind have been carried out. Thus whether sources and sinks occur generally in farmland is unknown, but studies of the reproductive ecology of migrants nesting in rowcrop field and edge (see Table 4) strongly suggest that sinks do exist.

PROSPECTS FOR NEOTROPICAL MIGRANTS IN AGRICULTURE

Because agriculture is currently undergoing rapid change, it is important to consider agricultural practices and farmland structures in the future as a part of developing management recommendations for the conservation of Neotropical migrants. Previous sections of this paper have dealt exclusively with past and present effects of agriculture on migrants. In this section, we consider how anticipated changes in agriculture might affect these species. We review Lower Input Sustainable Agriculture (LISA: see Edwards et al. 1990) in detail because it may offer better prospects than conventional agriculture for conservation of migrants (Papendick et al. 1986, Robinson 1991).

Several futures for agriculture are likely, but in each a proportion of farms accept sustainable agricultural practices (National Research Council 1989, Batie and Taylor 1989, Kirschenmann 1991). Very likely farming will develop along two tracks. Some farms will be large in size, externally owned and intensively managed; whereas others will be small, owner-operated (often part-time) and less intensively managed. Large farms will be clustered on the most productive soils in rural areas, whereas small farms will tend to be located near urban areas where non-farm income can be obtained. Prospects for Neotropical migrants on large, intensively managed farms will be poor because monoculture would be carried out in large, homogeneous fields with the aid of extensive chemical use. But prospects for migrants on small farms might be good, because operators of small farms would likely maximize profits by minimizing purchased inputs (i.e., machinery, fuel, inorganic fertilizer and pesticides) and diversifying farm production to include a variety of crop and animal products (National Research Council 1989, Van Dyne et al. 1992). Smaller field sizes, greater within-field plant and arthropod diversity, and enhanced landscape diversity will result. Together, these changes in practices and landscapes envisioned for small farms might benefit reproduction and survival of birds (Papendick et al. 1986, Robinson 1991). The extent of benefit, however, would depend on the relative areas of the two farming types and their spatial interspersion.

The changes projected for small farms are those being developed by LISA programs (Keeney 1989, National Research Council 1989). These systems differ from conventional agriculture in placing greater emphasis on retention of soil and soil nutrients, diversification of crops produced, management of crop and soil microclimate (National Research Council 1989, Edwards et al. 1990) and maximization of biological control of crop pests (weeds, pathogens and plant-feeding arthropods) by using integrated pest management (IPM) systems. Practices used to achieve these ends include establishing permanent cover on highly erodible land, reducing the frequency and intensity of tillage, including cover crops or green manures in production systems, rotating crops in multi-year cycles (Parr et al. 1990) and various forms of polyculture including agroforestry (Garrett 1991). Livestock may increasingly become a part of these production systems because it increases the on-farm use of forages included in crop rotations for weed control and maintenance of soil fertility (Benbrook 1990). Production of livestock will probably benefit migratory birds through enhanced arthropod abundances on manure-fertilized soils (O'Connor and Shrubb 1986, Rogers and Freemark 1991). Establishment of native prairie grasses as forage crops would likely increase the value of pasture and hayfields for wildlife, because of the nesting cover provided and because these warm-season forage crops are mowed or grazed later in the avian breeding season than cool-season forage crops such as alfalfa (e.g., George et al. 1979). Agroforestry provides opportunities to enhance the amount of wooded vegetation in farmland, to greatly increase farmland diversity and to contribute to crop production and farm profit (Wilson and Diver 1991).

The adoption of integrated pest management (IPM) procedures would probably result in increased food abundance for Neotropical migrants, because within-field diversity and abundance of plant and arthropod species would be enhanced by control based on "economic thresholds" (Luna and House 1990). According to IPM, pest populations (plant and animal) are monitored closely, and pesticides are only used when pest populations threaten to reduce crop yield, and hence, cause economically important damage. Perhaps most important for migrants, management of uncultivated habitats will become a central part of pest management planning in IPM. For example, uncultivated strips of perennial vegetation might be established within crop fields, or field borders might be widened for pest management purposes (Thomas et al. 1991, El Titi and Landes 1990, Rodenhouse et al. 1992). Such uncultivated habitats enhance populations of arthropods within croplands, and they effectively reduce field size (Price 1976). Reduced field size would increase the amount of cropland suitable for use by migrants when nesting or migrating (Best et al. 1990). Wider field borders may reduce rates of nest predation, particularly when complex vegetation structure is allowed to develop within field borders (Gates and Gysel 1978, Angelstam 1986, Johnson and Temple 1990). Including birds in IPM research and planning would greatly raise awareness of potential contributions of Neotropical migrant bird species to agriculture. Ongoing negative impacts of chemical pesticides on migrant reproduction and survival also would be reduced by using IPM, because lesser amounts of toxic chemicals would be used (Luna and House 1990).

Trends in agriculture strongly suggest continued use of agricultural chemicals (e.g., inorganic fertilizers and pesticides; Brady 1982), even if application rates are lowered by use of IPM techniques. Application rates of inorganic fertilizers may fall as a result of better monitoring of available nutrients and use of crop rotations including legumes (Jarrell 1990). The amount of pesticide applied will also continue to fall as applications become more highly targeted in space and time (Andow and Rosset 1990). For example, herbicide applications can be confined to bands along crop rows, and broadcast spraying of field margins and border vegetation may become less common (Sotherton 1991). Whether these changes in chemical use will benefit wildlife is currently being investigated (Kendall 1992).

Implementation of sustainable production practices projected for small farms could be profitably employed by large farms as well (National Research Council 1989) to benefit Neotropical migrants. But development of these methods has just begun, and additional research investigating the long-term profitability of low input sustainable agriculture will be required to gain widespread acceptance (Madden and Dobbs 1990). Long-term farm programs such as CRP are needed because they allow opportunities for creative research of bird responses to farm management, as well as time for monitoring and adjusting management to benefit migrants and agriculture (Hays et al. 1989). Because of costs of research, training, and transition to sustainable farming systems, agricultural policy will play a key role in development and implementation of sustainable agriculture (O'Connell 1990).

MANAGEMENT RECOMMENDATIONS AND RESEARCH NEEDS

The potential impact of changes in agriculture on populations of Neotropical migrants is great because a large number of Neotropical migrant species are associated with farmland and vast areas of North America are farmed (397.6 million hectares are farmland in the contiguous 48 states, USDA 1992; and 67.8 million hectares are in Canada, Freemark and Boutin 1992). Furthermore, most cultivated land is devoted to few crops, and these are produced using methods that differ surprisingly little among most farm operators. Thus, relatively few changes in management might be both widely accepted and have broad impact on Neotropical migrants. The key to acceptance is that management recommendations do not reduce, and preferably enhance, farm profits. Such recommendations can be developed when research on migrants and other farmland wildlife are included as an integral part of interdisciplinary research on agricultural production systems and when this research considers farmland structure as well as agricultural practices. Developing such recommendations, however, is greatly hindered by the paucity of current knowledge about the ecology of Neotropical migrants in farmland and by rapid change in agriculture. Avian ecologists will have the greatest impact on the direction of changes in agriculture when they work with interdisciplinary teams developing farm management systems.

Highest research priority should be placed on determining the dynamics of Neotropical migrants in farmland (Robinson 1992b, Warner 1992a). Very likely, this will include identifying habitat features, agricultural practices, and farmland structures that may create and maintain population sources and/or sinks. Studies of the annual breeding productivity and survival of migrants nesting in fields and edges are few, and potential source areas that should be protected or expanded have not yet been identified. Because of the current paucity of information, special emphasis should be placed on determining the effects of agricultural practices on the abundance and activities of nest predators in farmland. Intensive study of mechanisms causing population change would be complemented by monitoring abundances of Neotropical migrants in farmland and farmland features (e.g., fencerows), and by developing spatially-explicit computer models to simulate population dynamics of migrants (Freemark et al. this proceedings). Documenting the dynamics of Neotropical migrants in farmland will require adequately replicated research on large spatial scales, but this research is essential for developing management plans that will aid migrant populations.

We propose in this section general management recommendations for the conservation of Neotropical migrants that use farmland. These recommendations are grouped into two categories: those that focus on agricultural practices and those that address farmland structure. Agricultural practices influence the local reproduction and survival of migrants that obtain food, shelter, and nesting sites within farmland. Recommendations for farmland structure are proposed because the presence of suitable habitat features largely determines the presence of migrant species.

It is important to note that the purpose of these management recommendations is to identify agricultural practices and farmland structures that will favor Neotropical migrant landbirds. Assessment of the economic impact of implementing these practices is not considered in detail in this paper, but recent reports (National Research Council 1989, Batie and Taylor 1989, Dobbs and Cole 1992, Van Dyne et al. 1992) have supported the economic viability of some sustainable agricultural systems that incorporate a number of these recommendation. The economic viability of other recommendations such as crop residue management (e.g., Weersink et al. 1992) and IPM have been evaluated elsewhere (reviewed by National Research Council 1989). However, additional research is needed before a full assessment of the impacts of these recommendation on farm profitability can be made.

Agricultural Practices

1. Crop residue should be retained on the soil surface. Residue sustains populations of arthropods that are food for migrants, and it will provide cover for foraging or breeding birds.
2. Integrated pest management (IPM) should be used for management of pest weeds and arthropods. IPM will reduce destruction of non-target arthropods that are food for many migrants and minimize exposure of migrants to harmful chemicals.
3. The number of field operations that destroy nests should be minimized, and methods that destroy fewest nests (e.g., subsurface tillage) should be used where possible. In hayfields, spring mowing should be delayed as long as possible, nighttime mowing avoided, and mowings should be spaced as widely as possible in time to allow greatest probability of successful nesting.
4. Inorganic fertilizers should be applied only based on measured soil requirements because their excessive use can harm soil organisms that are food for some migrants.
5. Uncultivated areas such as fencerows or grassed waterways should neither be sprayed with herbicide nor mowed wherever possible. Necessary field operations such as thinning woody plant growth in fencerows or mowing grassed waterways should be carried out either before or after the avian breeding season to prevent destruction of nests.

Farmland Structure

1. Uncultivated edge or its ecological equivalent should be preserved and allowed to develop complex vegetation structure. Complex strip vegetation is used in numerous ways by migrant species, but such strip cover also reduces soil erosion and movement of agricultural chemicals off fields. Alley cropping, including strips of trees between rowcrops, might achieve these objectives and also retain more land area in crop production.
2. Farmland diversity should be maintained or enhanced. This can be done in several ways.
   a. Unmowed grassed strips could be maintained within fields for grassland birds that do not nest near edges. Grassed strips would also be refuges for arthropods, and hence, food sources for migrants.
   b. Crop diversity could be increased by adding to the number of crops rotated.
   c. Field sizes could be reduced by using land removed from production, e.g., CRP land could be allocated to strip cover within fields or along field edges to reduce field sizes.
   d. Actual or potential wetlands could be preserved and protected by encircling them with broad buffer zones of natural vegetation.

Agricultural Policy and Extension

The favorability of farmland for Neotropical migrants will depend on farmer attitudes and involvement (Nassauer and Westmacott 1987). Farmer cooperation will be strongly influenced by agricultural policy and education of farmers through various forms of outreach (Kurzejeski et al. 1992). Agricultural policy determines compliance with conservation regulations, sets funding levels for research and farmer education about advances in agriculture and strongly influences land use through programs such as the CRP. Education of both farmers and policy makers about the importance of farmland in sustaining populations of migratory birds will raise awareness of this consideration among farmers when making land-use decisions or among policy makers when assessing potential impacts of policy implementation (Jahn and Schenck 1990). Because both agricultural practices and farmland structure are strongly influenced by agricultural policy, successful conservation programs for Neotropical migrants in agriculture will necessarily begin with policy decisions that foster agricultural practices and farmland structures that favor migrant reproduction and survival.

Much more needs to be done to facilitate dissemination of information about the effects of agriculture on Neotropical migrants and other wildlife. Studies that evaluate the effects of agricultural practices or farmland structure on migratory birds are of little value in effecting land-use changes if their results are only reported in technical journals. Few, if any, farm operators read such literature; thus, technical information must be converted to a form or format that is both readable and accessible to the audience actually responsible for farmland management. Several forms of outreach have proven effective in communicating new research findings and other technical information. Perhaps the most frequently used is the USDA Extension Service which provides publications and employs specialists trained in information transfer and education of general audiences (Sauer 1990). Also effective are workshops and demonstration farms which provide hands-on exposure to new and alternative land-management methods. In our view, conservation of Neotropical migrants in farmland will be most effectively promoted when those who have knowledge of the effects of agriculture on Neotropical migrants play an active role in shaping contemporary and future agriculture.

ACKNOWLEDGEMENTS

We thank R. Dolbeer and K. Freemark for providing helpful comments on a draft of the manuscript.

Literature Cited

Altieri, M. A.; Whitcomb, W. H. 1980. Weed manipulation for insect pest management in corn. Environmental Management. 4: 483-489.

Andow, D. A.; Rosset, P. M. 1990, Integrated pest management. ln: Carroll, C. R Vandermeer, J. H. Rosset, P. M. eds. Agroecology. New York: McGraw-Hill Publishing Company: 413-439.

Angelstam, P. 1986. Predation on ground-nesting birds' nests in relation to predator densities and habitat edge. Oikos. 47: 365-373.

Baltensperger, B. H. 1987. Hedgerow distribution and removal in nonforested regions of the Midwest. Journal of Soil and Water Conservation. 42: 60-64.

Barrett, G. W.; Rodenhouse, N. L.; Bohlen, P. J. 1990. Role of sustainable agriculture in rural landscapes. ln: Edwards, C. A.; Lal, R.; Madden, P.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 624-636.

Basore, N. S.; Best, L. B.; Wooley, J. B. Jr. 1986. Bird nesting in Iowa no-tillage and tilled cropland. Journal of Wildlife Management. 50: 19-28.

Basore, N. S.; L. B. Best and J. B. Wooley, Jr. 1987. Arthropod availability to pheasant broods in no-tillage fields. Wildlife Society Bulletin 15:229-233.

Batie, S. S.; Taylor, D. B. 1989. Widespread adoption of non-conventional agriculture: profitability and impacts. American Journal of Alternative Agriculture. 4: 128-134.

Bendell, B. E.; Weatherhead, P. J.: Stewart, R. K. 1981. The impact of predation by Red-winged Blackbirds on European corn borer populations. Canadian Journal of Zoology. 59: 1535-1538.

Benbrook, C. M. 1990. Society's stake in sustainable agriculture. ln: Edwards, C. A.; Lal, R.; Madden, P.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 68-76.

Besser, J. F.; Brady, D. J. 1986. Bird damage to ripening field corn increase in the United States from 1971 to 1981. Washington, DC: United States Department of Interior, Fish and Wildlife Service, Fish and Wildlife Leaflet 7.

Best, L. B. 1978. Field sparrow reproductive success and nesting ecology. Auk. 95: 9-22.

Best, L. B. 1983. Bird use of fencerows: implications for contemporary fencerow management practices. Wildlife Society Bulletin. 11:343:347.

Best, L. B. 1986. Conservation tillage: ecological traps for nesting birds? Wildlife Society Bulletin. 14: 308-317.

Best, L. B.; Rodenhouse, N. L. 1984. Territory preference of Vesper Sparrows in cropland. Wilson Bulletin. 96: 72-82.

Best, L. B.; Whitmore, R. C.; Booth, G. M. 1990. Bird use of cornfields during the breeding season: the importance of edge habitat. American Midland Naturalist. 123: 84-99.

Bollinger, E. K.; Caslick, J. W. 1985. Red-winged Blackbird predation on northern corn rootworm beetles in field corn. Journal of Applied Ecology. 22: 39-48.

Bollinger, E. K.; Gavin, T. A. 1992. Eastern Bobolink populations: ecology and conservation in an agricultural landscape. ln: Hagan, J. M.; Johnston, D. W., eds. Ecology and conservation of neotropical migrant landbirds. Washington, DC: Smithsonian Institution Press: 497-506.

Bollinger, E. K.; Bollinger, P. B.; Gavin, T. A. 1990. Effects of hay-cropping on eastern populations of the bobolink. Wildlife Society Bulletin. 18: 142-150.

Boone, R. B. 1991. Construction of a database used in the study of bird populations and agriculture, with a study of density dependence. M. S. Thesis, University of Maine, Orono.

Boyer, J. S. 1982. Plant productivity and environment. Science 218: 443-448.

Brady, N. C. 1982. Chemistry and world food supplies. Science. 218:847-853.

Brittingham, M. C.; Temple, S. A. 1983. Have cowbirds caused forest songbirds to decline? Bioscience. 33: 31-35.

Brooks, B. L.; Temple, S. A. 1990. Dynamics of a Loggerhead Shrike population in Minnesota. Wilson Bulletin. 102: 441-450.

Brust, G. E.; House, G. J. 1988. Weed seed destruction by arthropods and rodents in low-input soybean agroecosystems. Journal of Alternative Agriculture. 3: 19-25.

Bryan, G. G. 1990. Species abundance patterns and productivity of birds using grassed waterways in Iowa rowcrop fields. M.S. Thesis, Iowa State University, Ames.

Bryan, G. G.; Best, L. B. 1991. Bird abundance and species richness in grassed waterways in Iowa rowcrop fields. American Midland Naturalist. 126: 90-102.

Cade, T. J.; Enderson, J. H.; Thelander, C. G.; White, C. M., editors. 1988. Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Boise, Idaho.

Camp, M. 1990. Species composition, abundance and nesting of birds in roadsides adjacent to Iowa rowcrop fields. M.S. thesis, Iowa State University, Ames.

Cassel, J. F.; Wiehe, J. M. 1980. Uses of shelterbelts by birds. ln: DeGraff, R. M., ed. Management of western forests and grasslands for nongame birds. USDA Forest Service General Technical Report INT-86: 78-87.

Castrale, J. S. 1985. Responses of wildlife to various tillage conditions. Transactions of the North American Wildlife and Natural Resources Conference. 50: 142-156.

Chiverton, P. A.; Sotherton, N. W. 1991. Effects on beneficial arthropods of the exclusion of herbicides from cereal crop edges. Journal of Applied Ecology. 28: 1027-1039.

Clark, R. G.; Weatherhead, P. J.; Greenwood, H.; Titman, R.D. 1986. Numerical responses of Red-winged Blackbird populations to changes in regional land-use patterns. Canadian Journal of Zoology 64: 1944-1950.

Culin, J. D.; Yeargan, K. V. 1983. Comparative study of spider communities in alfalfa and soybeans ecosystems: ground surface dwellers. Annals of the Entomological Society of America. 78: 832-838.

Dambach, C. A. 1948. A study of the ecology and economic value of crop field borders. Columbus: Biological Sciences Series 2, Graduate School Studies, Ohio State University Press: 1-204.

DeGeus, D. W. 1990. Productivity and habitat preferences of loggerhead shrikes inhabiting roadsides in a midwestern agroenvironment. M. S. Thesis, Iowa State University, Ames. 50 pp.

Dobbs, T. L.; Cole, J. D. 1992. Potential effects on rural economies of conversion to sustainable farming systems. Journal of Alternative Agriculture. 7: 70-80.

Dolbeer, R. A. 1990. Ornithology and integrated pest management: Red-winged Blackbirds Agelaius phoeniceus and corn. Ibis. 132: 309-322.

Duelli, P.; Studer, M.; Marchand, I.; Jakob, S. 1990. Population movements of arthropods between natural and cultivated areas. Biological Conservation. 54: 193-207.

Dyer, M. I.; Ward, P. 1977. Management of pest situations. In: Pinowski, J.; Kendeigh, S. C., eds. Granivorous birds in ecosystems. New York: Cambridge University Press: 267-300.

Edwards, C. A.; Lofty, J. R. 1969. The influence of agricultural practice on soil microarthropod populations. In: Sheals, J. G., ed. The soil ecosystem: systematic aspects of the environment, organisms and communities. Systematics Association Publication. 8: 237-247.

Edwards. C. A.; Lal, R.; Maden, P.; Miller, R. H.; House, G. 1990. Sustainable Agricultural Systems. Ankeny: Soil and Water Conservation Society.

El Titi, A.; Landes, H. 1990. Integrated farming system of Lautenbach: a practical contribution toward sustainable agriculture in Europe. In: Edwards, C. A.; Lal, R.; Madden, P.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 265-286.

Finch, D. M. 1991. Population ecology, habitat requirements, and conservation of Neotropical migratory birds. USDA Forest Service, General Technical Report RM-205.

Franzreb, K. E. 1990. An analysis of options for reintroducing a migratory, native passerine, the endangered Least Bell's Vireo Vireo bellii pusillus in the Central Valley, California. Biological Conservation 53:105-123.

Frawley, B. J. 1989. The dynamics of nongame bird breeding ecology in Iowa alfalfa fields. M. S. Thesis, Iowa State University, Ames. 93 p.

Frawley, B. J.; Best, L. B. 1991. Effects of mowing on breeding bird abundance and species composition in alfalfa fields. Wildlife Society Bulletin. 19: 135-142.

Freemark, K.; Boutin, C. 1992. Non-target-plant risk assessment for pesticide registration in Canada. Environmental Management. In press.

Freemark, K.; Dewar, H.; Saltman. J. 1991. A literature review of bird use of farmland habitats in the Great Lakes - St. Lawrence Region. Canadian Wildlife Service, Technical Report Series No. 114.

Freemark, K.; Dunning, J. B.; Hejl, S.; Probst, J. 1993. Landscape ecology of Neotropical migrant birds. These proceedings.

Fritzell, E. K. 1978. Habitat use by prairie raccoons during the water fowl breeding season. Journal of Wildlife Management. 42: 118-127.

Gaines, D.; Laymon, S. A. 1984. Decline, status and preservation of the Yellow-billed Cuckoo in California. Western Birds. 15: 49-80.

Gard, N. W.; Hooper, M. J.; Bennett, R, S. 1993. Effects of pesticides and environmental contaminants on Neotropical migrants. These proceedings.

Garrett, H. E., ed. 1991. Proceedings of the second conference on agroforestry in North America. University of Missouri, Columbia.

Gates, J. E.; Gysel, L. W. 1978, Avian nest dispersion and fledging success in field-forest ecotones. Ecology. 59: 871-883.

Gauthreaux, S. A. 1992. Preliminary list of migrants for Partners in Flight Neotropical Migratory Bird Program. Partners in Flight 2: 30.

George, R. R.; Farris, A. L.; Schwartz, C. C.; Humburg, D. D.; Coffey, J. C. 1979. Native prairie grass pastures as nest cover for upland birds. Wildlife Society Bulletin 7: 4-9.

Glahn, J. F. 1983. Blackbird and starling depredations of Tennessee livestock farms. Proceedings of the Bird Control Seminar. 9: 125-134.

Glueck, T. F.; Clark, W. R.; Andrews, R. D. 1988. Raccoon movement and habitat use during the fur harvest season. Wildlife Society Bulletin. 16: 6-11.

Goldwasser, S.; Goines, D.; Wilbur, S. R. 1980. The Least Bell's Vireo in California: a defacto endangered race. American Birds. 34: 742-745.

Graber, R.; Graber, J. 1963. A comparative study of bird populations in Illinois, 1906-1909 and 1956-1958. Illinois Natural History Survey Bulletin. 28: 1-528.

Graber, R.; Graber, J, 1983. The declining grassland birds. Illinois Natural History Survey Reports No. 227.

Greenberg, R. 1992. Forest migrants in non-forest habitats on the Yucatan Peninsula. In: Hagan, J. M.; Johnston, D. W., eds. Ecology and conservation of neotropical migrant landbirds. Washington, DC: Smithsonian Institution Press: 273-286.

Grzybowski, J. A.; Clapp, R. B.; Marshall, J. T., Jr. 1986. History and current population status of the Black-capped Vireo in Oklahoma. American Birds. 40: 1151-1161.

Hamel, P. B. 1986. Bachman's Warbler: a species in peril. Smithsonian Institution press, Washington, D. C.

Harris, J. H. 1991. Effects of brood parasitism by Brown-headed Cowbirds on Willow Flycatcher nesting success along the Kern River. Western Birds. 22: 13-26.

Hays, R. L.; Webb, R. P.; Farmer, A. H. 1989. Effects of the Conservation Reserve Program on wildlife habitat: results of 1988 monitoring. Transactions of the North American Wildlife and Natural Resources Conference. 54: 365-376.

Hendrix, P. F.; Crossley, D. A. Jr.; Blair, J. M.; Coleman, D. C. 1990. Soil biota as components of sustainable agroecosystems. In: Edwards, C. A.; Lal, R.; Madden, P.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 637-654.

Hokkanen, H.; Holopainen, J. K. 1986. Carabid species and activity densities in biologically and conventionally managed cabbage fields. Journal of Applied Entomology. 102: 353-363.

House, G. J.; All, J. H. 1981. Carabid beetles in soybeans agroecosystems. Environmental Entomology. 10: 194-196.

House, G. J.; Stinner, B. R. 1983. Arthropods in no-tillage soybeans agroecosytems: community composition and ecosystem interactions. Environmental Management. 7: 23-28.

House, G. J.; Parmelee, R. W. 1985. Comparison of arthropods and earthworms from conventional and no-tillage agroecosystems. Soil Tillage Research. 5: 351-360.

Houston, C. S.; Fox. G. A.; Crawford, R. D. 1991. Unhatched eggs in Swainson's Hawk nests. Journal of Field Ornithology. 62: 479-485.

Howe, R. W.; Davis, G. J. 1991. The demographic significance of 'sink' populations. Biological Conservation. 57: 239-255.

Jahn, L. R.; Shenck, E. W. 1990. U. S. agricultural programs: implications for wildlife and potential for improvement. Pages 359-371. In Church, K. E.; Warner, R. E.; Brady, S. J., eds. Perdix V: gray partridge and ring-necked pheasant workshop. Kansas Department of Wildlife and Parks, Emporia.

James, F. C.; D. A. Wiedenfeld; C. E. McCulloch. 1992. Trends in breeding populations of warblers: declines in the southern highlands and increases in the lowlands. In: Hagan, J. M.; Johnston, D. W., eds. Ecology and conservation of neotropical migrant landbirds. Washington, DC: Smithsonian Institution Press: 43-56.

Jarrell, W. M. 1990. Nitrogen in agroecosystems. In: Carroll, C. R.; Vandermeer, J. H.; Rosset, P. M., eds. Agroecology. New York: McGraw-Hill Publishing Company: 385-411.

Johnson, R. J.; Beck, M. M. 1988. Influences of shelterbelts on wildlife management and biology. Agriculture, Ecosystems and Environment. 22/23: 301-335.

Johnson, R. G.; Temple, S. A. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management. 54: 106-111.

Johnson, W. C.; Adkisson, C. S. 1985. Dispersal of beech nuts by blue jays in fragmented landscapes. American Midland Naturalist. 113: 319-324.

Keeney, D. R. 1989. Toward a sustainable agriculture: Need for clarification of concepts and terminology. American Journal of Alternative Agriculture. 4: 101-105.

Kemp, J. C.; Barrett, G. W. 1989. Spatial patterning: impact of uncultivated corridors on arthropod populations within soybeans agroecosystems. Ecology. 70: 114-128.

Kendall, R. J. 1992. Farming with agrochemicals: the response of wildlife. Environmental Science and Technology. 26: 239-245.

Kirschenmann, F. 1991. Fundamental fallacies of building agricultural sustainability. Journal of Soil and Water Conservation. 46: 165-168.

Kurzejeskl, E. W.; Burger, L. W., Jr.; Monson, M. J.; Lenkner, R. 1992. Wildlife conservation attitudes and land use intentions of conservation reserve program participants in Missouri. Wildlife Society Bulletin. 20: 253-259.

Lauber, T. B. 1991. Birds and the Conservation Reserve Program: a retrospective study. M. S. Thesis, University of Maine, Orono.

Lewis, T. 1965. The effects of shelter on the distribution of insect pests. Scientific Horticulture. 17:74-84.

Lewis, T. 1969. The diversity of the insect fauna in a hedgerow and neighboring fields. Journal of Applied Ecology 6:453-458.

Lima, S. L.; K. L. Wiebe and L. M. Dill. 1987. Protective cover and the use of space by finches: is closer better? Oikos 50:225-230.

Luna, J. M.; House, G. J. 1990. Pest management in sustainable agricultural systems. In: Edwards, C. A.; Lal, R.; Madden, P.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 157-173.

Madden, J. P.; Dobbs, T. L. 1990. The role of economics in achieving low-input farming systems. In: Edwards, C. A.; Lal, R.; Madden, P.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 459-477.

Martin, T. E.; Vohs, P. A. 1978. Configuration of shelterbelts for optimum utilization by birds. Great Plains Agricultural Council Publication No. 87: 79-88.

Martin, A. C.; Zim, H. S.; Nelson, A. L. 1961. American wildlife and plants. New York, New York: Dover Publications, Inc.

Mayse, M. A.; Price, P. W. 1978. Seasonal development of soybeans arthropod communities in east central Illinois. Agro-ecosystems. 4: 387-405.

McNaughton, K. G. 1988. Effects of windbreaks on turbulent transport and microclimate. Agriculture, Ecosystems and Environment. 22/23: 17-39.

Mohlis, C. K. 1974. Land use and pheasant habitat in northcentral Iowa, 1938-1973. M. S. Thesis, Iowa State University, Ames. 84 pp.

Nakamura, K.; Matsuoka, S. 1987. The feeding from edge towards inner part in soybeans plot in Rufous Turtle Dove, *Streptopelia orientalis* (Latham) and the estimation of passing rate of the flock. Research in Population Ecology. 29: 45-55.

Nassauer, J.I.; Westmacott, R. 1987. Progressiveness among farmers as a factor in heterogeneity of farm landscapes. In: Turner, M. G., ed. Landscape heterogeneity and disturbance. New York: Springer-Verlag: 199-210.

National Research Council. 1989. Alternative agriculture. Washington, DC: National Academy Press.

O'Connell, P. F. 1990. Policy development for the low-input sustainable agriculture program. In: Edwards, C. A.; Lal, R.; Madden, P.l.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 453-458.

O'Connor, R. J.; Boone, R. B. 1990. A retrospective study of agricultural bird populations in North America. In: McKenzie, D. M.; Hyatt, D. E.; McDonald, V. J., editors. Ecological indicators. New York: Elsevier. In press.

O'Connor, R. J.; Shrubb, M. 1986. Farming and Birds. Cambridge: Cambridge University Press.

O'Connor, R. J.; Boone, R.B,; Devaul, H.; Jones, M. T. 1992. Abstract: The relative effects of environment and agricultural practices on bird populations in the United States. 43rd AIBS Annual Meeting, Honolulu, Hawaii.

Papendick, R. I.; Elliot, L. F.; Dahlgren, R. B. 1986. Environmental consequences of modern production agriculture: How can alternative agriculture address these issues and concerns? American Journal of Alternative Agriculture. 1: 3-10.

Parr, J. F.; Papendick, R. I.; Youngberg, I. G.; Meyer, R. E. 1990. Sustainable agriculture in the United States. In: Edwards, C. A.; Lal, R.; Madden, P.; Miller, R. H.; House, G., eds. Sustainable agricultural systems. Ankeny: Soil and Water Conservation Society: 50-67.

Pasek, J. E. 1988. Influence of wind and windbreaks on local insect dispersal. Agriculture, Ecosystems and Environment. 22/23: 539-554.

Perritt, J. E.; Best, L. B. 1989. Effects of weather on the breeding ecology of Vesper Sparrows in Iowa crop fields. American Midland Naturalist. 121: 355-360.

Petit, D. R.; Waide, R. B.; Hutto, R.L.; Lynch, J. F.; Blake, J. G. 1993. Management and conservation of migratory landbirds overwintering in the Neotropics. These proceedings.

Price, P. W. 1976. Colonization of crops by arthropods: nonequilibrium communities in soybeans fields. Environmental Entomology. 5: 605-611.

Probst, J. R. 1986. A review of factors limiting the Kirtland's Warbler on its breeding grounds. American Midland Naturalist. 116: 87-100.

Pulich, W. M. 1976. The Golden-cheeked Warbler. Texas Parks and Wildlife Department, Austin, Texas.

Rasmussen, W. D. 1982. The mechanization of agriculture. Scientific American 247: 77-89.

Risebrough, R. W.; Schlorff, R. W.; Bloom, P. W. 1989. Investigations of the decline of Swainson's Hawk populations in California. Journal of Raptor Research. 23: 63-71.

Robbins, S. 1982. Wisconsin's Breeding Bird Survey results: 1966-1979, Passenger Pigeon. 44: 97-119.

Robinson, A. Y. 1991. Sustainable agriculture: the wildlife connection. American Journal of Alternative Agriculture. 6: 161-167.

Robinson, S. K. 1992a. Population dynamics of breeding neotropical migrants in a fragmented Illinois landscape. In: Hagan, J. M.; Johnston, D. W., eds. Ecology and conservation of Neotropical migrant landbirds. Washington, DC: Smithsonian Institution Press: 408-418.

Robinson, S. K. 1992b. The breeding season: introduction. In: Hagan, J. M.; Johnston, D. W., eds. Ecology and conservation of neotropical migrant landbirds. Washington, DC: Smithsonian Institution Press: 405-407.

Rodenhouse, N. L.; Best, L. B. 1983. Breeding ecology of Vesper Sparrows in corn and soybeans fields. American Midland Naturalist. 110: 265-275.

Rodenhouse, N. L.; Barrett, G. W.; Zimmerman, D. M.; Kemp, J. C. 1992. Effects of uncultivated corridors on arthropod abundances and crop yields in soybeans agroecosystems. Agriculture, Ecosystems and Environment. 38: 179-191.

Rodenhouse, N. L.; Best, L. B.; O'Connor, R. J.; Bollinger, E. K. 1993. Effects of temperate agriculture on Neotropical migrant landbirds. In: Martin, T. E.; Finch, D. M. eds. Status and management of Neotropical migratory birds.

Rodgers, R. D. 1983. Reducing wildlife losses to tillage in fallow wheat fields. Wildlife Society Bulletin. 11: 31-38.

Rogers, C. A.; Freemark, K. E. 1991. A feasibility study comparing birds from organic and conventional (chemical) farms in Canada. Canadian Wildlife Service, Technical Report Series No. 137.

Sauer, R. 1990. Meeting the challenges to agricultural research and extension. Journal of Alternative Agriculture. 5: 184-187.

Sauer, J. R.; Droege, S. 1992. Geographic patterns in population trends of Neotropical migrants in North America. In: Hagan, J. M.; Johnston, D. W., eds. Ecology and conservation of neotropical migrant landbirds. Washington, DC: Smithsonian Institution Press: 26-42.

Schmutz, J. K. 1989. Hawk occupancy of disturbed grasslands in relation to models of habitat selection. Condor. 91: 362-371.

Schneider, K. J. 1984. Dominance, predation, and optimal foraging in White-throated Sparrow flocks. Ecology. 65: 1820-1827.

Seamons, T. W.; Caslick, J. W. 1983. An assessment of bird damage and bird control measures in New York vineyards. Cornell University, Agricultural Experiment Station, Natural Resources Research and Extension Series No. 19.

Shalaway, S. D. 1985. Fencerow management for nesting birds in Michigan. Wildlife Society Bulletin. 13: 302-306.

Sloneker, L. L.; Moldenhauer, W. C. 1977. Measuring the amounts of crop residue remaining after tillage. Journal of Soil and Water Conservation. 32: 231-236.

Sotherton, N. W. 1991. Conservation headlands: a practical combination of intensive cereal farming and conservation. In: Firbank, L. G.; Cater, N.; Darbyshire, J. F.; Potts, G. R., editors. The ecology of temperate cereal fields. Blackwell Scientific Publications, Oxford: 373-397.

Stone, C.P.; Danner, C. R. 1980. Autumn flocking of Red-winged Blackbirds in relation to agricultural variables. American Midland Naturalist. 103: 196-199.

Sullivan, K. A. 1989. Predation and starvation: age-specific mortality in juvenile juncos (Junco phaenotus). Journal of Animal Ecology 58: 275-286.

Taylor, D. M.; Littlefield, C. D. 1986. Willow Flycatcher and Yellow Warbler response to cattle grazing. American Birds. 40: 1169-1173.

Taylor, M. W.; Wolfe, C. W.; Baxter, W. L. 1978. Land-use change and Ring-necked Pheasants in Nebraska. Wildlife Society Bulletin. 6: 226-230.

Terborgh, J. 1989. Where have all the birds gone? Princeton University Press, Princeton, New Jersey.

Thomas, M. B.; Wratten, S. D.; Sotherton, N. W. 1991. Creation of 'island' habitats in farmland to manipulate populations of beneficial arthropods: predator densities and emigration. Journal of Applied Ecology. 28: 906-917.

Tobin, M. E.; Dolbeer, R. A.; Webster, C. M.; Seamons, T. W. 1991. Cultivar differences in bird damage to cherries. Wildlife Society Bulletin. 19: 190-194.

Tobin, M. E.; Woronecki, P. P.; Dolbeer, R. A.; Bruggers, R. L. 1988. Reflecting tape fails to protect ripening blueberries from bird damage. Wildlife Society Bulletin. 16: 300-303.

Twedt, D. J.; Bleier, W. J.; Linz, G. L. 1991. Geographic and temporal variation in the diet of Yellow-headed Blackbirds. Condor. 93: 975-986.

Tyler, J. D. 1992. Nesting ecology of the Loggerhead Shrike in southwestern Oklahoma. Wilson Bulletin. 104: 95-104.

USDA 1990. 1990 Agricultural Chartbook. United States Department of Agriculture. Agriculture Handbook No. 689.

USDA 1992. Agricultural Statistics, 1991. United States Department of Agriculture, Washington, DC.

Vance, D. R. 1976. Changes in land use and wildlife populations in southeastern Illinois. Wildlife Society Bulletin. 4:1-15.

Van Dyne, D. L; Monson, S. J.; Ikerd, J. E. 1992. Potential energy impacts of low input sustainable agriculture. Prepared for the U.S. Department of Energy.

Walkinshaw, L. H. 1983. Kirtland's Warbler: the natural history of an endangered species. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

Warbuton, D. B.; Klimstra, W. D. 1984. Wildlife use of no-tilled and conventional tilled corn fields. Journal of Soil and Water Conservation. 39: 327-330.

Warner, R. E. 1992a. Agricultural land use and grassland habitat in Illinois: future shock for midwestern birds? Conservation Biology. In press.

Warner, R. E. 1992b. Nest ecology of grassland passerines on road rights-of-way in central Illinois. Biological Conservation. 59:1-7.

Weersink, A.; Walker, M.; Swanton, C.; Shaw, J. E. 1992. Costs of conventional and conservation tillage systems. Journal of Soil and Water Conservation. 47: 328-334.

White, S. B.; Dolbeer, R. A.; Bookhout, T. A. 1985. Ecology, bioenergetics, and agricultural impacts of a winter-roosting population of blackbirds and starlings. Wildlife Monographs 93: 1-42.

Wilson, R. J.; Diver, S. G. 1991. The role of birds in agroforestry systems. In: Garrett, H. E., ed. Proceedings of the 2nd conference on agroforestry in North America. University of Columbia, Missouri.

Wiens, J. A.; Rotenberry, J. T. 1981. Censusing and the evaluation of avian habitat occupancy. Studies in Avian Biology. 6: 522-532.

Woronecki, P. P.; Dolbeer, R. A. 1980. The influence of insects in bird damage control. In: Clark, J. P., ed. Davis: Proceedings of the Vertebrate Pest Conference: 53-59.

Yahner, R. H. 1982. Avian use of vertical strata and plantings in farmstead shelterbelts. Journal of Wildlife Management. 46: 50-60.

Yahner, R. H. 1983. Seasonal dynamics, habitat relationships, and management of avifauna in farmstead shelterbelts. Journal of Wildlife Management. 47: 85-104.

Zaletel, L. R. and J. J. Dinsmore. 1985. Breeding bird populations in Iowa, 1968-1980. Proceedings of the Iowa Academy of Sciences 92:85-94.

APPENDIX

Common name	Scientific name	Migratory status[1]	Number of significant crop associations[2]	Consumes grains[3]
American Goldfinch	*Carduelis tristis*	B	5	Yes
American Kestrel	*Falco sparverius*	B	7	No
American Robin	*Turdus migratorius*	B	3	No
Baird's Sparrow	*Ammodramus bairdii*	A	3	Yes
Barn Swallow	*Hirundo rustica*	A	10	No
Bobolink	*Dolichonyx oryzivorus*	A	8	Yes
Brewer's Blackbird	*Euphagus cyanocephalus*	B	8	Yes
Bronzed Cowbird	*Molothrus aeneus*	C	1	Yes
Brown-headed Cowbird	*Molothrus ater*	B	9	Yes
Chestnut-collared Longspur	*Calcarius ornatus*	B	7	Yes
Chipping Sparrow	*Spizella passerina*	A	6	Yes
Common Nighthawk	*Chordeiles minor*	A	14	No
Common Yellowthroat	*Geothlypis trichas*	A	6	No
Dickcissel	*Spiza americana*	A	10	Yes
Eastern Bluebird	*Sialia sialis*	B	10	No
Eastern Kingbird	*Tyrannus tyrannus*	A	12	No
Eastern Meadowlark	*Sturnella magna*	B	17	Yes
Eastern Phoebe	*Sayornis phoebe*	B	7	No
Ferruginous Hawk	*Buteo regalis*	B	3	No
Grasshopper Sparrow	*Ammodrammus savannarum*	A	16	Yes
Gray Catbird	*Dumetella carolinensis*	A	2	No
Horned Lark	*Ermophila alpestris*	B	12	Yes
House Wren	*Troglodytes aedon*	A	9	No
Indigo Bunting	*Passerina cyanea*	A	9	Yes
Killdeer	*Charadrius vociferus*	B	14	No
Lark Bunting	*Calmospiza melanocorys*	A	8	Yes
Lazuli Bunting	*Passerina amoena*	A	6	Yes
Lesser Nighthawk	*Chordeiles acutinennis*	A	0	No
Loggerhead Shrike	*Lanius ludovicianus*	B	8	No
Long-billed Curlew	*Numenius americanus*	A	5	No
McCown's Longspur	*Calcarius mccownii*	B	1	Yes
Mississippi Kite	*Ictinia mississippiensis*	A	3	No
Mourning Dove	*Zenaida macroura*	B	10	Yes
Northern Mockingbird	*Mimus polyglottos*	B	5	No
Prairie Falcon	*Falco mexicanus*	B	1	No
Purple Finch	*Carpodacus purpureus*	B	9	Yes
Red-tailed Hawk	*Buteo jamaicensis*	B	4	No
Red-winged Blackbird	*Agelaius phoeniceus*	B	13	Yes
Savannah Sparrow	*Passerculus sandwichensis*	B	8	Yes
Say's Phoebe	*Sayornis saya*	B	7	No
Short-eared Owl	*Asio flammeus*	B	2	No
Song Sparrow	*Melospiza melodia*	B	8	Yes
Swainson's Hawk	*Buteo swainsoni*	A	9	No
Turkey Vulture	*Cathartes aura*	B	6	No
Vesper Sparrow	*Pooecetes gramineus*	B	12	Yes
Water Pipit	*Anthus spinoletta*	B	0	No
Western Bluebird	*Sialia mexicana*	B	4	No
Western Kingbird	*Tyrannus verticalis*	A	10	No
Western Meadowlark	*Sturnella neglecta*	B	9	Yes
White-eyed Vireo	*Vireo flavifrons*	A	8	No
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	A	11	Yes
Yellow Warbler	*Dendroica petechia*	A	5	No

[1] Migratory status: A, includes species that breed in North America and spend their nonbreeding period south of the United States; B, includes species that breed and winter in North America, but some populations winter south of the United states; C includes species that breed primarily south of the United States but their ranges extend north of the U. S. border (Gauthreaux 1992).

[2] Number of statistically significant associations at the county level between breeding bird Survey abundances and the proportion of county area planted to one of 22 major crop types or in the Conservation Reserve Program; see text for details.

[3] Indicates species that consume crop grains or weed seeds; crop grains may be consumed as waste grain. The primary source of information about bird diets was Martin et al. (1961).

Effects of Livestock Grazing on Neotropical Migratory Landbirds in Western North America

Carl E. Bock[1], Victoria A. Saab[2],
Terrell D. Rich[3], and David S. Dobkin[4]

Abstract — Livestock grazing is a widespread and important influence on neotropical migratory birds in four major ecosystems in western North America: grasslands of the Great Plains and Southwest, riparian woodlands, Intermountain shrubsteppe, and open coniferous forests. We have reviewed available literature on avian responses to grazing in these habitats. Among 35 plains species for which data are available, 9 responded positively to grazing, 8 responded negatively, 8 showed a graded response, from generally negative in shorter grasslands to generally positive in taller grasslands, while 8 were unresponsive or inconsistent. A similar comparison for riparian woodlands revealed that 8 of 43 species responded positively to grazing, while 17 were negatively affected, and 18 were unresponsive or showed mixed responses. Data for shrubsteppe habitats are much more limited, but only 3 of 23 species probably have been positively affected, at least by current grazing practices, while 13 probably have been negatively influenced, and at least 7 species showed mixed responses. Virtually nothing is known about effects of grazing on birds of coniferous forests. Most species negatively influenced by grazing have been those dependent on herbaceous ground cover for nesting and/or foraging. Given the ubiquity of livestock in the American West, species dependent upon lush ungrazed ground cover are at risk, and doubtless already are at population levels far below historical levels. Protection and restoration of riparian habitats is of particular importance, because of their limited geographic extent, and the extraordinary abundance and diversity of their neotropical migrants. There is an urgent need for long-term, well-replicated, field studies comparing bird populations in grazed and ungrazed shrubsteppe and montane coniferous forest habitats.

INTRODUCTION

Of all the issues facing public land managers in western North America, none is more contentious than grazing by domestic livestock. This is in part because of competing economic, social, and conservation interests involved. In this sense, the grazing issue is analogous to the controversy surrounding harvest of old growth timber. However, a complicating factor unique to grazing is that herbivory by native hooved mammals has been an important, natural, ecological and evolutionary force in certain non-forested ecosystems, including

[1]*Department Environmental, Population, and Organismic Biology, University of Colorado, Boulder, Colorado 80309-0334.*

[2]*USDA Forest Service, Intermountain Research Station, 316 E. Myrtle, Boise, Idaho 83702.*

[3]*USDI Bureau of Land Management, 3380 Americana Terrace, Boise, Idaho 83706.*

[4]*The High Desert Museum, 59800 S. Highway 97, Bend, Oregon 97702-8933.*

many in central and western North America (e.g., Stebbins 1981, McNaughton 1986). To be sure, domestic livestock have greatly increased the influence of grazing in most of these ecosystems historically, and this influence has been particularly destructive to those ecosystems where native grazing ungulates were scarce or absent (e.g., Mack and Thompson 1982, Milchunas et al. 1988, Schlesinger et al. 1990). Nevertheless, it is possible to argue that, for certain habitats, livestock grazing simulates a natural ecological event, and one which native flora and fauna tolerate or perhaps even require. Therefore, assertions about consequences of grazing must be habitat and species-specific, and to be credible they should be based on quantitative data resulting from carefully designed and executed field studies. Livestock grazing is the most widespread economic use of public land in the American West. For example, approximately 86 million hectares of federal land in 17 western states are used for livestock production (Sabadell 1982). Grazing is the primary land-use in four habitat types important to western neotropical migratory birds: 1) Great Plains and Southwest grasslands, 2) Intermountain region shrubsteppe communities, 3) meadows and understory associated with montane conifer forests, and 4) riparian communities. Our objective is to provide a succinct management-oriented overview of the species-specific avian responses to grazing in these habitats. Our conclusions are based on studies of bird populations in areas experiencing different levels of grazing, or, in cases where we lack such information, on known effects of livestock on vegetation, and known habitat requirements of the birds.

GRASSLANDS OF THE GREAT PLAINS AND SOUTHWEST

The Region and Its Avifauna

The Great Plains are one of the largest grassland biomes on earth, extending from the Rocky Mountain Front Range east to forests and woodlands of the central U. S. and Canada, and from the Canadian prairie provinces south to desert and semidesert grasslands surrounding the Chihuahuan Desert. We include southwestern grasslands as part of the region because of their strong floral and evolutionary ties to grasslands of the central and northern plains (Axelrod 1985). Within the region, precipitation increases from west to east, while temperature increases from north to south, with the result that grasslands to the south and west are increasingly water-stressed. Following these climatic gradients, comparatively lush tallgrass prairie and prairie-parkland occur east of the 100th meridian, with mid-height mixed-grass steppe in the northwestern plains, shortgrass steppe in the west-central plains, and desert and semidesert grasslands in the Southwest (Bailey 1978).

The Great Plains achieved their maximum treeless extent only within the past few thousand years, and they remain vulnerable to invasions by shrubs and trees (Sauer 1950, Daubenmire 1978). Density and variety of birds are low in plains grasslands, compared to most forested ecosystems. This has been attributed to their recent evolutionary origin, low productivity, structural simplicity, and ecological instability (Mengel 1970, Wiens 1974, Cody 1985). The typical plains grassland supports 200-400 birds/km^2, including 2-5 sparrow-like species, a meadowlark or other blackbird relative, a shorebird, a grouse, frequently a dove, and 1-3 birds of prey (Wiens 1974, Cody 1985).

Effects of Livestock Grazing on Vegetation

Drought, fire, and ungulate grazing were and are the major ecological and evolutionary forces determining dynamics of Great Plains ecosystems (Anderson 1982). Millions of bison (*Bison bison*) once occupied the plains, and we suspect (but cannot know) that they, along with periodic fires, imposed on the region a broad-scale mosaic of grasslands in various stages of post-fire and post-grazing ecological succession. Introduction of domestic livestock greatly increased the importance of grazing, relative to drought and fire, in determining the nature of Great Plains grasslands. This was particularly the case in relatively humid sites, and/or in places where bison were scarce or absent (Milchunas et al. 1988).

In general, livestock on Great Plains ecosystems have reduced fire frequency and intensity through consumption of fine fuels, thereby encouraging invasions by woody plants, and to favor short-stature sodgrasses (e.g., *Buchloe, Hilaria* spp) over taller, less grazing-tolerant, bunchgrasses (e.g., *Agropyron, Stipa* spp.). However, the nature and magnitude of these effects have varied greatly across the plains. Fires play a critical role in keeping tallgrass prairies free of woody vegetation (Gibson and Hulbert 1987). By consuming burnable fine fuels, livestock have caused many tallgrass sites to become woodlands or shrublands. In arid parts of the Southwest, where there were no bison, historical livestock grazing degraded many grasslands into permanent desert scrub (Schlesinger et al. 1990). In certain mixed-grass ecosystems, livestock grazing favored short-stature sodgrasses over taller bunchgrasses that otherwise would dominate the landscape (e.g., Bock and Bock, in press). However, in shortgrass steppe, low-stature and/or sod-grasses that tolerate grazing are the same plant species able to survive frequent droughts, so that here livestock may have little or no impact on grassland structure or species composition (Milchunas et al. 1988).

Response of Grassland Neotropical Migrants to Grazing

We found published data on responses of 35 neotropical migrants to livestock grazing in Great Plains ecosystems (Table 1). In all studies listed, data were presented on relative abundances of birds in moderately or heavily grazed grasslands, compared either ungrazed or lightly grazed sites. There is an obvious problem with these qualitative assessments of grazing

Table 1. — Responses to livestock grazing by neotropical migratory birds breeding and/or wintering in grasslands of the North American Great Plains and Southwest.[1]

Species usually responding positively to grazing:

Killdeer (*Charadrius vociferans*)	Northern Mockingbird(*Mimus polyglottos*)
Mountain Plover (*Charadrius montanus*)	Lark Sparrow (*Chondestes grammacus*)
Burrowing Owl (*Athene cunicularia*)	Black-throated Sparrow (*Amphispiza bilineata*)
Common Nighthawk (*Chordeiles minor*)	McCown's Longspur (*Calcarius mccownii*)
Horned Lark (*Eremophila alpestris*)	

Species usually responding negatively to grazing:

Northern Harrier (*Circus cyaneus*)	Cassin's Sparrow (*Aimophila cassinii*)
Short-eared Owl (*Asio flammeus*)	Savannah Sparrow (*Passerculus sandwichensis*)
Common Yellowthroat (*Geothlypis trichas*)	Baird's Sparrow (*Ammodramus bairdii*)
Botteri's Sparrow (*Aimophila botterii*)	Henslow's Sparrow (*Ammodramus henslowii*)

Species usually responding positively, at least to moderate grazing in taller grasslands, but responding negatively, at least to heavier grazing in shorter grasslands:

Upland Sandpiper (*Bartramia longicauda*)	Chestnut-collared Longspur (*Calcarius ornatus*)
Sprague's Pipit (*Anthus spraguei*)	Bobolink (*Dolichonyx oryzivorus*)
Dickcissel (*Spiza americana*)	Redwinged Blackbird (*Agelaius phoeniceus*)
Lark Bunting (*Calamospiza melanocorys*)	Eastern Meadowlark (*Sturnella magna*)
Grasshopper Sparrow (*Ammodramus savannarum*)	Western Meadowlark (*Sturnella neglecta*)

Species unresponsive, or showing mixed or uncertain responses to grazing:

Ferruginous Hawk (*Buteo regalis*)	Brewer's Sparrow (*Spizella breweri*)
Long-billed Curlew (*Numenius americanus*)	Vesper Sparrow (*Pooecetes gramineus*)
Mourning Dove (*Zenaida macroura*)	LeConte's Sparrow (*Ammodramus leconteii*)
Clay-colored Sparrow (*Spizella pallida*)	Brown-headed Cowbird (*Molothrus ater*)

[1]References: Baker and Guthery 1990, Bock and Bock 1988, Bock et al. 1984, Duebbert and Lokemoen 1977, Graul 1975, Kantrud 1981, Kantrud and Higgins 1992, Kantrud and Kologiski 1982, Krisch and Higgins 1976, Lokemoen and Deubbert 1976, Maher 1979, Owens and Myres 1973, Risser et al. 1981, Ryder 1980, Skinner 1975, Tester and Marshall 1961, Webb and Bock 1990, Wiens 1973.

intensity, but frequently no other information was given. We listed a response as positive or negative only where the differences between treatments appeared > 25%. The studies differed widely in such critical variables as size and replication of plots. Despite these inevitable limitations, the results generally revealed consistent and interpretable patterns.

One group poorly represented in the data set are birds of prey (Table 1). Most hawks and owls have such large home ranges that their densities cannot be meaningfully compared on plots of sizes typically used in these studies. An increased number of large livestock exclosures therefore would have value for research on, as well as conservation of, this component of the Great Plains avifauna. Certain raptors (e.g., Burrowing Owl) clearly require much bare ground, and probably are favored by grazing, while others (e.g., Northern Harrier) select heavier cover of ungrazed or lightly grazed sites (see references in Table 1). The Ferruginous Hawk may require both sorts of habitats: open country for foraging, and lush vegetation for nesting.

Shorebird species have responded variously to livestock grazing, though in general birds in this group prefer to nest in relatively sparse (= moderately to heavily grazed) grasslands (Kantrud and Higgins 1992). Mountain Plovers require sites with minimal vegetation, whereas the Upland Sandpipers require more grass cover. Construction of livestock watering tanks may improve certain arid grasslands as shorebird habitat.

Songbirds show the full range of responses to grazing. At one extreme are species such as Horned Lark, Lark Sparrow, and McCown's Longspur, that doubtless have benefitted throughout the Plains from effects of livestock activity. At the other extreme is a group of songbirds apparently so dependent upon heavy litter cover and grass canopy that their response to grazing has been universally negative. Examples include Savannah Sparrow, Baird's Sparrow, Henslow's Sparrow, and Botteri's Sparrow. A third group appear to require intermediate levels of ground cover, such that grazing creates habitats of their preferred structure in tallgrass and some mixed-grass communities, while it eliminates them in shorter grasslands. The best-studied of these species is the Grasshopper Sparrow. Other examples include Sprague's Pipit, Bobolink, and Chestnut-collared Longspur.

Among neotropical migrants as a whole, 8 of 35 species showed a weak or inconsistent response to grazing, 9 were positively affected, 8 were negatively affected, and 10 showed some manifestation of a graded response: from positive in taller grasslands to negative in shorter grasslands (Table 1).

Management Implications and Recommendations

Birds are particularly responsive to changes in the physical structure of habitats in which they nest and forage (Cody 1985). Therefore, livestock potentially have their greatest impact on birds where grazing most changes the habitat physical structure. In the Great Plains, this includes taller rather than shorter grasslands, and certain arid regions of the Southwest where historical grazing converted desert grasslands into desert scrub. However, evidence suggests that every type of North American grassland includes a fauna of grazing-tolerant or grazing-dependent species, and another of species equally intolerant of grazing. Neotropical migratory birds clearly fall into both groups.

Two specific recommendations for management of Great Plains grasslands emerge from these considerations. The first is to substantially increase the amount of public rangeland from which all livestock are permanently excluded. Of particular importance on the Great Plains are National Grasslands, which include more than 1.5 million ha presently managed by the U. S. Forest Service largely for livestock production (West 1990). Many of these areas are managed by applying some sort of rotational grazing, and it could be argued that this imposes on the National Grasslands a mosaic of habitats resembling the prehistoric condition. However, ecological succession in most of these grasslands is far slower than the frequency of grazing rotation, thus leading to relatively uniform vegetative communities. Rather, we believe that permanent livestock exclusion, or at least exclusion for 25-50 years, might allow some of these important grasslands eventually to provide habitat for grazing-intolerant neotropical migrants and other species.

Our second recommendation is to continue a modified version of the Federal Conservation Reserve Program (CRP), to encourage landowners to convert and maintain formerly tilled croplands as grassland planted to native vegetation. Millions of hectares of CRP grasslands have been planted on the Great Plains since 1985, though the majority are dominated by exotic rather than native grasses (Joyce et al. 1991). Nevertheless, CRP grasslands are much more valuable for most wildlife than the croplands they have replaced (Kantrud and Higgins 1992, D. H. Johnson, Pers. comm.).

CRP grasslands remain vulnerable to recultivation, and this decision rightly is in the hands of landowners. However, it would be unfortunate if CRP lands were tilled (setting the successional clock back to zero), only to be returned to grassland when declining crop prices or future government incentives dictate. It would be much better from a conservation perspective to find ways of making present CRP grasslands valuable to their owners, possibly by encouraging moderate livestock grazing or haying. This would be an especially desirable strategy if it could be coupled with creation of livestock exclosures in other areas such as the National Grasslands.

RIPARIAN HABITATS

Avifauna of Riparian Ecosystems

In arid portions of western North America, riparian habitats consist of well-defined, narrow zones of vegetation along ephemeral, intermittent, and perennial streams and rivers. Some riparian communities are dominated by shrubs such as shorter willow (*Salix* spp.) or alder (*Alnus* spp.), but the most conspicuous communities, and those most important to breeding birds, include mature trees such as cottonwood (*Populus* spp.), taller willow, or sycamore (*Platanus* spp., Johnson and Jones 1977). These wooded riparian habitats are particularly valuable to wildlife when adjacent to relatively unproductive steppe, shrubsteppe, and desert communities (Knopf 1993).

Conservation of riparian areas is of great concern because they have extraordinary wildlife value and are vulnerable to disturbance and fragmentation associated with livestock grazing, agriculture, water management, timber harvest, recreation, urbanization, and other land-use activities (e.g., Thomas et al. 1979, Knopf et al. 1988a). Riparian habitats are the most modified land type in the American West (Chaney et al. 1990).

Despite their limited geographic extent (less than 1% of the land area), western riparian habitats are very important to neotropical migratory landbirds (Szaro 1980). The highest densities of breeding birds in all of North America have been reported from southwestern riparian woodlands (Carothers and Johnson 1975, Ohmart and Anderson 1982, Rice et al. 1983). More than 75% (127 of 166) of southwestern bird species nest primarily in riparian woodlands, and neotropical migrants comprise 60% of the 98 landbirds (Johnson et al. 1977). In Idaho, 60% of neotropical migrant landbirds are associated with riparian habitats (Saab and Groves 1992). In northern Colorado, 82% of all nesting species use riparian areas, and 78% (93 of 119) of landbird species are neotropical migrants (Knopf 1985).

Migratory landbirds inhabiting riparian vegetation in western North America are particularly vulnerable to disturbance. Their habitats are so fragmented and limited in distribution that total populations are much smaller than those of most neotropical migrants associated with woodlands of eastern North America (Terborgh 1989). Conservation of neotropical migratory landbirds in the western United States will depend very much on protection and restoration of riparian woodlands.

Effects of Livestock Grazing on Riparian Habitats

Livestock grazing has caused geographically extensive impacts on western riparian areas (Carothers 1977, Chaney et al. 1990). Grazing tends to be more damaging in riparian bottomlands than in adjacent uplands (Platts and Nelson 1985), especially in arid regions where livestock are attracted to water, shade, more succulent vegetation, and flatter terrain (Platts 1991). Cattle compact soil by hoof action, remove plant materials, and indirectly reduce water infiltration, all of which result in decreased vegetation density (Holechek et al. 1989). Grazing potentially can eliminate riparian areas through channel widening, channel aggrading, or lowering the water table. Because birds are known to be responsive to alterations in structure and floristics of riparian habitats (e.g., Szaro and Jakle 1985), it is not surprising that neotropical migrants are affected by livestock-induced changes in these habitat characteristics (Sedgwick and Knopf 1987, Knopf et al. 1988b).

Livestock management systems differ in their seasons and intensities of grazing. Year-long and summer grazing have proven particularly damaging to riparian vegetation (Kauffman and Krueger 1984, Platts 1991), whereas moderate late-fall or winter grazing may have relatively little impact (Sedgwick and Knopf 1987, 1991). In late fall and winter, water levels typically are low, stream banks are dry, and vegetation is dormant, thus minimizing the effects of trampling, soil compaction, erosion, and browsing (Rauzi and Hanson 1966). However, fall-winter grazing should be carefully controlled to leave protective plant cover for the following spring stream-flow periods (Clary and Webster 1989).

Livestock can damage riparian systems in early fall. Given the opportunity, cattle will concentrate in riparian areas at this season, because adjacent upland vegetation is dry and less palatable. As herbaceous cover is depleted, livestock will shift to browsing riparian shrubs (especially willow) before leaf drop, reducing residual cover needed for stream bank maintenance during subsequent high spring flows (Clary and Webster 1989, Kovalchick and Elmore 1992).

Short-term, early spring grazing may also help maintain riparian vegetation relative to summer grazing (Clary and Webster 1989). Early season grazing can result in better distribution of livestock use between riparian and upland zones, because upland vegetation is succulent at this time, and because livestock may avoid the wetter riparian environment.

Two difficulties in evaluating impacts of grazing on riparian ecosystems are 1) a shortage of long-term studies (Sedgwick and Knopf 1991), and 2) uncertainty as to pre-livestock condition of plant communities. Existing riparian vegetation may prove resilient in the presence of livestock, at least for several years. However, in the long-term, species composition, structural diversity, width of the riparian zone, and succession patterns of riparian woodlands may be affected further by the influence of livestock on establishment and survival of tree seedlings (Glinski 1977, Ohmart and Anderson 1986). This is an area of much-needed additional research. Ornithological studies described in the following section involved comparisons of existing riparian habitats experiencing different levels of grazing. They do not account for the possibility that certain riparian plant communities might ultimately be eliminated by grazing.

Response of Riparian Neotropical Migrants to Grazing

We know of nine published studies providing quantitative comparisons of abundances of 68 neotropical migrants in western riparian ecosystems experiencing different levels of livestock grazing (Table 2); six compared grazed to ungrazed sites, two used sites with different intensities of grazing, and one involved sites grazed at different seasons. Despite small sample sizes and differences in quantity and nature of data in the various studies, their results provide generally consistent and biologically meaningful insights into the responses of riparian neotropical migrants to grazing.

Forty-three species were evaluated by two or more studies. For these, we listed species as responding positively or negatively to grazing if their mean abundances differed between treatments by > 25%, and if both (n =2) or a majority (n = 3 to 8) of comparisons were consistent in the direction of response to grazing (Table 2). By these criteria, 8 species have been positively influenced by grazing, 17 species have been negatively affected, and 18 species were unresponsive or showed inconsistent or uncertain responses.

Distribution of species among three response groups generally reflects what is known of their habitat requirements. Species responding positively to grazing included aerial foragers associated with open habitats (e.g., Lewis' Woodpecker, Mountain Bluebird), ground foragers preferring areas with relatively little cover (e.g., American Robin, Killdeer), or, in one case, a species directly attracted to livestock Brown-headed Cowbird).

Most neotropical migrants negatively impacted by livestock grazing were species that nest and/or forage in heavy shrub or herbaceous ground cover (e.g., Common Yellowthroat, Lincoln's Sparrow), and/or that may be especially vulnerable to cowbird parasitism (e.g., Willow Flycatcher; Sedgwick and Knopf 1988). In addition to the 17 taxa listed in Table 2, at least 7 more species with similar habitat requirements probably also have been harmed by grazing in riparian ecosystems. Three of these were evaluated in only one of 9 studies, but showed strongly negative responses: Veery (*Catharus fuscescens*), Nashville Warbler (*Vermivora ruficapilla*), and Fox Sparrow (*Passerella iliaca*). Other species showed uncertain or inconsistent responses to grazing, based on limited published data, but almost certainly would be negatively affected by grazing, based on what is known of their habitat requirements. Conspicuous among these species that require further study are the Yellow Warbler (see Taylor and Littlefield 1986), American Redstart, Gray Catbird, and Yellow-breasted Chat.

Table 2. — Responses to livestock grazing by 43 neotropical migratory bird species breeding in riparian habitats in the western United States, for which data are available from at least two studies. [1]

Species usually responding positively to grazing:

Killdeer (*Charadrius vociferans*)	American Robin (*Turdus migratorius*)
Lewis' Woodpecker (*Melanerpes lewis*)	Brewer's Blackbird (*Euphagus cyanocephalus*)
House Wren (*Troglodytes aedon*)	Brown-headed Cowbird (*Molothrus ater*)
Mountain Bluebird (*Sialia currucoides*)	Pine Siskin (*Carduelis pinus*)

Species usually responding negatively to grazing:

American Kestrel (*Falco sparverius*)	Chipping Sparrow (*Spizella passerina*)
Calliope Hummingbird (*Stellula calliope*)	Dark-eyed Junco (*Junco hyemalis*)
Willow Flycatcher (*Empidonax trailii*)	White-crowned Sparrow (*Zonotrichia leucophrys*)
Cedar Waxwing (*Bombycilla cedrorum*)	Lincoln's Sparrow (*Melospiza lincolnii*)
Yellow-rumped Warbler (*Dendroica coronata*)	Redwinged Blackbird (*Agelaius pheoniceus*)
MacGillivray's Warbler (*Oporornis tolmiei*)	Northern Oriole (*Icterus galbula*)
Wilson's Warbler (*Wilsonia pusilla*)	American Goldfinch (*Carduelis tristis*)
Common Yellowthroat (*Geothlypis trichas*)	Cassin's Finch (*Carpodacus cassinii*)
Savannah Sparrow (*Passerculus sandwichensis*)	

Species unresponsive, or showing mixed or uncertain responses to grazing:

Mourning Dove (*Zenadia macroura*)	Warbling Vireo (*Vireo gilvus*)
Yellow Warbler (*Dendroica petechia*)	Broad-tailed Hummingbird (*Selasphorus platycerus*)
Northern Flicker (*Colaptes auratus*)	Yellow-breasted Chat (*Icteria virens*)
American Redstart (*Setophaga ruticilla*)	Red-naped Sapsucker (*Sphyrapicus nuchalis*)
Eastern Kingbird (*Tyrannus tyrannus*)	Black-headed Grosbeak (*Pheucticus melanocephalus*)
Tree Swallow (*Tachycineta bicolor*)	Rufous-sided Towhee (*Pipilo erthrophthalmus*)
Song Sparrow (*Melospiza melodia*)	Western Wood-pewee (*Contopus sordidulus*)
Gray Catbird (*Dumetella carolinensis*)	Western Meadowlark (*Sturnella neglecta*)
Brown Thrasher (*Toxostoma rufum*)	Western Tanager (*Piranga ludoviciana*)

[1] References: Crouch 1982, Knopf et al. 1988b, Medin and Clary 1990, 1991, Mosconi and Hutto 1982, Pate et al. 1978, Schulz and Leininger 1991, Sedgwick and Knopf 1987, Taylor 1986.

Certain foraging and nesting guilds have been affected by grazing more than others, in ways that are consistent with impacts of livestock on their habitat requirements. As a group, cavity-nesters have been essentially unaffected, whereas open-nesting birds were significantly influenced by grazing practices (Good and Dambach 1943, Butler 1979, plus references cited in Table 2). Aerial, bark, and canopy insectivores have been less influenced by grazing than species feeding on nectar, insects, or seeds in the understory or on the ground (see references in Table 2, plus Szaro and Rinne 1988).

Management Implications and Recommendations

More than any other western habitat, riparian woodlands are centers of high diversity and abundance of neotropical migratory birds. Livestock grazing is a widespread impact on these ecosystems, and one to which many neotropical migrants have responded negatively. Therefore, livestock management decisions about riparian habitats will significantly affect many neotropical migrants.

Further research is needed to refine our understanding of the relationships between neotropical migrants and grazing in riparian ecosystems. First, more studies are needed on long-term effects of grazing on riparian vegetation (Sedgwick and Knopf 1991). Second, avian abundance data do not tell the whole story with regard to habitat suitability. Equally important, but rarely reported, are data on reproductive success and survivorship in different habitats (Van Horne 1983). Finally, more information is needed on the importance of riparian habitats to wintering and migrating, as well as nesting, neotropical migratory birds (Mosconi and Hutto 1982). Despite these limitations to current knowledge, the following general management recommendations are unlikely to change:

First, it is critical to consider condition of riparian areas when implementing grazing systems, and, when practical, to manage riparian woodlands separately from adjacent uplands (Platts 1991). Where livestock must have access to riparian zones for water, restricted-access fencing can localize and minimize their impacts on streambanks and riparian vegetation. Development of alternate water sources also could help reduce concentration of livestock in riparian zones. When uplands and riparian zones must be managed together, grazing strategies should be keyed to condition of riparian vegetation.

Second, when riparian systems are grazed, moderate use during late-fall and winter, or short-term use in spring, will be less damaging than continuous or growing-season grazing. Fall-winter grazing should be carefully controlled to ensure the maintenance of residual plant cover.

Third, degraded riparian habitats may require complete rest from livestock grazing to initiate the recovery process. In systems requiring long-term rest, the necessary period will be highly variable depending upon the situation (Clary and Webster 1989). Management also should consider rehabilitating damaged riparian areas through revegetation with native species.

Fourth, given their scarcity, fragility, and importance to neotropical migrants and other wildlife, western riparian ecosystems should be excluded from livestock grazing wherever possible. Few species appear to benefit from grazing in these habitats, and those that do are not restricted to riparian communities.

SHRUBSTEPPE HABITATS OF THE INTERMOUNTAIN WEST

The Region and Its Avifauna

Shrubsteppe habitats, characterized by woody, mid-height shrubs and perennial bunchgrasses, are distributed in the Intermountain West from eastern Washington south to southern Nevada and northern Arizona, and east to central Wyoming (Daubenmire 1978). The region is characterized by aridity (usually < 20 cm annual precipitation), hot summers, cold winters, wind, low soil stability, and other attributes of a stressful physical environment (Short 1986). It is difficult to reconstruct the prehistoric condition of shrubsteppe biotic communities, because of major changes in vegetation that took place following introductions of domestic grazers (e.g., Cottam and Stewart 1940).

There is little doubt that sagebrush (*Artemisia tridentata*) always has been a major component of many shrubsteppe communities (Vale 1975). Other important shrubs include smaller sages (*Artemisia* spp.), saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus* spp.), and bitterbrush (*Purshia tridentata*; Tisdale and Hironaka 1981). Dominant native perennial bunchgrasses include species in genera such as *Agroprryon* (wheatgrasses), *Festuca* (fescues), *Stipa* (needle grasses), and *Poa* (bluegrasses; Yensen 1981). Prior to European settlement, cryptograms such as the lichen *Parmelia chlorochroa* covered undisturbed soil surfaces not populated by vascular plants (MacCracken et al. 1983). Because of loss of this layer through trampling by domestic livestock, we do not know what role it played in the original ecosystems.

Long-term studies by Wiens and Rotenberry have thoroughly documented dynamics of shrubsteppe bird communities (e.g., Wiens and Rotenberry 1981, Wiens 1985). While more than 50 neotropical migratory birds may breed in various parts of the region, the typical community has 2-7 regular breeders, with 100-600 birds/km^2, and over half the individuals belonging to the single most common species. The most important shrubsteppe birds are Horned Lark, Sage Thrasher, Brewer's Sparrow, Sage Sparrow, and, in areas with more grass cover, Vesper Sparrow, and Western Meadowlark.

Shrubsteppe bird populations fluctuate independently of one another and of variations in habitat structure, at least at the scales studied (Wiens et al. 1986). There is some association between birds and particular plant species, their seed crops, and, perhaps, their insect faunas (Geobel and Berry 1976, Wiens and Rotenberry 1981). Overall, however, it appears that shrubsteppe bird populations are influenced primarily by extreme and irregular fluctuations in precipitation and ecosystem productivity. Probably as a result, most species are highly opportunistic and ecologically adaptable.

Effects of Livestock Grazing on Vegetation

Shrubsteppe ecosystems did not evolve with large ungulate herds (Mack and Thompson 1982), and their grasses were evolutionarily unprepared for introductions of domestic grazers. Historical changes in shrubsteppe plant communities can be attributed to two major factors: domestic livestock grazing and facilitated invasions by exotic plants (e.g., Yensen 1981, Mack and Thompson 1982). Resulting changes included 1) loss of the cryptogram layer, 2) lost of native seral grasses, 3) reduction in cover of perennial grasses, 4) reduction in forb cover, 5) increase in shrub cover, and 6) increase in cover of non-native grasses and forbs, particularly cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum asperum*), Russian thistle (*Salsola iberica*), tumblemustard (*Sisymbrium altissimum*), tansymustard (*Descurainia sophia*), and crested wheatgrass (*Agropyron cristatum*).

Present-day grazing continues to influence species composition and structure of shrubsteppe communities. Because most herbaceous species are more palatable than shrubs during the growing season, grazing tends to increase shrub cover and reduce the understory of palatable annuals and perennials (e.g., Ellison 1960, Tisdale et al. 1969, Ryder 1980). Grazing also facilitates spread of junipers (Little 1977), reduces vegetation diversity (Reynolds and Rich 1978), and encourages spread of exotics such as cheatgrass (Young et al. 1979). Generally, spring and summer cattle grazing favors shrubs and forbs over grasses, whereas other grazing patterns, such as fall grazing by sheep, may have different effects (e.g., Laycock 1967, Urness 1979). Our general conclusions about impacts of livestock on neotropical migrants (Table 3) are based on the known or probable effects of the predominant type of grazing in shrubsteppe communities: by cattle, during the growing season.

Table 3. — Probable effects of livestock grazing on some neotropical migratory landbirds breeding in shrubsteppe habitats of the Intermountain West.[1]

Species probably responding positively to grazing:

Golden Eagle (*Aquila chrysaetos*)
Brown-headed Cowbird (*Molothrus ater*)*
Sage Sparrow (*Amphispiza belli*)

Species probably responding negatively to grazing:

Long-billed Curlew (*Numenius americanus*)
Brewer's Sparrow (*Spizella breweri*)*
Vesper Sparrow (*Pooecetes gramineus*)*
Ferruginous Hawk (*Buteo regalis*)
Burrowing Owl (*Athene cunicularia*)*
Short-eared Owl (*Asio flammeus*)
Western Meadowlark (*Sturnella neglecta*)*
Northern Harrier (*Circus cyaneus*)
Swainson's Hawk (*Buteo swainsoni*)
Red-tailed Hawk (*Buteo jamaicensis*)
Savannah Sparrow (*Passerculus sandwichensis*)
Grasshopper Sparrow (*Ammodramus savannarum*)
White-crowned Sparrow (*Zonotrichia leucophrys*)

Species unresponsive, or showing mixed responses to grazing:

Mourning Dove (*Zenaida macroura*)*
Horned Lark (*Eremophila alpestris*)*
Loggerhead Shrike (*Lanius ludovicianus*)*
Sage Thrasher (*Oreoscoptes montanus*)*
Lark Sparrow (*Chondestes grammacus*)*
Black-throated Sparrow (*Amphispiza bilineata*)*
Brewer's Blackbird (*Euphagus cyanocephalus*)*

[1] Emphasis is on cattle grazing during the growing season. Effects of other classes of stock and/or grazing season may differ.

[2] Based on Nydigger and Smith's (1986) observation that increased shrub densities favor jackrabbits, the eagle's primary prey.

* References for species indicated with an asterisk: Gleason (1978), Medin (1986), Monson (1941), Olson (1974), Page et al. (1978), Reynolds and Trost (1980, 1981), Rich (1986), Rich and Rothstein (1985), and Rotenberry and Knick (1992), Wiens (1985). Information is unavailable for other species, for which our categorizations are based on data about the effects of grazing on habitat characteristics, and known habitat requirements of the birds.

Response of Neotropical Migrants to Grazing

Unfortunately, there have been no long-term, well-replicated studies comparing the avifaunas of grazed and ungrazed shrubsteppe communities. Wiens and Dyer (1975) suggested that ecological plasticity of many shrubsteppe birds would make them unresponsive to moderate levels of livestock grazing. Major avifaunal shifts may occur only after some threshold of habitat change has been passed. It is likely that such thresholds were passed historically, when livestock were first introduced into the region. However, there are virtually no pristine ecosystems left where this hypothesis might be tested.

As a result of the scarcity of ungrazed shrubsteppe communities not dominated by exotic vegetation, and a paucity of ornithological studies comparing those that do exist, our conclusions about effects of grazing on neotropical migrants are largely speculative. Nevertheless, we are in a position to make some tentative conclusions, based either on limited published information, or on knowledge about effects of grazing on vegetation, and known habitat requirements of the birds (Table 3).

A major difficulty in assigning shrubsteppe birds to grazing response categories is the need to distinguish between historical and current livestock activities. For example, certain birds requiring shrubs as nest sites may have benefitted from grazing-related early increases in woody vegetation, yet may now be harmed by heavy present grazing that removes understory grasses. Brewer's Sparrow may be one such example, and we only tentatively place it in the "negative" category (Table 3). An ungrazed shrubsteppe in south-central Montana supported Western Meadowlarks and Grasshopper, Lark, and Brewer's Sparrows (Bock and Bock 1987). However, only meadowlarks remained following a wildfire that killed all sagebrush.

By contrast, certain birds responded positively to bare ground and low cover created by grazing in the Great Plains may have declined following historical grazing in shrubsteppe, because of their intolerance for increased shrub cover. Likely examples include Burrowing Owl and Horned Lark, species that doubtless benefit from reduced amounts of herbaceous ground cover, but that may avoid areas of high shrub density.

There is practically no information on responses to grazing by avian predators in the shrubsteppe. Our categorization of the Golden Eagle as a species positively affected by grazing is based solely on the known association of its preferred prey (jackrabbits) with shrubby habitats (Nydegger and Smith 1986). Likewise, our tentative designation of a variety of raptors as species negatively affected by grazing is based on likely associations of their rodent prey with herbaceous ground cover, and, in the case of Northern Harrier, Ferruginous Hawk, and Short-eared Owl, on a requirement for cover for ground nests. Much more work is needed on responses of raptors to grazing in shrubsteppe habitats.

As in Great Plains grasslands and riparian habitats, a number of species nesting in herbaceous ground cover may respond negatively to grazing in shrubsteppe. There are data supporting this conclusion for Vesper Sparrow and Western Meadowlark, and we suspect it would be the case for three other species more peripherally associated with shrubsteppe: Savannah, Grasshopper, and White-crowned Sparrows (Table 3).

Another potentially significant indirect effect of grazing on neotropical migrants is nest parasitism by Brown-headed Cowbirds. The presence of livestock undoubtedly has brought cowbirds into broader contact with shrubsteppe breeding birds. However, almost no data are available on this subject (Rich and Rothstein 1985).

Management Implications and Recommendations

No aspect of grazing effects on shrubsteppe neotropical migratory birds is well understood. Basic long-term research is badly needed. This research, and interpretation of its results, will be complicated by lack of close coupling between shrubsteppe bird populations and habitat features, and by differences between historical and current effects of grazing. Our lack of knowledge about this ecosystem is particularly unfortunate, because it rapidly is being replaced by exotic, fire-adapted annuals. As much as 25 million ha of shrubsteppe is being converted to a biologically depauperate annual grassland desert (USDA Forest Service 1993). Ultimately, Horned Lark may be the only species that will find these areas suitable for breeding (Rotenberry and Knick 1991).

Traditional grazing practices in shrubsteppe involved destructive continous growing-season presence of livestock. A noteworthy long-term trend on public land has been replacement of season-long cattle grazing with various rotational grazing systems that can be less damaging to native grasses (Stoddart et al. 1975). Nevertheless, 50% of Bureau of Land Management rangelands remain in fair or poor condition (USDI Bureau of Land Management 1991), and 54% of Forest Service lands are in early or mid-seral stages of ecological succession (U.S. General Accounting Office 1988). These conditions reflect continuing effects of grazing: increased shrub cover, decreased cover of native perennial grasses and forbs, and increased cover of exotic annuals.

Certain historical shrubsteppe communities likely have been entirely eliminated by agricultural conversion. Deeper, more productive soils that supported especially tall stands of sagebrush, for example, undoubtedly were converted to crop production long ago (Symons 1967). The avian component of these habitats and others such as the historic grasslands of eastern Washington and central Oregon are largely unknown.

All of these factors lead us to conclude that there is an urgent need for protection, restoration, and long-term study of shrubsteppe ecosystems (including their avifaunas) dominated by native perennial grasses, cryptogams, and moderate densities of shrubs, as we suspect these ecosystems existed prior to introductions of domestic livestock.

MONTANE CONIFEROUS FOREST HABITATS

Virtually nothing is known about impacts of livestock on neotropical migrants associated with western coniferous forests, despite the fact that a significant number of species could be affected. However, the extent, composition, and land-use history of these forests are detailed by various authors contributing to the recent and thorough overview of terrestrial plant communities in North America edited by Barbour and Billings (1988). This body of work provides a useful starting point for a general consideration of likely impacts of grazing on birds in these habitats.

Within forested landscapes in general, the impacts of livestock grazing tend to be concentrated in drainage bottoms, wet meadows, and grassy slopes (Sampson 1980,Willard 1989). In Rocky Mountain forests, the most widespread and heavily impacted communities have been those dominated by ponderosa pine (*Pinus ponderosa*; Peet 1988). These open woodlands historically were characterized by a lush herbaceous understory of perennial graminoids (e.g., *Poa* and *Carex* spp.) and forbs, and by varying densities of shrubs such as currant (*Ribes* spp.), skunkbush (*Rhus trilobata*), and species of *Ceanothus*. Frequent non-catastrophic fire was the most important determinant of plant community structure and composition, prior to introductions of domestic livestock. A major consequence of livestock grazing has been removal of much herbaceous vegetation that provided fine fuels necessary to carry frequent, low intensity fires. Domestic livestock, in conjunction with active fire suppression, have caused a widespread transformation of these woodlands into denser forests with a decreased understory of herbaceous plants. One result of this transformation is the impressive accumulations of heavy fuels in these forests that now produce catastrophic fires resulting in widespread tree mortality (Peet 1988).

At lower elevations, there has been a strong positive correlation between heavy cattle grazing and expansion of juniper (*Juniperus* spp.) woodland (Johnsen 1962, West 1988). Again, grazing reduced cover of grasses, facilitating establishment of juniper seedlings and simultaneously reducing ground fires that otherwise might eliminate woody vegetation. West (1984) concluded that juniper woodlands were open savannahs prior to European settlement, and stressed the role of fire in maintaining this condition. Grazing reduced or eliminated the fires, with the net effect being an increase in tree density in woodlands, as well as expansion of woodlands into former grasslands and shrubsteppe at both higher and lower altitudes. A similar situation has been documented at higher elevations in the Warner Mountains of northeastern California, where past heavy grazing by sheep appears to have caused both upslope and downslope invasions by pine and fir into grassland and shrubsteppe (Vale 1977).

As in the Rockies, frequent low-intensity fires were extremely important governors of plant communities throughout much of the southern Cascades and Sierra Nevada (Barbour 1988). While fire suppression is known to have influenced forest structure throughout much of this region (Barbour 1988), relatively little attention has been given to historical effects of livestock grazing. An exception is the work of Vankat and Major (1978), who concluded that sheep grazing altered conditions of montane meadows in the southern Sierra Nevada, facilitating invasions by lodgepole pine (Pinus contorta). Heavy use of these meadows by sheep led to increased runoff, erosion, and stream entrenchment. The result was a lower water table and a drier meadow where pine seedings could become established. Similar invasions of conifers into subalpine meadows were coincident with periods of intense grazing in the central Rockies (Dunwiddie 1977).

Fire, livestock grazing, and logging all have contributed importantly to the present community mosaic of the central and northern Cascade Mountains in the Pacific Northwest (Franklin 1988). However, little attempt has been made to tease out specific effects of grazing. As in the Rockies, the effects of livestock grazing may be most important in ponderosa pine forests, which are widely distributed on the east side of the Cascades.

Among the varied altitudinally-distributed forest communities dominated by conifers, those occurring at lower elevations may have been more influenced by livestock grazing, by virtue of their longer snow-free periods. However, this conclusion ignores the extraordinary numbers of sheep that once used the full altitudinal range of habitats in the region. Sheep numbers rose spectacularly between 1865 and 1901, reached a peak in 1910, and have been declining steadily since that time (Thilenius 1975). Grazing was year-round, with flocks moving upslope in spring, following receding snow lines. Although high altitude ecosystems were usable for grazing only during summer, they were subject to extreme grazing pressure for this short period, and it is likely that their present structure is at least partially a consequence of this historic grazing pressure.

As little as we know about impacts of livestock on western coniferous forests, information is extensive compared to our direct knowledge about effects of grazing on neotropical migratory birds in these habitats. In fact, we can only speculate (albeit with some confidence) that birds most likely to have been negatively affected were 1) species dependent on herbaceous and shrubby ground cover for nesting and/or foraging, or 2) species requiring open savannahs as opposed to closed-canopy forests. Likely examples from the first group would be Nashville Warbler, Fox Sparrow, and Lincoln Sparrow. Examples from the second group would be Lewis' Woodpecker, Violet-green Swallow, and Mountain Bluebird.

Land managers and field biologists have an opportunity to provide information about impacts of grazing on neotropical migrants in western coniferous forests, where virtually none exists currently. We encourage studies both during nesting and migration seasons, especially where comparisons are possible between replicted forested stands with known differences in grazing regimes or grazing histories. Quantitative assessment of vegetation structure and composition should accompany standardized bird counts.

CONCLUSION

Livestock grazing probably is the most widespread economic land use in western North America, and it is one that potentially affects a large number of neotropical migratory birds. We reject the notion that livestock grazing is either universally detrimental (Ferguson and Ferguson 1983) or beneficial (Savory 1988) to rangelands and their wildlife. However, it does appear that livestock operate as a keystone species (Paine 1966) in many if not most habitats they occupy at economically meaningful densities. That is, livestock are the organisms largely responsible for determining structure and function of ecosystems of which they are a part. The problem with livestock across much of the West today is not with their presence, but with their ubiquity. Those plants and animals, including neotropical migratory birds, intolerant of activities of domestic grazers have comparatively few places left to live. This undoubtedly is true for grasslands that evolved in the absence of large numbers of bison, and for most riparian woodlands. We suspect it is true for shrubsteppe and montane ecosystems, but more field research is urgently needed for these habitats. Protection and restoration of ungrazed ecosystems resembling their prehistoric counterparts as closely as possible must be an essential part of any plan to conserve neotropical migratory birds in western North America.

AKNOWLEDGEMENTS

We thank Alexander Cruz, Warren Clary and Peter Stangel for constructive comments on an earlier version of this manuscript.

LITERATURE CITED

Anderson, R. C. 1982. An evolutionary model summarizing the roles of fire, climate, and grazing animals in the origin and maintenance of grasslands: an end paper. Pages 297-308 *in* Grasses and grasslands; systematics and ecology (J. R. Estes, R. J. Tyrl, and J. N. Brunken, Eds.). Univ. Oklahoma Press, Norman, Oklahoma.

Axelrod, D. I. 1985. Rise of the grassland biome, central North America. Bot. Rev. 51:163-201.

Bailey, R. G. 1978. Description of the ecoregions of the United States. USDA Forest Service, Intermountain Region, Ogden, Utah.

Baker, D. L., and F. S. Guthery. 1990. Effects of continuous grazing on habitat and density of ground-foraging birds in south Texas. J. Range Manage. 43:2-5.

Barbour, M. G. 1988. Californian upland forests and woodlands. Pages 131-164 *in* North American terrestrial vegetation (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.

Barbour, M. G., and W. D. Billings (Eds). 1988. North American terrestrial vegetation. Cambridge Univ. Press, Cambridge, England.

Bock, C. E., and J. H. Bock. 1987. Avian habitat occupancy following fire in a Montana shrubsteppe. Prairie Nat. 19:153-158.

Bock, C. E., and J. H. Bock. 1988. Grassland birds in southeastern Arizona: impacts of fire, grazing, and alien vegetation. Pages 43-58 *in* Ecology and conservation of grassland birds (P. D. Goriup, Ed.). International Council for Bird Preservation, Publication No. 7, Cambridge, England.

Bock, C. E., and J. H. Bock. Effects of livestock grazing on cover of perennial grasses in southeastern Arizona. Conserv. Biol., in press.

Bock, C. E., J. H. Bock, W. R. Kenney, and V. M. Hawthorne. 1984. Responses of birds, rodents, and vegetation to livestock exclosure in a semidesert grassland site. J. Range Manage. 37:239-242.

Butler, D. C. 1979. Effects of a high-density population of ungulates on breeding bird communities in deciduous forest. M. S. Thesis, Colorado State University, Fort Collins, Colorado.

Carothers, S. W. 1977. Importance, preservation, and management of riparian habitats: an overview. Pages 2-4 *in* Importance, preservation, and management of riparian habitat: a symposium (R. R. Johnson, and D. A. Jones, Tech. Coords.). USDA Forest Service Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Carothers, S. W., and R. R. Johnson. 1975. Water management practices and their effects on nongame birds in range habitats. Pages 210-222 *in* Management of forest and range habitats for nongame birds (D. R. Smith, Ed.). USDA Forest Service, Gen. Tech. Rep. WO-1. Washington, D. C.

Chaney, E., W. Elmore, and W. S. Platts. 1990. Livestock grazing on western riparian areas. Produced for the Environmental Protection Agency by Northwest Resource Information Center, Inc., Eagle, Idaho.

Clary, W. P., and B. F. Webster. 1989. Managing grazing of riparian areas in the Intermountain Region. USDA Forest Service Gen. Tech. Rep. INT-263. Intermountain Research Station, Ogden, Utah.

Cody, M. L. 1985. Habitat selection in grassland and open-country birds. Pages 191-226 in Habitat selection in birds (M. L. Cody, Ed.). Academic Press, New York.

Cottam, W. P., and G. Stewart. 1940. Plant succession as a result of grazing and of meadow desiccation by erosion since settlement. Ecology 34:613-626.

Crouch, G. L. 1982. Wildlife on ungrazed and grazed bottomlands on the South Platte River, northeastern Colorado. Pages 188-197 *in* Wildlife-livestock relationships symposium (J. M. Peek and P. D. Dalke, Eds.). Forestry, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.

Daubenmire, R. 1978. Plant geography. Academic Press, New York.

Duebbert, H. F., and J. T. Lokemoen. 1977. Upland nesting of American bitterns, marsh hawks, and short-eared owls. Prairie Nat. 9:33-40.

Dunwiddie, P. W. 1977. Recent tree invasions of subalpine meadows in the Wind River Mountains, Wyoming. Arct. Alp. Res. 9:393-399.

Ellison, L. 1960. Influence of grazing on plant succession in rangelands. Bot. Rev. 26:1-78.

Ferguson, D., and N. Ferguson. 1983. Sacred cows at the public trough. Maverick Publications, Bend, Oregon.

Franklin, J. F. 1988. Pacific Northwest forests. Pages 103-130 *in* North American terrestrial vegetation (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.

Goebel, C. J., and G. Berry. 1976. Selectivity of range grass seeds by local birds. J. Range Manage. 29:393-395.

Gibson, D. J., and L. C. Hulbert. 1987. Effects of fire, topography and year-to-year climate variation on species composition in tallgrass prairie. Vegetatio 72:175-185.

Gleason, R. S. 1978. Aspects of the breeding biology of burrowing owls in southeastern Idaho. MS Thesis, University of Idaho, Moscow, Idaho.

Glinski, R. L. 1977. Regeneration and distribution of sycamore and cottonwood trees along Sonoita Creek, Santa Cruz County, Arizona. Pages 116-123 *in* Importance, preservation, and management of riparian habitat: a symposium (R. R. Johnson and D. A. Jones, Tech. Coords.). USDA Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Good, E. E., and C. A. Dambach. 1943. Effect of land use practices on breeding bird populations in Ohio. J. Wildl. Manage. 7:291-297.

Graul, W. D. 1975. Breeding biology of the mountain plover. Wilson Bull. 87:6-31.

Holechek, J. L., R. D. Piper, and C. H. Herbel. 1989. Range management: principles and practices. Prentice Hall, Englewood Cliffs, New Jersey.

Johnsen, T. N., Jr. 1962. One-seed juniper invasion of north Arizona grasslands. Ecol. Monogr. 32:187-207.

Johnson, R. R., and D. A. Jones (Technical Coordinators). 1977. Importance, preservation, and management of riparian habitats: a symposium. USDA Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Johnson, R. R., L. T. Haight, and J. M. Simpson. 1977. Endangered species vs. endangered habitats: a concept. Pages 68-79 *in* R.R. Johnson, and D. A. Jones (Technical Coordinators). Importance, preservation, and management of riparian habitats: a symposium. USDA Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.preceeding reference.

Joyce, L. A., J. E. Mitchell, and M. D. Skold, editors. 1991. Proceedings, the Conservation Reserve - yesterday, today, and tomorrow. USDA Forest Service, Gen. Tech. Rep. RM-203. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Kantrud, H. A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. Can. Field Nat. 95:404-417.

Kantrud, H. A., and K. F. Higgins. 1992. Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grasslands. Prairie Nat. 24:67-84.

Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. USDI Fish and Wildlife Service, Wildl. Res. Rep. No. 15, Washington, D. C.

Kauffman, J. B., and W. C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management: a review. J. Range Manage. 37:430-438.

Kirsch, L. M., and K. F. Higgins. 1976. Upland sandpiper nesting and management in North Dakota. Wildl. Soc. Bull. 4:16-20.

Knopf, F. L. 1985. Significance of riparian vegetation to breeding birds across an altitudinal cline. Pages 105-111 in Riparian ecosystems and their management: reconciling conflicting uses (R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre, Tech. Coords.). USDA Forest Service, Gen. Tech. Rep. RM-120. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Knopf, F. L. 1993. Conservation of avian diversity in riparian corridors. Bird Conserv., in press.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Sampson, and R. C. Szaro. 1988a. Conservation of riparian ecosystems in the United States. Wilson Bull. 100:272-284.

Knopf, F. L., J. A. Sedgwick, and R. W. Cannon. 1988b. Guild structure of a riparian avifauna relative to seasonal cattle grazing. J. Wildl. Manage. 52:280-290.

Kovalchik, B. L., and W. Elmore. 1992. Effects of cattle grazing systems on willow-dominated plant associations in central Oregon. Pages 111-119 in Proceedings of a symposium on ecology and management of riparian shrub communities (W. P. Clary, E. D. McArthur, D. Bedunah, and C. L. Wambolt, Compilers). USDA Forest Service, Gen. Tech. Rep. INT-289. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Laycock, W. A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. J. Range Manage. 20:206-213.

Lokemoen, J. T., and H. F. Duebbert. 1976. Ferruginous hawk nesting ecology and raptor populations in northern South Dakota. Condor 78:464-470.

Mack, R. N., and J. N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. Am. Nat. 119:757-773.

Macracken, J. G., L. E. Alexander, and D. W. Uresk. 1983. An important lichen of southeastern Montana rangelands. J. Range Manage. 36:35-37.

Maher, W. J. 1979. Nestling diets of prairie passerine birds at Matador, Saskatchewan, Canada. Ibis 121:437-452.

McNaughton, S. J. 1986. On plants and herbivores. Am. Nat. 128:765-770. Medin, D. E. 1986. Grazing and passerine breeding birds in a Great Basin low-shrub desert. Great Basin Nat. 46:567-572.

Medin, D. E., and W. P. Clary. 1990. Bird and small mammal populations in a grazed and ungrazed riparian habitat in Idaho. USDA Forest Service Res. Pap. INT-425. Intermountain Research Station, Ogden, Utah.

Medin, D. E., and W. P. Clary. 1991. Breeding bird populations in a grazed and ungrazed riparian habitat in Nevada. USDA Forest Service Res. Pap. INT-441. Intermountain Research Station, Ogden, Utah.

Mengel, R. M. 1970. The North American Central Plains as an isolating agent in bird speciation. Pages 280-340 *in* Pleistocene and recent environments of the central Great Plains (W. Dort and J. K. Jones, Eds.). University of Kansas Press, Lawrence, Kansas.

Milchunas, D. G., O. E. Sala, and W. K. Lauenroth. 1988. A generalized model of the effects of grazing by large herbivores on grassland community structure. Am. Nat. 132:87-106.

Monson, G. 1941. The effect of revegetation on the small bird population in Arizona. J. Wildl. Manage. 5:395-397.

Mosconi, S. L., and R. L. Hutto. 1982. The effects of grazing on land birds of a western Montana riparian habitat. Pages 221-233 in Wildlife-livestock relationships symposium (J. M. Peek, and P. D. Dalke, Eds.). Forest Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.

Nydegger, N. C., and G. W. Smith. 1986. Prey populations in relation to Artemisia vegetation types in southwestern Idaho. Pages 152-156 in Symposium on the biology of Artemisia and Chrysothamnus (E. D. McArthur and B. L. Welch, Eds.). USDA Forest Service, Gen. Tech. Rep. INT-200. Intermountain Research Station, Ogden, Utah.

Ohmart, R. D., and B. W. Anderson. 1982. North American desert riparian ecosystems. Pages 433-479 in Reference handbook on the deserts of North America (G. L. Bender, Ed.). Greenwood Press, Westport, Connecticut.

Ohmart, R. D., and B. W. Anderson. 1986. Riparian habitat. Pages 169-199 in Inventory and monitoring of wildlife habitat (A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, Eds.). USDI Bureau of Land Management, Service Center, Denver, Colorado.

Olson, R. A. 1974. Bird populations in relation to changes in land use in Curlew Valley, Idaho and Utah. MS Thesis, Idaho State Univ., Pocatello, Idaho.
Owens, R. A., and M. T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Can. J. Zool. 51:697-713.
Page, J. L., N. Dodd, T. O. Osborne, and J. A. Carson. 1978. The influence of livestock grazing on non-game wildlife. Cal.-Nev. Wildl. 1978:159-173.
Paine, R. T. 1966. Food web complexity and species diversity. Am. Nat. 100:65-75.
Peet, R. K. 1988. Forests of the Rocky Mountains. Pages 63-101 in North American terrestrial vegetation (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.
Platts, W. S. 1991. Livestock grazing. Influences of forest and rangeland management on salmonid fishes and their habitats. Amer. Fish. Soc., Spec. Publ. 19: 389-423.
Platts, W. S., and R. L. Nelson. 1985. Streamside and upland vegetation use by cattle. Rangelands 7:5-7.
Rauzi, F., and C. L. Hanson. 1966. Water uptake and runoff as affected by intensity of grazing. J. Range Manage. 35:351-356.
Reynolds, T. D., and T. D. Rich. 1978. Reproductive ecology of the sage thrasher (*Oreoscoptes montanus*) on the Snake River Plain in south-central Idaho. Auk 95:580-582.
Reynolds, T. D., and C. H. Trost. 1980. The response of native vertebrate populations to crested wheatgrass planting and grazing by sheep. J. Range Manage. 33:122-125.
Reynolds, T. D., and C. H. Trost. 1981. Grazing, crested wheatgrass, and bird populations in southeastern Idaho. Northwest Sci. 55:225-234.
Rice, J., R. D. Ohmart, and B. W. Anderson. 1983. Turnovers in species composition of avian communities in contiguous riparian habitats. Ecology 64:1444-1455.
Rich, T. D. 1986. Habitat and nest-site selection by burrowing owls in the sagebrush steppe of Idaho. J. Wildl. Manage. 50:548-555.
Rich, T. D., and S. I. Rothstein. 1985. Sage thrashers reject cowbird eggs. Condor 87:561-562.
Risser, P. G., E. C. Birney, H. D. Blocker, S. W. May, W. J. Parton, and J. A. Wiens. 1981. The true prairie ecosystem. Hutchinson Ross Publishing Company, Stroudsburg, Pennsylvania.
Rotenberry, J. T., and S. T. Knick. 1991. Passerine surveys on the Snake River Birds of Prey Area. Pages 220-228 *in* Snake River Birds of Prey Area, 1991 Annual Report (K. Steenhof, Ed.). USDI Bureau of Land Management, Boise, Idaho.
Ryder, R. A. 1980. Effects of grazing on bird habitats. Pages 51-66 *in* Management of western forests and grasslands for nongame birds (R. M. DeGraff and N. G. Tilghman, Comps.). USDA Forest Service, Gen. Tech. Rep. INT-86. Intermountain Forest and Range Experiment Station, Ogden, Utah.
Saab, V. A., and C. R. Groves. 1992. Idaho's migratory landbirds: description, habitats, and conservation. Nongame wildlife leaflet No. 10. Idaho Wildl., Summer 1992:11-26.
Sabadell, J. E. 1982. Desertification in the United States. USDI Bureau of Land Management, Washington, D.C.
Sampson, F. B. 1980. Use of montane meadows by birds. Pages 113-129 *in* Management of western forests and grasslands for nongame birds (R. M. DeGraff, Tech. Coord.). USDA Forest Service, Gen. Tech. Rep. INT-86. Intermountain Forest and Range Experiment Station, Ogden, Utah.
Sauer, C. O. 1950. Grassland, climax, fire, and man. J. Range Manage. 3:16-22.
Savory, A. 1988. Holistic resource management. Island Press, Washington,D.C. Schlesinger, W. H., J. F. Reynolds, G. L. Cunningham, L. F. Huenneke, W. M. Jarrell, R. A. Virginia, and W. G. Whitford. 1990. Biological feedbacks in global desertification. Science 247:1043-1048.
Schlesinger, W. H., J. F. Reynolds, G. L. Cunningham, L. F. Huenneke, W. M. Jarrell, R. A. Virginia, and W. G. Whitford. 1990. Biological feedbacks in global desertification. Science 247:1043-1048.
Schulz, T. T., and W. C. Leininger. 1991. Nongame wildlife communities in grazed and ungrazed montane riparian sites. Great Basin Nat. 51:286-292.
Sedgwick, J. A., and F. L. Knopf. 1987. Breeding bird response to cattle grazing of a cottonwood bottomland. J. Wildl. Manage. 51:230-237.
Sedgwick, J. A., and F. L. Knopf. 1988. A high incidence of brown-headed cowbird parasitism of willow flycatchers. Condor 90:253-256.
Sedgwick, J. A., and F. L. Knopf. 1991. Prescribed grazing as a secondary impact in a western riparian floodplain. J. Range Manage. 44:369-373.
Short, H. L. 1986. Rangelands. Pages 93-122 *in* Inventory and monitoring of wildlife habitat (A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, Eds.). USDI Bureau of Land Mangement, Service Center, Denver, Colorado.
Skinner, R. M. 1975. Grassland use patterns and prairie bird populations of Missouri. Pages 171-180 *in* Prairie: a multiple view (M. K. Wati, Ed.). Univ. North Dakota Press, Grand Forks, North Dakota.
Stebbins, G. L. 1981. Coevolution of grasses and herbivores. Ann. Missouri Bot. Garden 68:75-86.
Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. Range management. McGraw-Hill Book Co., New York, New York.
Symons, T. W. 1967. The Symons report on the Upper Columbia River and the Great Plain of the Columbia. The Galleon Press, Fairfield, Washington.
Szaro, R. C. 1980. Factors influencing bird populations in southwestern riparian forests. Pages 403-418 *in* Management of western forests and grasslands for nongame birds (R. M. DeGraff, Tech. Coord.). USDA Forest Service, Gen. Tech. Rep. INT-86. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Szaro, R. C., and M. D. Jakle. 1985. Avian use of a desert riparian island and its adjacent scrub habitat. Condor 87:511-519.

Szaro, R. C., and J. N. Rinne. 1988. Ecosystem approach to management of southwestern riparian communities. Trans. 53rd N. Amer. Wildl. Nat. Res. Conf.: 502-511.

Taylor, D. M. 1986. Effects of cattle grazing on passerine bird nesting in riparian habitat. J. Range Manage. 39:254-258.

Taylor, D. M., and C. D. Littlefield. 1986. Willow flycatcher and yellow warbler response to cattle grazing. Am. Birds 40:1169-1173.

Terborgh, J. 1989. Where have all the birds gone? Princeton Univ. Press, Princeton, New Jersey.

Tester, J. R., and W. H. Marshall. 1961. A study of certain plant and animal interrelations on a native prairie in northwestern Minnesota. University of Minnesota Museum of Natural History, Occ. Pap. No. 8.

Thilenius, J. F. 1975. Alpine range management in the western United States - principles, practices, and problems: the status of our knowledge. USDA Forest Service, Res. Pap. RM-157. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Thomas, J. W., C. Maser, and J. E. Rodiek. 1979. Wildlife habitats in managed rangelands - the great basin of southeastern Oregon. USDA Forest Service Gen. Tech. Rep. PNW-80. Pacific Northwest Forest and Range Experiment Station, Olympia, Washington.

Tisdale, E. W., and M. Hironaka. 1981. The sagebrush-grass region: a review of the literature. For. Wildl. Range Exper. Sta., Bull. 33. Univ. Idaho, Moscow, Idaho.

Tisdale, E. W., M. Hironaka, and M. A. Fosberg. 1969. The sagebrush region in Idaho: a problem in range resource management. Agric. Exp. Sta., Bull. 512. Univ. Idaho, Moscow, Idaho.

Urness, P. J. 1979. Wildlife habitat manipulation in sagebrush ecosystems. Pages 169-178 *in* The sagebrush ecosystem: a symposium. Utah State University, Logan, Utah.

U.S.D.A. Forest Service. 1993. Ecology, management, and restoration of Intermountain annual rangelands. USDA Forest Service, Gen. Tech. Rep., in press. Intermountain Research Station, Ogden, Utah.

U.S.D.I. Bureau of Land Management. 1991. Public land statistics -1990. U.S. Government Printing Office, Washington, D.C.

U. S. General Accounting Office. 1988. Rangeland management: more emphasis needed on declining and overstocked grazing allotments. U. S. Government Printing Office, Washington, D.C.

Vale, T. R. 1975. Presettlement vegetation in the sagebrush-grass area of the Intermountain West. J. Range Manage. 28:32-36.

Vale, T. R. 1977. Forest changes in the Warner Mountains, California. Ann. Assoc. Amer. Geogr. 67:28-45.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893-901.

Vankat, J. L., and J. Major. 1978. Vegetation changes in Sequoia National Park, California. J. Biogeogr. 5:377-402.

Webb, E. A., and C. E. Bock. 1990. Relationship of the Botteri's sparrow to sacaton grassland in southeastern Arizona. Pages 199-209 *in* Managing wildlife in the Southwest (P. R. Krausman and N. S. Smith, Eds.). Arizona Chapter of the Wildlife Society, Phoenix, Arizona.

West, N. E. 1984. Successional patterns and productivity potentials of pinyon-juniper ecosystems. Pages 1301-1332 *in* Developing strategies for range management (National Academy of Science). Westview Press, Boulder, Colorado.

West, N. E. 1988. Intermountain deserts, shrub steppes, and woodlands. Pages 209-230 *in* North American terrestrial vegetation (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.

West, T. 1990. USDA Forest Service management of the National Grasslands. Agric. Hist. 64:86-98. Wiens, J. A. 1973. Pattern and process in grassland bird communities. Ecol. Monogr. 43:237-270.

Wiens, J. A. 1974. Climatic instability and the "ecological saturation" of bird communities in North American grasslands. Condor 76:385-400.

Wiens, J. A. 1985. Habitat selection in variable environments: shrubsteppe birds. Pages 227-251 *in* Habitat selection in birds (M. L. Cody, Ed.). Academic Press, Inc., New York, New York.

Wiens, J. A., and M. I. Dyer. 1975. Rangeland avifaunas: their composition, energetics, and role in the ecosystem. Pages 146-182 *in* Symposium on management of forest and range habitats for nongame birds (D. R. Smith, Ed.). USDA Forest Service, Gen. Tech. Rep. WO-1. Washington, D.C.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure in shrubsteppe environments. Ecol. Monogr. 51:21-41.

Wiens, J. A., J. T. Rotenberry, and B. Van Horne. 1986. A lesson in the limitations of field experiments: shrubsteppe birds and habitat alteration. Ecology 67:365-376.

Willard, E. E. 1989. Use and impact of domestic livestock in whitebark pine forests. Pages 201-277 *in* Symposium on whitebark pine ecosystems (W. C. Schmidt and K. J. McDonald, Comps.). USDA Forest Service, Gen. Tech. Rep. INT-270. Intermountain Research Station, Ogden, Utah.

Yensen, D. L. 1981. The 1900 invasion of alien plants into southern Idaho. Great Basin Nat. 41:176-183.

Young, J. A., R. E. Eckert,Jr., and R. A. Evans. 1979. Historical perspectives regarding the sagebrush ecosystem. Pages 1-13 *in* The sagebrush ecosystem: a symposium. Utah State University, Logan, Utah.

Effects of Pesticides and Contaminants on Neotropical Migrants

Nicholas W. Gard[1], Michael J. Hooper[1], and Richard S. Bennett[2]

Abstract — Many agricultural pesticides and industrial contaminants are capable of adversely affecting birds through direct effects such as elevated mortality rates and decreased reproductive success or indirectly by modifying habitat composition or food availability. Although neotropical migrants are potentially exposed to these contaminants on their breeding, migratory and wintering habitats, the impact of pollutants on population declines of migrant species is poorly understood. We review the effects of these contaminants on birds, evaluate the ability of current monitoring techniques to detect and assess the magnitude of exposure, and suggest research and management needed to improve our understanding of the contribution of environmental pollutants to population declines of neotropical migratory birds.

INTRODUCTION

Substantial quantities of pesticides and industrial contaminants are released into the environment every year, both intentionally and accidentally. Many of these chemicals become distributed over vast geographical regions either due to widespread usage or movement through environmental compartments. As a result, contamination or modification of many ecosystems occurs, with the subsequent potential for adverse effects on the biota inhabiting those ecosystems. Migratory bird species are potentially be exposed to a wider range of pollutants than non-migratory species, as their annual movements can bring them into contact with pollutants in breeding and wintering regions and on migration routes. However, our understanding of the contribution of pesticides and pollutants to population declines of neotropical migrants is hindered by a lack of knowledge on the extent to which migrants are exposed to these chemicals and the importance of pollutant-induced changes in mortality and reproductive success relative to other anthropomorphic or natural factors which may also affect population size.

[1]*The Institute of Wildlife and Environmental Toxicology, and Department of Environmental Toxicology, Clemson University, P.O. Box 709, Pendleton, South Carolina 29670.*

[2]*United States Environmental Protection Agency, Environmental Research Laboratory, 200 SE 35th Street, Corvallis, Oregon 97333.*

This report briefly summarizes the potential effects of pesticides and pollutants on birds, discusses the issues which monitoring techniques must address to detect and assess the magnitude of these effects, and comments on the potential contribution of contaminants to population declines of neotropical migratory birds.

MODES OF EXPRESSION OF TOXIC EFFECTS

Pesticides and contaminants exert their toxic effects on birds in varying manners depending upon their chemical nature, environmental persistence, mode of action and methods by which they are metabolized in birds. Even within any class of contaminants, toxic effects may be expressed differently depending on the magnitude of exposure, and environmental conditions under which exposure occurs.

Acute toxic effects are exhibited following brief exposures to single or multiple doses of a chemical. Mortality is a typical response to acute doses of many pesticides, although other responses may include behavioral or reproductive alterations. Chronic effects are exhibited after a long period of uptake of small amounts of a toxicant. Chronic effects may be expressed in many forms including reproductive or behavioral changes, immunological impairment, carcinogenesis, and teratogenesis. Chronic effects often do not become apparent until after the source pollutant has disappeared or may be a response to very low concentrations of a pollutant, therefore it may be more difficult to establish cause and effect relationships following chronic exposure than following acute poisonings.

Direct effects are changes induced in a bird following exposure to a xenobiotic, with increased mortality, decreased reproductive success, increased susceptibility to predation or behavioral impairment being among the most common. Indirect effects are responses to pesticide-induced changes in food resources, habitat structure and predator or competitor abundance. Since changes in habitat structure or animal abundance may not occur until a considerable period after the exposure event, the relationship between cause and effect may not be readily apparent.

CONTAMINANTS OF CONCERN

There are five major classes of environmental contaminants which may be most likely to affect neotropical migrants:

1. Organochlorine pesticides and related industrial contaminants

This group encompasses the chlorinated hydrocarbon insecticides (e.g. DDT and analogs, dicofol, dieldrin, aldrin, endrin, hexachlorocyclohexanes, mirex, heptachlor), and related industrial contaminants (polychlorinated biphenyls (PCBs), dioxins and furans) which display similarities in environmental fate and biological effects. These compounds typically have low acute toxicity, and the greatest risk to wildlife is due to their chemical stability which confers prolonged environmental persistence. The nonpolar chemical structure of these chemicals causes them to partition into lipids and bioaccumulate in food chains with resulting biomagnification in wildlife (Risebrough 1986).

2. Organophosphorus and carbamate insecticides

These compounds are widely used in North America for insect pest control in agricultural, rangeland and forestry applications (Szmedra 1991), and use in Latin American countries is apparently increasing (Forget 1991). These compounds exert toxic effects by binding to and inhibiting acetylcholinesterase (AChE) enzyme at synapses in the central and autonomic nervous systems and at nerve endings in striated muscle. AChE regulates normal nerve function by hydrolyzing the neurotransmitter acetylcholine (ACh) at nerve synapses. These compounds generally have low environmental persistence, but their acute toxicity has resulted in numerous avian die-offs which may cause local population perturbations (Grue et al. 1983).

3. Herbicides

Herbicides are generally non-toxic to birds, but can have a severe impact on avian populations since they produce extensive habitat modification (Morrison and Meslow 1983). Habitat alterations may require years to have their greatest effect on bird populations, whereas the direct effects of herbicides on plants may be observed more rapidly. Consequently, secondary and tertiary effects of herbicide use within terrestrial communities may be more difficult to relate back to the original cause, but have long-term consequences for avian species.

4. Acidic Precipitation

Impacts on birds using acid-stressed ecosystems are likely, particularly indirect effects due to changes in habitat structure or prey availability (Blancher 1991). Habitat acidification can also increase the bioavailability of several non-essential, potentially toxic metals, including mercury, aluminum, cadmium, and lead, which can move through food chains to piscivorous and insectivorous birds (Scheuhammer 1991).

5. Metals

Metals have high environmental persistence because natural cycling in the environment is extremely slow. Metals have the ability to bioaccumulate through food chains, especially in aquatic ecosystems. Only about 30 metals are considered toxic, and of these the ones of greatest toxicological concern include mercury, cadmium, aluminum, lead and selenium. Dietary exposure to some metals can lead to reproductive dysfunction or increased susceptibility to disease at levels too low to cause acute effects (Scheuhammer 1987).

ASSESSMENT OF THE EFFECTS OF TOXICANTS ON NEOTROPICAL MIGRANTS

The likelihood that a pollutant will detrimentally affect neotropical migrants is governed by numerous factors including its chemical and physical properties, environmental movement and fate, and ecological and behavioral traits of individual species that alter their probability of coming in contact with the pollutant. To address these factors requires a multi-stage assessment procedure which provides either quantitative or qualitative rankings of ecological risk (US Environmental Protection Agency 1991). Some stages of this procedure will require the expertise of environmental chemists or toxicologists. The crucial role of the field biologist or ornithologist will be to integrate toxicological and environmental contamination data with a thorough knowledge of the ecological and behavioral characteristics of individual species to predict which species are at greatest risk.

The preliminary phase of the procedure involves hazard identification to determine which chemicals are present in the habitat or ecosystem of interest. Identification may be based on environmental sampling, a knowledge of regional pesticide use patterns and industrial emissions or on the basis of information pertaining to known or suspected past pollution events. When chemical identification is complete, the magnitude and frequency of release of those chemicals into the environment and their spatial and temporal distribution patterns need to be quantified. This is a particularly important step, since the risk to avian populations from chemicals with localized distributions or which are present only at times when migrants are absent from the contaminated area is likely to be low. Concentrations of the chemicals or metabolites should be measured, and evaluated to verify whether they are in a bioavailable form, or are sequestered in environmental compartments where they are unavailable to birds.

When the presence of a chemical has been confirmed, biologists can undertake an exposure assessment to decide which species are most liable to come in contact with the pollutant. Previous field studies or toxicity data derived from laboratory experiments may help in evaluating which species are most sensitive to the pollutant, and whether the concentrations present are sufficient to elicit toxic effects. However, in most cases, very little is known about the toxic effects of pesticides and pollutants on migratory passerines. Extrapolating toxicology data from other species may give an indication of the potential toxic responses, but inter-specific variability is often great, and such extrapolations should be undertaken with caution.

Birds are exposed to xenobiotics via ingestion, dermal absorption and inhalation, with ingestion (either through food consumption or preening) being the most important route. The extent of exposure is moderated by the environmental persistence of the chemical and the magnitude and frequency of its release into the ecosystem. A thorough understanding of the behavioral and ecological traits of individual species greatly improves the ability to estimate the extent of exposure. Habitat use of a species will determine whether it is occupies an ecosystem or area where the contaminant is present. For chemicals with low environmental persistence, seasonal and annual movement patterns will determine whether presence of a species in an area coincides with presence of the active compound. Since ingestion is a primary route of exposure, diet and feeding habits will greatly influence which species are most apt to come in contact with the chemical. If sufficient toxicological and ecological information exists, researchers should be able to integrate both sets of data to predict which species are at greatest risk of exposure, and therefore potentially warrant investigation for contaminant-induced population effects. However, since our present understanding of the toxic effects of contaminants on migrants is limited, that predictive capability is likely to be poor in most cases.

When exposure is known or suspected, verification can be obtained from a variety of quantitative measurement endpoints. Selection of the appropriate measurement endpoint is important. For example, tissue residue analyses would be inappropriate for chemicals which do not bioaccumulate or which have low persistence. At the cellular level, use of contaminant-induced biochemical and physiological changes as markers of exposure and environmental quality are becoming increasingly popular. At the organismal level, mortality, reproductive performance, behavioral changes, and carcass contaminant residues are commonly utilized measurement endpoints. An important consideration, however, is that none of these measurement endpoints are necessarily indicators of adverse effect. The ultimate endpoint of concern is whether exposure is responsible for population declines. The value of any measurement endpoint from an ecological viewpoint will ultimately depend on being able to correlate observed changes with population level effects. Predicting population level effects from residue levels or biomarker responses is not a straightforward process, however. In order for measurement endpoints to provide valuable risk assessment data, quantitative models need to be developed which permit extrapolation to population level responses (Emlen 1989).

While an assessment procedure such as that outlined above could prove useful in determining the impact of xenobiotics on neotropical migrants, several problems hinder widespread applicability at present. First, characterization of the extent of environmental contamination is far from complete, both in terms of the types of contaminants present and extent of their distribution. This is particularly valid for Central and South American regions where migrants winter, but also applies in many regions of their North American breeding ranges. Second, there are probably very few instances where polluted areas are subject to only one chemical stress, and when multiple contaminants are present, synergistic or additive effects of compounds can occur. The toxic effects of exposure to several chemicals simultaneously are often difficult to predict from effects elicited by chemicals acting individually. More importantly, chemical stresses typically occur in ecosystems subject to other anthropomorphic, non-chemical stresses such as habitat conversion or fragmentation. The contribution of contaminants to population declines observed in many migrant species relative to these other pressures may be difficult to determine. Finally, as noted previously, many chronic or indirect effects of contaminants may not become obvious until long after the pollution event has occurred, and cause and effect may not be readily apparent.

MONITORING TECHNIQUES

We currently lack sufficient information to satisfactorily evaluate the effects of xenobiotics on population dynamics of neotropical migrants. An appropriate first step to strengthen hazard assessment procedures would be the collection of baseline data on contaminant levels in migrants. Subsequent research should attempt to correlate that data with changes in mortality and fecundity rates or population abundance. Comprehensive monitoring programs are required to provide this baseline data.

Several non-lethal monitoring techniques can provide useful information. Blood samples obtained from birds trapped in mist-net studies or banding programs can be analyzed for organochlorine residues, because levels in blood are indicative of levels in other tissues (Henny and Meeker 1981). Plasma can also be assayed for the presence of certain metals such as lead. Metal residues in feathers have also been used as indicators of contamination (Scheuhammer 1987). Plasma can be easily assayed for cholinesterase activity, which is a sensitive indicator of exposure to organophosphorus and carbamate insecticides (Hooper et al. 1990).

Incident monitoring involving collection of mortalities following pesticide applications or pollution events allows for testing of carcasses for the presence of pesticides or residues. This is a simple, but effective, means of assessing actual poisoning incidents. Various federal and state agencies use incident monitoring schemes which vary widely in effectiveness due to differences in scope, data collection methods and funding (Avian Effects Dialogue Group 1989). This form of monitoring can create useful databases of contaminant-induced bird mortality, but a lack of reports is not indicative of no adverse effects since geographic coverage is not uniform, and sublethal effects are rarely studied. Standardized data collection methods are required in order for incident monitoring programs to reliably document the frequency of mortality incidents and their potential impact on avian populations.

A more comprehensive form of monitoring, targeted monitoring, incorporates design and implementation of planned field studies to evaluate potential acute and subacute effects of contaminants on bird populations under actual exposure conditions.

In order for monitoring programs to provide pertinent data for estimating contaminant effects on migrants, several criteria must be met. Monitoring programs must cover a broad geographic range and incorporate a diversity of ecosystems to successfully demarcate the extent of contamination. Since this range must encompass breeding, wintering and migratory habitats, collaboration between agencies or researchers in various countries will be essential. Programs must also operate on a multi-year basis to document long-term trends in contaminant levels. For pollutants with limited environmental persistence, however, monitoring must be precisely timed in order to detect effects that occur immediately after the chemical is released into the environment. All monitoring programs must also include an ecosystem-based hazard identification component to quantify what contaminants are present, and their concentrations, transport and fate in the ecosystem.

Since monitoring programs can not be created for all neotropical migrants, it will probably be necessary to select several focal species which can serve as indicators of exposure to, and toxicity of, contaminants for other migrants. A suitable focal species must be sufficiently abundant, easily manipulated, and possess ecological and behavioral characteristics similar to those of other migrants. It is also important that focal species display representative sensitivity to contaminants, however that will be difficult to evaluate until more research focuses on the toxic effects of contaminants in migrants. Monitoring of focal species should be conducted year-round, and should evaluate reproductive success, mortality rates, habitat use and behavioral characteristics in addition to assessing contaminant levels.

Finally, evaluations of pesticide effects on birds are typically based on acute effects such as mortality, while often overlooking the more subtle sub-acute effects. Therefore, for all species, population censusing techniques are required which are sensitive to sublethal effects of pesticides, and which incorporate evaluations of reproductive success. Population- level effects of some pesticides may not have been well documented in previous studies due to inappropriate census methods (Mineau and Peakall 1987).

CONCLUSION

Pollutants and pesticides are widely distributed in the environment. Despite our current lack of knowledge on contaminant loads of these chemicals in migrants, it is very likely that birds are being exposed to at least some of these chemicals, and it is reasonable to expect that some adverse effects are occurring. The importance of the role of contaminant exposure to population declines in neotropical migrants relative to other anthropomorphic stresses is difficult to quantify at present. In order to improve our understanding of the effects of environmental pollutants the following research and management needs must be addressed: 1) expansion and standardization of monitoring programs; 2) selection of appropriate neotropical migrants as indicator species; 3) improvement of hazard identification procedures in wintering regions and on breeding habitats; 4) assessment of sublethal impacts of contaminant exposure; and 5) development of quantitative population models which incorporate appropriate ecological and toxicological data to predict the effects of environmental contaminants on population dynamics of neotropical migrants.

LITERATURE CITED

Avian Effects Dialogue Group. 1989. Pesticides and birds: improving impact assessment. The Conservation Foundation, Washington D.C.

Blancher, P. J. 1991. Acidification: Implications for wildlife. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 56:195-204.

Emlen, J. M. 1989. Terrestrial population models for ecological risk assessment: a state-of-the-art review. Environ. Toxicol. Chem. 8:831-842.

Forget, G. 1991. Pesticides and the Third World. J. Toxicol. Environ. Health 32:11-31.

Grue, C. E., W. J. Fleming, D. G. Busby, and E. F. Hill. 1983. Assessing hazards of organophosphate pesticides to wildlife. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:200-220.

Henny, C. J., and D. L. Meeker. 1981. An evaluation of blood plasma for monitoring DDE in birds of prey. Environ. Pollut. Ser. A. 25:291-304.

Hooper, M. J., L. W. Brewer, G. P. Cobb, and R. J. Kendall. 1990. An integrated laboratory and field approach for assessing hazards of pesticide exposure to wildlife. Pp. 271-283 *in* Pesticide effects on terrestrial wildlife (L. Somerville and C. H. Walker, Eds.). Taylor & Francis, London.

Mineau, P., and D. B. Peakall. 1987. An evaluation of avian impact assessment techniques following broad-scale forest insecticide sprays. Environ. Toxicol. Chem. 6:781-791.

Morrison, M. L., and E. C. Meslow. 1983. Impacts of forest herbicides on wildlife: toxicity and habitat alteration. Trans. N. Am. Wildl. Nat. Resour. Conf. 48:175-185.

Risebrough, R. W. 1986. Pesticides and bird populations. Current Ornithol. 3:397-427.

Scheuhammer, A. M. 1987. The chronic toxicity of aluminum, cadmium, mercury, and lead in birds: a review. Environ. Pollut. 46:263-295.

Scheuhammer, A. M. 1991. Effects of acidification on the availability of toxic metals and calcium to wild birds and mammals. Environ. Pollut. 71:329-375.

Szmedra, P. I. 1991. Pesticide use in agriculture. Pp. 649-677 *in* CRC handbook of pest management in agriculture (D. Pimentel, Ed.). CRC Press, Boca Raton, Florida.

U.S. Environmental Protection Agency. 1991. Summary report on issues in ecological risk assessment. EPA/625/3-91/018. Washington, DC: U.S. Environmental Protection Agency.

Effects of Land Use Practices on Neotropical Migratory Birds in Bottomland Hardwood Forests

David N. Pashley[1] and Wylie C. Barrow[2]

DESCRIPTION OF THE SYSTEM

Bottomland hardwood forests (including bald cypress and tupelo swamp forests) are historically the dominant natural community of riverine floodplains of the southeastern United States. Their greatest single expanse was in the 21 million acre floodplain of the lower Mississippi River Valley from southern Illinois to coastal marshes along the Gulf of Mexico, but the community also occurs along rivers of the piedmont and southern coastal plain from Virginia to east Texas (Patrick et al. 1981). The biotic and physical features of this system are determined by hydrology and sedimentation (Bedinger 1981). A key factor in the evolution of bottomland hardwood plants has been their ability to persist under anaerobic conditions when soil becomes saturated with water. As a result, the distribution of species within the community is dependant to a large extent upon the timing, frequency, and duration of flooding (Huffman and Forsythe 1981).

A complex series of levees, meander scrolls, sloughs, and oxbow lakes is characteristic of alluvial plains (Taylor et al. 1990). Bottomland forests typically flood as rising rivers back into tributaries. As overbank flooding occurs and water spreads out and slows down, sediments and nutrients are deposited across the floodplain. The heaviest sediments drop out adjacent to the channel, resulting in natural levees that are higher and drier than land behind them. River meander curves produce point bars on the inside of meanders where water velocity is reduced and sediments drop out. Meanders tend to migrate downstream, and, as they become more exaggerated, stream segments are abandoned for more direct routes, leaving behind oxbow lakes (Bedinger 1981). All of this activity results in a complex topography of parallel ridges and swales in which a six inch difference in elevation can result in great differences in the duration and frequency of soil saturation and thus the species of plants that grow on a site. Another influence on distributions are adaptations to the rich nutrient influx that may be as important as stress from inundation (Gosselink et al. 1981).

There is much variation and overlap among the 100 or so woody plant species inhabiting bottomland forests in their ability to deal with the peculiar stresses and opportunities inherent in this system. Areas that are inundated or saturated most of the time and only intermittently exposed are typically dominated by bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*). Somewhat drier areas that are saturated or inundated typically more than 25% of most growing seasons support such species as overcup oak (*Quercus lyrata*) and water hickory (*Carya aquatica*). Areas saturated or inundated periodically for a month or so, less than 25% of the growing season, in most years, feature a great diversity of tree species, including hackberry (*Celtis laevigata*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), sweetgum (*Liquidambar styraciflua*), Nuttall oak (*Q. nuttallii*), and willow oak (*Q. phellos*). Areas temporarily inundated in a minority of years support species less tolerant of anaerobic conditions such as cherrybark oak (*Q. falcata* var. *pagodaefolia*) and pecan (*Carya illinoensis*).

There are other disturbances that influence plant distribution. As in other southern deciduous forest types, tree fall is common, perhaps exacerbated here by the plastic nature of the saturated soil (Tanner 1986). Winds aggravate this, and occasional tornadoes and other storm events can knock down the overstory on significantly sized areas. Prior to European settlement and increasingly so again now, beaver activity can alter local hydrology and expose plants to more frequent or even continuous flooding. And last, although not well-documented, bottomland forests may have been subject to infrequent fires.

These disturbances cause mortality and influence regeneration, and thus affect species composition. There is not only a wide variety among plants in tolerance to soil saturation but also to shade (McKnight et al. 1981). Light gaps may be necessary for some dominant tree species to become established or achieve canopy height.

Tanner (1986) reported on the tree species and size composition of a virgin bottomland hardwood stand in northeast Louisiana in which he studied Ivory-billed Woodpeckers in the

[1]*The Nature Conservancy of Louisiana, P.O. Box 4125, Baton Rouge, LA 70821*

[2]*U.S. Fish and Wildlife Service, National Wetlands Research Center, 6300 Ocean Dr., Corpus Christi, TX 78412*

late 1930's. He found that the hydric extremes (almost always flooded and almost never flooded) were very distinct, but that continuous change was evident in the distribution of species across intermediate zones. Most interestingly, he found a very large number of small, young trees, including those species that are intolerant of shade, throughout the system. Although old trees were numerous, accidental death and turnover were frequent but spatially variable, resulting in a highly uneven age distribution. This contradicts notions of old growth bottomland hardwoods as a static, unproductive community consisting of a closed canopy of senescent trees. There is an emerging sense that old growth was a shifting mosaic of even-aged small patches of all ages, further complicated by minute differences in elevation and tolerances among a large number of woody plant species.

The bottomland forest then is a result of a combination of: 1) high productivity resulting from a long growing season and abundant water and nutrients; 2) topographic diversity which, although superficially minor, interacts with varying anaerobic tolerances of plants to produce a broad continuum of community types; and 3) a disturbance regime with a reoccurrence frequency sufficient to maintain a dynamic mosaic of recovering gaps of many ages across the landscape. As in other southern deciduous forests, much of the plant species diversity of bottomland hardwoods is a result of the woody, smaller-statured species of the understory.

NEOTROPICAL MIGRATORY BIRD USE OF BOTTOMLAND HARDWOOD FORESTS

Approximately 70 species of birds breed regularly in bottomland hardwood forests; about 30 of these are Neotropical migrants. At specific sites, from 48% to 65% of species recorded are Neotropical migrants. A study conducted in the Tensas River basin of northeast Louisiana revealed differences in use among bald cypress habitat, seasonally flooded forest, and non-flooded forest (Barrow 1990). The long-distance migrants encountered more frequently in bald cypress habitat than elsewhere were the Yellow-throated Warbler and Northern Parula. Five species, the Eastern Wood-Pewee, Great Crested Flycatcher, Yellow-throated Vireo, Prothonotary Warbler, and Blue-gray Gnatcatcher, were most common in the seasonally flooded zones. Areas that do not typically flood were used preferentially by the Red-eyed Vireo, American Redstart, Swainson's Warbler, and Hooded Warbler.

Differences in habitat use by other migrants are not readily apparent. Indeed, in a variety of forests, limited data suggest there may be little difference between tree species availability and bird use. In other words, the tree species composition of those zones may not be particularly important to many species of foraging birds.

Differences are apparent in comparison between use of early and later post-disturbance habitats. Several species are found most frequently in areas that have been disturbed and are recovering, along edges, or in shrub-maintained habitat. These include the Orchard Oriole, Yellow-breasted Chat, Indigo Bunting, and, at least in many areas, Wood Thrush.

A variety of habitat features in bottomland hardwood landscapes are absent or not well expressed in other forest ecosystems. The following microhabitat features are of apparent importance in influencing the distribution and abundance of Neotropical migrants:

Spanish moss (*Tillandsia usneoides*) - There is an apparent correlation between Spanish moss and Northern Parula distribution and abundance (Bent 1953, Barrow 1990). This epiphyte serves as nest support and concealment for breeding Northern Parulas and, to a lesser extent, Yellow-throated Warblers. The latter also frequently probe clumps of Spanish moss in search of arthropod prey. Spanish moss becomes rare to the north and does not occur in the northern Mississippi Valley.

Scour channels - Floodplain terraces are marked by parallel series of shallow depressions, results of changing stream course and regular flooding, that hold water through much of the year. Prothonotary Warblers forage in a variety of forest types, but tend to concentrate their nesting efforts in and along the margins of these channels. Several species of wading birds also forage regularly in these areas.

Canebrakes - Dense thickets of switchcane (*Arundinaria gigantea*) occur on oxbow lake margins, river banks, and floodplain terraces. Meanley (1971) and Eddleman et al. (1980) have noted that Swainson's Warblers are especially common in cane thickets. Remsen (1986) has hypothesized that Bachman's Warbler (now probably extinct) was a cane specialist on its breeding grounds in the southern United States. White-eyed Vireos, Hooded Warblers, and Kentucky Warblers also use canebrakes during the breeding season.

Bald cypress - Bald cypress is typically found along the margins of rivers, sloughs, and oxbow lakes, often forming monospecific stands referred to as "cypress brakes." The exfoliating bark and branch structure provides excellent support for Spanish moss that is related to Northern Parula occurrence. In the Tensas River Basin, Yellow-throated Warblers were observed breeding only in habitats in which bald cypress was present. Over half of all Yellow-throated Warbler foraging observations were in bald cypress (Barrow 1990).

Vine tangles - Vine tangles are common along the margins of oxbow lakes and in light gaps created by tree falls. Furthermore, two species, *Parthenocissus quinquefolia* and *Rhus radicans*, grow abundantly on trees in a mature, closed canopy. Because vines climb by aerial rootlets and tendrils which adhere to the bark for support, they provide a carpet of foliage ranging from the ground to the canopy along the boles of trees. The result is greater foliage volume, which provides additional nest placement and foraging opportunities. White-eyed Vireo, American Redstart, Kentucky Warbler, and Hooded Warbler frequently use vine foliage as a foraging substrate during the breeding season (Barrow 1990, Moser et al. 1990).

Palmetto thickets - Palmetto (*Sabal minor*) often forms dense thickets in the understory of floodplain forests. Meanley (1971) considered "scrub palmetto" habitat to be one of three main plant formations selected by Swainson's Warblers in southern floodplains. Barrow (1990) found that Swainson's Warblers foraged in the ground leaf litter at sites with greater palmetto density than that which was randomly available. Like Spanish moss, palmetto does not occur in the northern stretches of the Mississippi Valley.

HISTORICAL CHANGES IN LAND USE

The majority of wetland acreage in the continental United States at the time of European colonization was bottomland hardwood forest (Turner et al. 1981). It has been estimated that there were approximately 130 million acres of forested wetlands in the lower 48 states at that time, with about 57% of this, largely bottomland hardwoods, in the Southeast (Harris and Gosselink 1990). Reduction in the acreage covered by this habitat and alterations in the character of the forest that remains has been accompanied by a reduction in population sizes of the birds present in the system.

Perhaps the earliest alteration in this system was caused by heavy trapping and local extirpation of beaver from the seventeenth century onward. Other early changes in flooding regimes occurred as streams were cleared of snags and obstructions to improve navigation. Levees were built to control flooding; by 1828 levees along the Mississippi in south Louisiana were essentially continuous (McPhee 1989). Reduced flooding made agricultural endeavors more feasible, and more land was cleared, drained and farmed. Federal government programs encouraged this conversion (Turner et al. 1981). Timber in the last extensive virgin stands was harvested in the 1940's. High soybean prices drove more clearing, often producing marginal agricultural land, in the 1960's and 1970's. Changes in economic conditions and government programs have greatly reduced the rate of clearing and conversion since about 1980. Most recently there have been some small-scale efforts at reforestation.

The loss of bottomland hardwoods is perhaps five times higher than for any other major hardwood forest type in the United States (Abernethy and Turner 1987). Estimating the current area of remaining forest is difficult; the best available figure for the Mississippi River Valley is 4.9 million acres (Creasman et al. 1992). Sheer acreage is not the only measure of loss. Because of changes in flooding and disturbance and varying histories of management, tree species composition and age distribution as well as the status of cavity trees, etc., are probably very different from pre-settlement conditions. Perhaps more critically, much of what is left consists of fragments embedded in a sea of agriculture. This potentially increases nest predation and parasitism. These changes over the course of several centuries surely had as a consequence an equivalent reduction in total forest bird population size. Loss of habitat in general, as well as changes in the character of that forested habitat that remained, brought about the demise of the Ivory-billed Woodpecker, Bachman's Warbler, and mammals including the red wolf and Florida panther.

Although the gross reduction in populations resulting from habitat changes must be assumed, the question remains as to whether populations are continuing to decline in the fragmented and altered habitat that remains. In an analysis of Breeding Bird Survey (BBS) data for the 25-year period from 1966 to 1990, Wiedenfeld et al. (unpubl. ms.) found that the Mississippi Alluvial Plain was one of five physiographic areas in the continental coverage of BBS in which extremely notable declines occurred. Of the 65 bird species they examined, 77% of those breeding in this area had declined. Declining species include interior forest birds such as Prothonotary Warbler, and also second growth or edge species such as the Orchard Oriole and Yellow-breasted Chat. Because much of this occurred during a period when the availability of forested habitat remained fairly stable, it must be inferred that factors other than sheer loss of bottomland hardwood habitat were contributing to these declines. A simple explanation based upon deterioration of winter grounds is unlikely in that the declining species use different habitats in different regions. As many populations of these birds are stable in other physiographic areas, it must be inferred that declining quality as well as quantity of bottomland hardwood breeding habitat has been a contributing factor. Whether fragmentation, an altered hydrological regime, or a plant species composition that may reflect historical silvicultural treatments more than natural conditions are causing migratory bird population declines is unknown.

MANAGEMENT RECOMMENDATIONS

There are two levels of management recommendations. The first is at a local level, in which the manager of a stand of forest or other habitat is in a position to decide what measures to take to most benefit migratory bottomland hardwood birds. The second is at the landscape or ecosystem level, at which decisions need to be made regarding the Mississippi River Alluvial Plain and other bottomland hardwood systems throughout the Southeast.

On the local level, the optimal condition is a very large forested tract on which a natural disturbance regime maintains a shifting mosaic of relatively even-aged patches the size of treefall gaps and of a great variety of ages. A hands-off, passive management strategy should be adopted where possible, such as on public lands, or on private, non-industrial forest sites on which the owner chooses to manage for natural values. Naturally occurring disturbances will inevitably create habitat for early successional species. Recent experience in south Louisiana with Hurricane Andrew is dramatic evidence that managers need not create gaps. Land that is ultimately intended for a natural area management scheme is often acquired in a degraded condition in which passive management is unlikely to achieve a desired level of ecosystem function in any reasonable time frame. In these cases, initial silvicultural or other efforts by managers to correct past abuses may be necessary.

One rationale for intentional creation of openings is to allow for oak regeneration, as oaks are important food sources for a number of species of wildlife and are desirable for quality timber production. However, Abrams (1992) argued, without specific attention to bottomland hardwood forests, that oak dominance in much of the eastern United States has been an artifact of anthropogenic management rather than a typical late successional condition. Fire, in particular, promoted the dominance and stability of oak by reducing shade and stimulating oak regeneration at the expense of more shade tolerant species. In bottomland hardwoods, flooding and perhaps occasional ground fires may have been sufficient to remove litter and allow oak seedling survival; subsequent treefall gaps could have stimulated growth. In any case, there is much that is not known concerning the "natural" abundance of oaks in bottomland hardwoods or the dynamics that promoted oak regeneration. Creation of openings to promote oak growth will initially provide habitat for some early gap bird species, but the ultimate result should not be construed as being particularly necessary for or beneficial to forest-dwelling Neotropical migratory birds. Indeed, if openings provide habitat for nest parasites or predators, and the extent of this is not known, they can potentially be extremely damaging.

Recommendations for public land managers may not be appropriate for private lands on which timber production is the highest priority. The three broad categories of silvicultural practices that managers of these lands have to choose among are large clearcuts (or other practices such as shelterwood or seedtree cuts in which large areas are essentially cleared), group selection or small clearcuts, and individual selection. Because of species-specific habitat preferences, no single choice will have a similar effect on all Neotropical migrants, and each practice will provide benefits for at least some species. Regardless of the harvest practice chosen, caution should be exerted to ensure the health of what remains. Whereas sensitive practices can leave a relatively intact ground cover from which prompt regeneration can be expected, heavy disturbance of soils will stimulate the establishment of weedy species, slow regeneration, and create unfavorable conditions for most birds.

Clearcuts will provide habitat for some declining species such as Orchard Oriole and Yellow-breasted Chat. However, a site in an even-aged, short rotation clearcut cycle will not provide suitable habitat for many forest-dwelling bird species. However, if it is necessary to extract a given volume of timber from a stand, it is quite possible that a single clear cut is preferable to multiple small clearings. The single cut will create a much shorter linear distance of edge, and if an edge effect reduces bird reproductive success well into the interior of remnant forest, could have a less negative impact of the remaining forest bird populations. Any negative effects of clearcuts can be mitigated to some extent by a lengthening of the rotation period.

Group selections, in which areas from about 1/4 to one acre are cleared, mimic in some ways a natural disturbance regime. This is the practice followed by the Anderson-Tully Company, the largest private landowner in the lower Mississippi River Valley. Preliminary studies have shown good densities of the full range of forest migrants on at least some of these lands. Larger group selection cuts may have all the negative features of clear cuts with the added impacts of greater edge and more roads.

Individual tree selection more closely mimics treefall disturbances. In one type of individual selection, trees are harvested in the same size and species ratios as those existing in a natural forest; this can potentially result in high quality conditions for birds. From a silvicultural perspective, removal of individual trees may be untenable if it does not create a sufficient light gap to allow regeneration of desired timber species. A diameter cut is a different method in which all merchantable trees above a certain size are removed, leaving a forest in which smaller individuals are allowed to move into larger diameter size classes in subsequent years. Although this may not initially be detrimental to most bird species, it must be cautioned that diameter cuts change the tree species composition of a forest, eventually leaving little but commercially undesirable individuals and a lack of a seed source for desired species. Thus, this practice, often referred to as "high grading", may ultimately be harmful to migratory birds.

At least six species respond positively to selective cutting operations that mimic treefalls. The Carolina Wren (a permanent resident), White-eyed Vireo, American Redstart, Swainson's Warbler, Kentucky Warbler, and Hooded Warbler all prefer microhabitats with foliage density profiles typical of 10-25 year old treefall gaps (Barrow 1990, Barrow and Hamilton, in prep.). Canopy gaps allow increased light intensity to reach the forest floor, promoting growth of denser foliage beneath the canopy than in the forest as a whole. Larger openings also promote dense vegetation, but none of the five above migrants tended to use areas that lacked a relatively closed canopy. Larger group selection cuts would fail to provide benefit to these species; the size of the largest group selection cut that would not be harmful is not known.

The effects of creating gaps or edges on nest parasitism and predation and forest-dwelling bird success are virtually unknown in bottomland hardwood forests. One thing that is clear, however, is that if a manager clears, for example, 10% of a forest of whatever size or configuration, at least 10% of the habitat for and populations of forest-dwelling birds will be gone. Whether more than 10% of the forest-dwelling bird population will be lost is dependant upon the placement of the clearing and the effects of it and its edges. There are some mitigating factors, in that habitat will be created for open area, edge, and shrub species. The desirability of this change depends upon the relative status of forest and shrub birds in the landscape under consideration. Given that forested habitat in Southeastern bottomland hardwood systems has been so greatly reduced, further clearing of forest should be considered, in general, detrimental to Neotropical migratory birds.

There are few conclusive data as to the relationship between management practices and breeding success of Neotropical migratory birds, the ultimate measure of suitability. Regardless of which management practice is chosen, there should be consideration given to protection of special habitat features of value for birds:

- Removal of all old and large trees, particularly bald cypress, will have a negative impact on Eastern Wood- Pewees, Yellow-throated Warblers, and Yellow-throated Vireos (Barrow 1990, Moser et al. 1990).
- Removal of dead snags will reduce populations of species that forage or nest in them, including migrants such as Eastern Wood-Pewee and Prothonotary Warbler as well as permanent resident woodpecker and other species.
- Loss of Spanish moss can be deleterious to the Northern Parula and Yellow-throated Warbler.
- Canebrakes are increasingly rare and sizeable remaining patches are worthy of consideration for protection.

Managers can have a quite different problem from how to manage existing forest habitat in cases where the land in question has been in agricultural production. In these cases, reforestation is recommended. Many of the considerations in how to reforest revolve around soils and hydrology and the nature of the plant community appropriate for a site. Choosing proper species for regeneration is critical to success. Off-site seed acquisition is often required. Where natural regeneration is part of reforestation efforts, the source of seed fall must be taken into account, with the understanding that heavier seeded species are less likely to uniformly establish themselves than are light seeded species. Soil microorganisms perhaps necessary for success of some vascular plants may have been eradicated under agricultural treatment. Consultation with experts, such as those at the USDA Southern Forest Experiment Station in Stoneville, MS, and the Louisiana Department of Wildlife and Fisheries, should include consideration of these and other topics in reforestation planning. In general, reforestation will do the most good adjacent to existing forested tracts by increasing patch size and reducing the effects of fragmentation. Reforestation along streams will increase connectivity and improve water quality, but the benefits to Neotropical migrants as nesting habitat and migratory corridors may be outweighed by the extreme edge conditions created.

Reforestation is a local activity that is important in management decisions at watershed, physiographic area, regional, ecosystem, or landscape scales. All management decisions of consequence should be made at these larger scales, with perhaps the physiographic area considered a management unit (Sharitz et al. 1992). Decisions made at an individual refuge or other small component of an ecosystem may or may not be wise from the perspective of a larger, more relevant geographic scale. Maximizing species diversity of a refuge, for example, often has the unintended effect of reducing regional species diversity by encouraging widespread habitat generalists at the expense of narrowly distributed specialized species.

There needs to be collaboration at the ecosystem level among researchers and managers. There is a great deal concerning the natural history of these birds, their response to various management practices, and the natural dynamics of bottomland hardwood forests that needs further investigation. Identification of practical information needs and networking among researchers can be one of the many benefits of the Partners in Flight process.

Ultimately, the goal is to reverse population declines among Neotropical migrants in the bottomland hardwood system of the Southeast. It can be said with some assurance that creation of more forested habitat and reduction of fragmentation will help to bring this about. Since habitat availability appears to have stabilized and declines appear to continue, however, the solution of some lingering mysteries will be necessary to achieve lasting success.

ACKNOWLEDGMENTS

Many individuals have contributed to our limited but growing knowledge of the relationship between migratory forest-dwelling birds and bottomland hardwood habitat. For contributions to and comments on this manuscript we particularly thank Lisa Creasman, Robert Hamilton, William C. Hunter, Lance Peacock, Bill Platt, J.V. Remsen, Jr., Peter Stangel, Mike Staten, and Mark Swan.

LITERATURE CITED

Abernethy, Y. and R. Turner. 1987. U.S. forested wetlands: status and changes 1940-1980. Bioscience 37:721-927.

Abrams, M.D. 1992. Fire and the development of oak forests. Bioscience 42:346-353.

Barrow, W.C. 1990. Ecology of small insectivorous birds in a bottomland hardwood forest. Unpubl. Ph.D. Diss., Louisiana State Univ., Baton Rouge.

Bedinger, M.S. 1981. Hydrology of bottomland forests of the Mississippi Embayment. Pages 161-176 *in* J.R. Clark and J. Benforado eds. Wetlands of bottomland hardwood forests. Elsevier Science Publishing Co., Amsterdam.

Bent, A. C. 1953. Life histories of North American wood warblers. Bull. U.S. Nat. Mus. 203:1-734.

Creasman, L., N.J. Craig, and M. Swan. 1992. The forested wetlands of the Mississippi River: An ecosystem in crisis. The Nature Conservancy of Louisiana, Baton Rouge. 24 p.

Eddleman, W. R., K.E. Evans, and W. H. Eldes. 1980. Habitat characteristics and management of Swainson's Warbler in southern Illinois. Wildl. Soc. Bull. 8:228-233.

Gosselink, J.G., S.E. Bayley, W.H. Conner, and R.E. Turner. 1981. Ecological factors in the determination of riparian wetland boundaries. Pages 197-219 *in* J.R. Clark and J. Benforado, eds. Wetlands of bottomland hardwood forests. Elsevier Science Publishing Co., Amsterdam.

Harris, L.D. and J.G. Gosselink. 1990. Cumulative impacts of bottomland hardwood forest conversion on hydrology, water quality, and terrestrial wildlife. Pages 259-322 *in* J.G. Gosselink, L.C. Lee, and T.A. Muir, eds., Ecological processes and cumulative impacts: Illustrated by bottomland hardwood wetland ecosystems. Lewis Publ., Inc., Chelsea, MI.

Huffman, R.T., and S. W. Forsythe. 1981. Bottomland hardwood forest communities and their relation to anaerobic soil conditions. Pages 187-196 *in* J. R. Clark and J. Benforado, eds. Wetlands of bottomland hardwood forests. Elsevier Science Publishing Co., Amsterdam.

McKnight, J.S., D.D. Hook, O.G. Langron, and R.L. Johnson. 1981. Flood tolerance and related characteristics of trees of the bottomland forests of the southern United States. Pages 29-69 *in* J.R. Clark and J. Benforado, eds. Wetlands of bottomland hardwood forests. Elsevier Science Publishing Co., Amsterdam.

McPhee, J. 1989. The control of nature. Farrar Straus Giroux, New York. 272 p.

Meanley, B. 1971. Natural History of Swainson's Warbler. U. S. Dept. of Interior, Bur. of Sport Fish and Wildl., N. A. Fauna No. 69, Washington, D. C. 90 p.

Moser, E.B., W.C. Barrow, and R.B. Hamilton. 1990. An exploratory use of correspondence analysis to study relationships between avian foraging behavior and habitat. P. 309-317 *in* M.S. Morrison, C.J. Ralph, J. Verner, and J.R. Jehl, Jr., eds. Avian foraging theory, methodology, and applications. Studies in Avian Biology No. 13, Cooper Ornith. Soc., Allen Press, Lawrence KS.

Patrick, W.H. Jr., G. Dissmeyer, D.D. Hook, V.W. Lambou, H.M. Leitman, and C.H. Wharton. 1981. Characteristics of wetland ecosystems of southeastern bottomland hardwood forests. Pages 276-300 *in* J.R. Clark and J. Benforado, eds. Wetlands of bottomland hardwood forests. Elsevier Science Publishing Co., Amsterdam.

Remsen, J.V., Jr. 1986. Was Bachman's Warbler a bamboo specialist? Auk 103:216-219.

Sharitz, R.R., L.R. Boring, D.H. Van Lear, and J.E. Pinder, III. 1992. Integrating ecological concepts with natural resource management of southern forests. Ecol. Appl. 2:226-237.

Tanner, J.T. 1986. Distribution of tree species in Louisiana bottomland forests. Castanea 51:168-174.

Taylor, J.R., M.A. Cardamone, and W.J. Mitsch. 1990. Bottomland hardwood forests: their functions and values. Pages 13-86 *in* J.G. Gosselink, L.C. Lee, and T.A. Muir, eds. Ecological processes and cumulative impacts; illustrated by bottomland hardwood wetland ecosystems. Lewis Publishers, Inc., Chelsea, MI.

Turner, R.E., S.W. Forsythe, and N.J. Craig. 1981. Bottomland hardwood forest land resources of the southeastern United States. Pages 13-38 *in* J.R. Clark and J. Benforado, eds. Wetlands of bottomland hardwood forests. Elsevier Science Publishing Co., Amsterdam.

Wiedenfeld, D.A., L.R. Messick, and F.C. James. unpubl. ms. Population trends in 65 species of North American birds: 1966-1990.

Effects of Land Use Practices on Western Riparian Ecosystems

David J. Krueper[1]

Abstract — Riparian ecosystems are among the rarest and most sensitive habitat types in the western United States. Riparian habitat is critical for up to 80% of terrestrial vertebrate species, and is especially important in the arid West. Estimates have placed riparian habitat loss at greater than 95% in most western states. Impacts to riparian ecosystems are reviewed along with mitigation and conservation recommendations for resource managers.

INTRODUCTION

Riparian refers to the vegetation, habitats and ecosystems associated with bodies of water (streams, springs or lakes) or dependent on the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage (Arizona Riparian Council 1988). This habitat is exceptionally important in the western United States due to presence of water and lush vegetation typically surrounded by harsher, drier, less productive environments (Chaney et al 1990). Western riparian systems differ significantly from eastern riparian systems primarily due to availability of water and resultant vegetative competition (Johnson and Lowe 1985). Whereas many eastern hardwood forests average between 35 and 50 inches of precipitation annually, most western systems receive 20 inches or less annually but pan evaporation rates can exceed 100 inches (Johnson and Lowe 1985). Johnson and Lowe (1985) state that eastern forest vegetation primarily competes for space and light whereas in the West competition is predominately for underground water. Riparian areas slow flood flows, filter out sediments, reduce erosion, buffer soil chemistry, enhance biodiversity, protect hydrologic systems from temperature extremes and evaporative loss, and slowly release retained water which extends quality and quantity of water for a variety of consumptive and non-consumptive uses (Carothers 1977, Hubbard 1977, Sands and Howe 1977, Chaney et al. 1990).

DISCUSSION

It is estimated that wetlands and riparian areas comprise less than 1% of the total land area in the western U. S., yet they support a tremendous number and diversity of aquatic and terrestrial wildlife (Chaney et al 1990). In portions of southeastern Oregon and southeastern Wyoming, more than 75% of terrestrial wildlife species are dependent upon riparian areas for at least a portion of their life cycle (Chaney et al 1990). In Arizona and New Mexico, at least 80% of all animals use riparian areas at some stage of their lives, with more than half of these species considered to be riparian obligates (Chaney et al. 1990). Studies in the southwest United States show that riparian areas support a higher breeding diversity of birds than all other western habitats combined (Anderson and Ohmart 1977, Johnson et al. 1977, Johnson and Haight 1985). Western riparian habitat also harbor the highest non-colonial avian breeding densities in North America (Johnson et al. 1977).

Over 60% of the species which ***Partners In Flight*** have identified as neotropical migratory birds use riparian areas in the West as stopover areas during migration or for breeding habitat (Bent 1919-1968, Ehrlich et al. 1988, Appendix 1). Riparian zones have been shown to be extremely important for migratory species by providing cover, food, and water in many areas of the West which are surrounded by habitats deficient in these critical elements (Wauer 1977). Stevens et al. (1977) reported that western riparian areas contained up to 10 times the number of migrants per hectare than adjacent non-riparian habitats. They also found at least twice as many breeding individuals and species occurring in riparian zones relative to non-riparian zones. Gori (1992) attributes this disparity to three factors: the presence of water attracts large numbers of predators and prey alike; plant growth and vegetative biomass are very high which leads to multi-storied vegetation and greater food production; and vegetation is deciduous in these habitats, so plants do not invest in chemical compounds to protect leaves from insect herbivores as do coniferous trees, thereby allowing abundant insect prey for avian consumption.

[1] *Bureau of Land Management, San Pedro NCA, RR#1 Box 9853, Huachuca City, AZ 85616.*

Due to the value and productivity of western riparian areas, human activities have been concentrated in these habitats. As a result, riparian areas are among the most modified habitat types in the West. Habitat alterations include river flow management and diversions (dams, reservoirs, canals, rip-rapping, channelization and dredging), agricultural clearing, firewood collecting, sand and gravel extraction, urbanization and development, recreation, grazing, groundwater pumping, pollution and effluent discharge, fire, flooding, erosion and soil deposition, and exotic plant invasion. The most threatened forest habitat of the 106 identified types in North America is western cottonwood/willow riparian (D. Campbell 1988 pers. comm.). Once extensive stands of riparian habitat throughout the West now exist only as cleared agricultural fields, dry riverine habitat, and urban development. California has lost approximately 98.5% of its historic riparian habitat (Dillinger 1989). Arizona has lost 90% of its historic gallery cottonwood/willow forests (Lofgren et al. 1990). For example, the Colorado River from Fort Mohave to Fort Yuma had 400,000 to 450,000 acres of riparian habitat at the turn of the century, but as of 1986, only 768 acres of pure cottonwood/willow riparian habitat remained (Ohmart et al. 1977, Ohmart et al. 1988). Fremont cottonwood habitat for the entire state of Arizona totals 6,000-8,000 acres (Barger and Ffolliott 1971). In many western states figures may not be as dramatic, but the trend is similar.

Impacts of riparian habitat loss on riparian obligates, many of which are neotropical migratory birds, have been severe. The western race of the yellow-billed cuckoo (*Coccyzus americanus occidentalis*) was once common in all riparian systems throughout the West (Grinnell and Miller 1986, Bent 1940). It's population is now estimated at 475-675 pairs primarily due to habitat loss or modification (Laymon and Halterman 1987). The southwest willow flycatcher (*Empidonax traillii extimus*), Least Bell's vireo (*Vireo bellii pusillus*) and yellow warbler (*Dendroica petechia*) have experienced precipitous population and range declines in western states (Franzreb 1987, Harris et al. 1987, Hunter et al. 1987, Laymon and Halterman 1989, Sanders and Flett 1989).

Johnson et al (1977) reported that of 166 species of nesting birds in the arid southwest, 127 (77%) were dependent on water associated habitats and 51% were completely dependent upon riparian habitat. They predict that if water dependent habitats were completely destroyed in the southwest, 47% of the lowland nesting birds would be extirpated. With continued riparian habitat loss, avian numbers will continue to decline. Once a species population deteriorates to the point where it becomes federally listed as threatened or endangered, a great deal of effort and money are required for protection and recovery. In 1989, the cost for attempted recovery of five avian species averaged more than $700,000 each (McClure et al. 1991). Preventing population declines of avian species will save significant funds which can better be used for funding recovery programs for other seriously threatened species or for implementing habitat conservation or improvement efforts.

The U.S.D.A. Forest Service (U.S.F.S), the U.S.D.I. Bureau of Land Management (B.L.M.), and various private sector companies administer lands in a multiple use manner which attempts to balance many different consumptive and non-consumptive activities (Fox 1977, Buckhouse 1985, Sweep et al. 1985, Vanderheyden 1985). This philosophy often affects one resource at the expense of another. Productive habitats which are especially rich in resources challenge the manager to balance competing demands from various special interest groups and the public at large (Hubbard 1977, Zube and Simcox 1987). In years past, riparian habitat protection and management were inadequate to maintain viable or productive systems in many western areas. Recently, riparian ecosystem awareness has increased in both public, private and scientific sectors. For public and private land managers to mitigate riparian loss and to reverse the trend of riparian habitat alteration and destruction, progressive management measures must be initiated.

Following are examples of current management practices with recommendations and citations providing information needed to administer western riparian habitats.

Grazing

One of the most significant adverse impacts within western riparian systems has been perpetuation of improper grazing practices (Hastings and Turner 1965, Ames 1977, Davis 1977, Glinski 1977, Marlow and Pogacnik 1985). Chaney et al (1990) noted that initial deterioration of western riparian systems began with severe overgrazing in the late nineteenth century. Native perennial grasses were replaced with annual or non-native grass species, salt cedar, juniper, mesquite, rabbitbrush, and other shallow-rooted vegetation less adapted for soil stabilization. Wind and water erosion stripped productive topsoil and began down-cutting and entrenchment of riparian systems. This resulted in lowered water tables and caused perennial watercourses to become ephemeral or dry. Chaney et al. (1990) estimate that resultant desertification reduced arable land of the West by 225 million acres (90 million hectares). Although management has greatly improved riparian habitat in some areas, field data compiled in the last decade showed that riparian areas throughout much of the West were in the worst condition in history due mainly to complications initiated by improper grazing management techniques (Chaney et al. 1990).

Proper management of riparian habitat requires that managers understand dynamics of grazing strategies and hydrologic processes of the affected watershed before attempting riparian restoration (Elmore 1989). It has been demonstrated that riparian habitat can be restored and protected if grazing interests and land managers join together and determine appropriate grazing systems. One method involves a strictly seasonal grazing system, where livestock may utilize the riparian zone during the non-growing season (Bryant, L. 1985, Krueger and Anderson 1985, Spear 1985). Cattle may utilize riparian areas after grasses have dispersed annual seed stock. Grazing within the riparian zone may be used to remove dense annual growth which may endanger the ecosystem due to high fuel loads during fire season. Complete exclusion of cattle from the riparian zone by fencing and establishing waters in neighboring habitat is another option and may be necessary to rehabilitate severely over-utilized habitat (Smith 1989, Swanson 1989, Szaro 1989). Neotropical migratory birds can benefit by excluding cattle from riparian areas, as evidenced within the San Pedro Riparian National Conservation Area in Arizona. Within 4 years after cattle removal, understory vegetation increased significantly (Figure 1). Avian understory obligates such as common yellowthroat (*Geothlypis trichas*), song sparrow (*Melospiza melodia*), and yellow-breasted chat (*Icteria virens*) responded with significant population increases (Table 1).

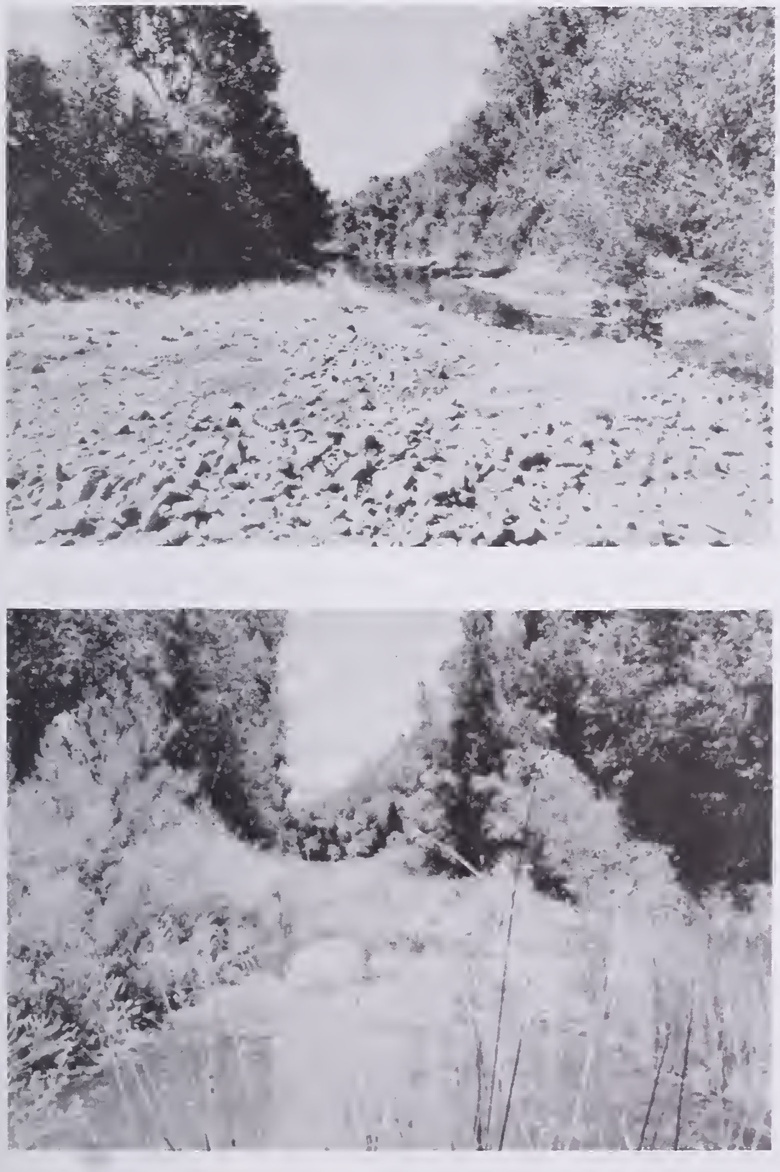


Figure 1. — Riparian vegetation within the San Pedro Riparian National Conservation area before (June 1987) and four years after (June 1991) livestock exclusion. Note changes in understory vegetation and total ground cover.

Table 1. — Neotropical migratory bird population response to retirement of grazing in riparian habitat, (beginning 1987), San Pedro Riparian National Conservation Area, AZ. Densities are number of individuals per 40 ha (100 acres) of habitat.

	YEAR					
Species	86	87	88	89	90	91
Yellow-billed cuckoo (*Coccyzus americanus*)	6	10	8	8	13	*
Western wood-pewee (*Contopus sordidus*)	8	16	22	38	28	29
Brown-crested flycatcher (*Myiarchus tyrannulus*)	21	33	27	36	26	26
Bell's vireo (*Vireo bellii*)	7	11	7	12	15	16
Yellow warbler (*Dendroica petechia*)	29	84	99	227	131	176
Common yellowthroat (*Geothlypis trichas*)	7	24	39	115	110	149
Yellow-breasted chat (*Icteria virens*)	26	44	47	95	100	110
Summer tanager (*Piranga rubra*)	44	84	73	167	94	108
Song sparrow (*Melospiza melodia*)	0	11	14	38	36	61
Northern oriole (*Icterus galbula*)	28	35	28	34	21	32

* Represents data not available

Timber Harvest

Western forest management practices have long been at the forefront of news due to past harvest rates and perceived impacts on habitats which many avian and anadramous salmonid species depend. However, federal land managers have progressed tremendously during recent years in timber harvest and riparian protection practices (Ice et al. 1989). Resource Management Plans for western Oregon B.L.M. administered public lands are presently being formulated to apply the concept of biological diversity to the management of the landscape (E. Campbell, pers. comm. 1992). Both the U.S.F.S. and the B.L.M. have initiated innovative protective measures to insure that adequate habitat remains undisturbed around riparian areas. Mandatory buffer zones became common practice in the 1970's to provide stream channel protection. Activities within zones are allowed, but are modified based on soil type, slope of surrounding terrain, vegetation present, and other variables. Maintenance of quality of streambed, streambank stability, stream temperature, water quality, wildlife habitat, and surrounding vegetation are of utmost concern (Anderson 1985, Steinblums and Leven 1985).

Another example of riparian management involves removal of slash from riparian zones and streambeds after harvest. Although large woody debris is an important component of riparian ecosystems, especially for rearing areas for juvenile salmonids (Bryant, M. 1985, O'Connor and Ziemer 1989), accumulated smaller slash in streams will block migratory fish passage. Judicious removal of slash accumulations and use of buffers strips greatly increases riparian protection. Each cutting unit may vary in the degree of protection, but timber harvest and land management plans are required for all timber sales and must involve an interdisciplinary team for their design and review.

Exotic Plant Invasion and Revegetation

Western riparian ecosystems have been adversely impacted by exotic plant invasions. One particularly prolific exotic, salt cedar (*Tamarisk chinensis*), has become established in almost all southwestern riparian systems, choking out or out-competing native vegetation and preventing natural vegetative succession (Horton 1977, Ohmart et al. 1977). Salt cedar root-sprouts faster than native vegetation after a fire, forms dense mats of fallen deciduous needles which increases fire threat, and exudes salt through evapotranspiration which increases soil salinity. Under these circumstances native plants cannot become established or compete. Some salt cedar roots have been documented over 100 feet below the ground surface, allowing it to survive in marginal habitats or in areas of scant rainfall (Ritzi et al. 1985). Loss of native riparian vegetation and spread of salt cedar has adversely affected native bird populations in the southwest (Carothers 1977). Anderson et al. (1977) reported that salt cedar habitat had lower value to birds than any other native tree community based on total avian density, number of species present, and bird species diversity along the lower Colorado River. Hunter (1984) identified nine avian species which were common along the lower Colorado River around the turn of the century but which now are approaching extirpation because they are riparian obligates and intolerant of salt cedar. Both aquatic and terrestrial flora and fauna can be severely affected by cumulative impacts of exotic vegetation establishment.

Methods to eradicate introduced vegetation has traditionally been costly and time-consuming, but some are effective. Managers attempting to eliminate noxious species and revegetate with native riparian vegetation need effective methods to achieve maximum success. These include application of chemical agents, prolonged inundation, plowing or clearing followed with root-ripping, and intensive hand removal (Anderson and Ohmart 1979, 1982, 1984, Kerpez and Smith 1987). Once removed, salt cedar can be controlled by replanting with native vegetation which prohibit salt cedar seedling establishment since salt cedar is not shade tolerant. It is critical to determine water table depth, soil and groundwater salinity, and soil type and structure for successful revegetation efforts. In areas of low water availability, planted seedlings must have access to water. In these areas, a system of irrigation may be required until roots reach free water. These methods have been employed with success along portions of the Colorado River (Anderson et al. 1977, Anderson and Ohmart 1982, 1984, 1985) and in New Mexico at Bosque del Apache National Wildlife Refuge (Kerpez and Smith 1987). These removal techniques can also be applied to other forms of exotic vegetation.

Other Riparian Impacts

Many human-induced influences have affected riparian ecosystems, significant among them being recreational disturbance. As human pressures multiply within finite western riparian systems, impacts will accelerate quickly. Hoover et al. (1985) found recreational visitors preferred environmental conditions which closely matched features which are found in healthy riparian ecosystems. Grazing, fishing, and excessive human contact were noted as detractants. Thus, the very nature of undisturbed riparian habitats acts as a major attractant for human use and recreational opportunities. As human populations increase in the West, riparian areas will continue to be affected. Managers must weigh recreational, wildlife, and purely aesthetic values against activities and other land use practices such as surface water use and pumping, grazing, mining, and urbanization (Johnson et al. 1977).

Other significant pressures on western riparian systems include oil and gas development, mining, urban development, flooding, groundwater pumping, and fire. Impacts by these activities are in direct proportion to the dimensions of local human populations. Resource strains by these varied but essential activities must be mitigated in a wide variety of ways, many of which are mentioned above. Lengthy specific management recommendations preclude listing here, but a wide variety of riparian literature is available. The manager is encouraged to consult with inter- and intra-agency specialists who have expertise for successful implementation of riparian initiatives.

CONCLUSION

Western riparian ecosystems are among the most productive habitats in North America, and among the rarest and most altered. Federal agencies, and many non-federal management agencies and private landowners, attempt to balance consumptive and non-consumptive land use practices in riparian areas and the watersheds on which they depend. This often results in sacrificing one resource for another. To properly administer riparian ecosystems, managers need to be aware of interrelationships between hydrological processes, vegetative communities, and wildlife populations (Heede 1985). If riparian values are to be conserved for future generations, management must exercise practices considered in terms of cumulative effects on biological and physical systems (Zube and Simcox 1987). Federal, state and private land managers and especially the general public need to address riparian management considering the following methods:

1) Involvement: Concerned citizens, environmental organizations, and public and private land managers must increase communication with state and federal agencies and elected officials to address riparian habitat issues. It is essential to strengthen environmental communication at both the local and national level. The public must get involved with the decision-making process and voice opinions and support of riparian area management.
2) Education: No other method will be more effective in preserving or expanding riparian habitats than education of private citizens and public land management officials. The public needs to become aware of the sensitivity and natural value of riparian ecosystems. Schools and other educational facilities need to begin to address issues such as riparian conservation, and concerned public officials need to get involved. Public land officials not aware of riparian concerns need to be informed and provided with tangible solutions to multiple use conflicts in riparian habitats by specialists and field personnel.
3) Partnerships: Private and public cost-sharing projects and encouragement of mutually beneficial partnerships, cooperative agreements, and conservation easements provide effective riparian protection measures. Many such successful partnerships have been established between private land owners and federal agencies and private conservation groups such as The Nature Conservancy and National Audubon Society. These partnerships must be expanded throughout the West.
4) Revegetation: Removal of exotic plants and reintroduction of extirpated species through revegetation efforts may be costly, but it provides a direct method of quickly re-establishing native riparian vegetation. Supplemental tree plantings in residential or "semi-artificial" habitats may help augment revegetation efforts and should be encouraged.
5) Grazing: Development of sound management practices for grazing systems in riparian areas may be the most important management tool available for riparian habitat conservation. Many riparian forests and wetlands have had their public values severely compromised through over-utilization (Brown et al. 1977). In habitats where little understory exists or where little or no vegetative regeneration is occurring, grazing should be limited or completely eliminated until proper seral stages are achieved. Once habitat recovers, grazing could be allowed under constraints and a managed rotational basis that meets riparian ecosystem objectives.
6) Inventory, Research and Monitoring: Long-term monitoring and evaluation efforts must accompany all riparian habitat management schemes to determine successes or failures. Statewide inventories, mapping projects and classification schemes need to be coordinated between federal, state and private agencies to prevent duplication and wasted effort. In addition, life history requirements and associations of floral and faunal riparian specialists, and studies of interrelationships of man and environment are required (Patton 1977).
7) Management: We must all encourage public land managers and private land owners to make riparian habitat improvement a desired end-product of stewardship of watersheds and ecosystems. Managers and specialists charged with development of land use plans must address potential riparian and watershed impacts before damage occurs. Administrators must cultivate interest, concern, and commitment beyond the agency's official mandate of multiple-use management for the benefit of riparian habitats. Managers have a very important responsibility to participate actively in educational programs which increase public knowledge of riparian values, potential threats to riparian ecosystems, and solutions to multiple use conflicts.

LITERATURE CITED

Ames, C. R. 1977. Wildlife conflicts in riparian management: Grazing. Pp. 49-51 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Anderson, B. W. and R. D. Ohmart. 1977. Vegetation structure and bird use in the lower Colorado River Valley. Pp. 23-34 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Anderson, B. W., A. Higgins, and R. D. Ohmart. 1977. Avian use of saltcedar communities in the lower Colorado River Valley. Pp. 128-136 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Anderson, B. W., and R. D. Ohmart. 1979. Riparian revegetation for mitigation and operational enhancement along the lower Colorado River. Center for Environmental Studies, Arizona St. Univ., Tempe, Ariz. 67 pp.

Anderson, B. W. and R. D. Ohmart. 1982. Revegetation for wildlife enhancement along the lower Colorado River. Final report to the U.S, Bureau of Reclamation, Boulder City, Nev. 215pp.

Anderson, B. W. and R. D. Ohmart. 1984. Vegetation management study for the enhancement of wildlife along the lower Colorado River. Comprehensive final report to the U. S. Bureau of Reclamation, Boulder City, Nev. 529 pp.

Anderson, B. W. and R. D. Ohmart. 1985. Riparian revegetation as a mitigating process in stream and river restoration. Pp. 41-80 in J.A. Gore, ed. The restoration of rivers and streams: Theories and experience. Butterworth Publishers, Boston, Mass. 280 pp.

Anderson, M. T. 1985. Riparian management of coastal Pacific ecosystems. Pp. 364-368 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Arizona Riparian Council Fact Sheet #1. 1988. Arizona State University, Center For Environmental Studies, Tempe, AZ 85287-1201

Bent, A.C. 1919-1968. Life Histories of North American Birds. United States National Museum. Washington D.C. 26 volumes. Reprinted by Dover, N.Y., 1962-1968.

Bent, A.C. 1940. Life Histories of North American Birds: Cuckoos, Goatsuckers, Hummingbirds and Their Allies. United States National Museum. Washington D.C. vol. 1. Reprinted by Dover, N.Y., 1962-1968.

Barger, R. L., and P. F. Ffolliott. 1971. Prospects for cottonwood utilization in Arizona. Progr. Agric. in Ariz. 23(3):14-16.

Brown, D. E., C. H. Lowe, and J. F. Hausler. 1977. Southwestern riparian communities: Their biotic importance and management in Arizona. Pp. 201-211 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Bryant, M. D. 1985. Changes 30 years after logging in large woody debris, and its use by salmonids. Pp. 329-334 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Bryant, L. D. 1985. Livestock management in the riparian ecosystem. Pp. 285-289. in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Buckhouse, J. C. 1985. Water and people: Common denominators in riparian zones. Pp. 369-370 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. Rep. RM 120.

Campbell, D. 1988. Pers. comm. The Nature Conservancy, Arizona Chapter. 300 East University Blvd., Suite 230, Tucson, AZ, 85705.

Campbell, E.C. 1992. Pers. comm. U.S.D.I. Bureau of Land Management, Oregon State Office, Box 2965, 1300 N.E. 44th, Portland, OR, 97208.

Carothers, S. W. 1977. Importance, preservation, and management of riparian habitats: An overview. Pp. 2-4 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Chaney, E., W. Elmore, and W. S. Platts. 1990. Livestock grazing on western riparian areas. U.S. Environmental Protection Agency. 45 pp.

Davis, G. A. 1977. Management alternatives for the riparian habitat in the Southwest. Pp. 59-67 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Dillinger, W. C. 1989. Yellow-billed cuckoos. Pp. 63-63 in Bird Watcher's Digest, July/Aug.

Ehrlich, P.R., D.S. Dobkin and D Wheye. 1988. The Birder's Handbook: A Field Guide to the Natural History of North American Birds. Simon and Schuster Inc., N.Y. 785 pp.

Elmore, W. 1989. Rangeland Riparian Systems. Pp. 93-95 in Proceedings of the California riparian systems conference: Protection, management, and restoration for the 1990's. D. L. Abell (tech. coord.), Davis, CA. Sept 22-24, 1988. USDA For. Serv. Gen. Tech. Rep. PSW 110. Berkeley, CA.

Fox, K. 1977. Importance of riparian ecosystems: Economic considerations. Pp. 19-22 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Franzreb, K. E. 1987. Endangered status and strategies for conservation of the least Bell's vireo (*Vireo bellii pusillus)* in California. Western Birds vol. 18 (1):43-49.

Gauthreaux, S. A. 1992. Preliminary lists of migrants for **Partners In Flight** neotropical migratory bird conservation program. Pg.30 in Partners in Flight newletter. vol. 2 No. 1 (winter 1992).

Glinski, R. L. 1977. Regeneration and distribution of sycamore and cottonwood trees along Sonoita Creek, Santa Cruz County, Arizona. Pp. 116-123 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Gori, D. 1992. Know your element: Cottonwood-willow riparian forests. The Nature Conservancy Arizona Chapter newsletter. vol. 14 no. 1., Tucson, Ariz. 12 pp.

Grinnell, J. and A.H. Miller 1986. The Distribution of the Birds of California. Pacific Coast Avifauna No. 27, publ 1944, reprinted by Artemesia Press, Lee Vining, CA.

Harris, J. H., S. D. Sanders, and M. A. Flett. 1987. Willow flycatcher surveys in the Sierra Nevada. Western Birds vol. 18 (1):27-36.

Hastings, J. R., and R. M. Turner. 1965. The changing mile. University of Arizona Press. Tucson, Ariz.

Heede, B. H. 1985. Interactions between streamside vegetation and stream dynamics. Pp. 54-58 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Hoover, S.L., D. A. King, and W. J. Matter. 1985. A wilderness riparian environment: Visitor satisfaction, perceptions, reality, and management. Pp. 223-226 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Horton, J. S. 1977. The development and perpetuation of the permanent Tamarisk type in the phreatophyte zone of the Southwest. Pp.124-127 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Hubbard, J. P. 1977. Importance of riparian ecosystems: Biotic considerations. Pp. 14-18 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Hunter, W. C. 1984. Status of nine bird species of special concern along the Colorado River. Wildl. Mgmt. Admin. Rep. 84-A, Cal. Dept. of Fish and Game, Nongame Wildlife Investigations, Sacramento, CA.

Hunter, W. C., R. D. Ohmart, and B. W. Anderson. 1987. Status of breeding riparian-obligate birds in southwestern riverine systems. Western Birds vol. 18 (1):10-18.

Ice, G. G., R. L. Beschta, R. S. Craig, and J. R. Sedell. 1989. Riparian protection rules for Oregon forests. Pp. 533-536 in Proceedings of the California riparian systems conference: Protection, management, and restoration for the 1990's. D. L. Abell (tech. coord.), Davis, CA. Sept 22-24, 1988. USDA For. Serv. Gen. Tech. Rep. PSW 110. Berkeley, CA.

Johnson, R. R., L. T. Haight, and J. M. Simpson. 1977. Endangered species vs. endangered habitats: A concept. Pp. 68-74 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Johnson, R. R., and L. T. Haight. 1985. Avian use of xeroriparian ecosystems in the North American warm deserts. Pp. 156-160 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Johnson, R. R., and C. H. Lowe. 1985. On the development of riparian ecology. Pp. 112-116 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Kerpez, T.A., and N. S. Smith. 1987. Saltcedar control for wildlife improvement in the southwestern United States. USDI Fish and Wildlife Service Res. Pub. 169. 16pp.

Krueger, H. O., and S. H. Anderson. 1985. The use of cattle as a management tool for wildlife in shrub-willow riparian systems. Pp. 300-304 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Laymon, S. A., and M. D. Halterman. 1987. Can the western subspecies of the yellow-billed cuckoo be saved from extinction? Western Birds vol. 18 (1):19-25.

Laymon, S. A., and M. D. Halterman. 1989. A proposed habitat management plan for yellow-billed cuckoos in California. Pp. 272-277 in Proceedings of the California riparian systems conference: Protection, management, and restoration for the 1990's. D. L. Abell (tech. coord.), Davis, CA. Sept 22-24, 1988. USDA For. Serv. Gen. Tech. Rep. PSW 110. Berkeley, CA.

Lofgren, S. et al. 1990. Final report and recommendations of the governor's riparian habitat task force (Executive Order 89-16, Streams and Riparian Resources). Report submitted to the Honorable Ros Mofford, Governor of the State of Arizona

Marlow, C. B., and T. M. Pogacnik. 1985. Time of grazing and cattle-induced damage to streambanks. Pp. 279-284 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

McClure, B. et al. 1991. Fish and Wildlife 2000: Nongame migratory bird habitat conservation plan. USDI Bur. of Land Mgmt. 27 pp.

O'Connor, M. D., and R. R. Ziemer. 1989. Coarse woody debris ecology in a second-growth *Sequoia sempervirens* forest stream. Pp. 165-171 in Proceedings of the California riparian systems conference: Protection, management, and restoration for the 1990's. D. L. Abell (tech. coord.), Davis, CA. Sept 22-24, 1988. USDA For. Serv. Gen. Tech. Rep. PSW 110. Berkeley, CA.

Ohmart, R. D., W. O. Deason, and C. Burke. 1977. A riparian case history: The Colorado River. Pp. 35-47 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Ohmart, R. D., B. W. Anderson, and W. C. Hunter. 1988. The ecology of the lower Colorado River from Davis Dam to the Mexico-United States International Boundary: A community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85(7.19). 296 pp.

Patton, D. R. 1977. Riparian research needs. Pp. 80-82 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Ritzi, R. W., H. Bouwer, and S. Sorooshian. 1985. Water resource conservation by reducing phreatophyte transpiration. Pp. 191-196 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Sanders, S. D., and M. A. Flett. 1989. Montane riparian habitat and willow flycatchers: Threats to a sensitive environment and species. Pp. 262-266 in Proceedings of the California riparian systems conference: Protection, management, and restoration for the 1990's. D. L. Abell (tech. coord.), Davis, CA. Sept 22-24, 1988. USDA For. Serv. Gen. Tech. Rep. PSW 110. Berkeley, CA.

Sands, A. and G. Howe. 1977. An overview of riparian forests in California: Their ecology and conservation. Pp. 98-99 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Smith, J. J. 1989. Recovery of riparian vegetation on an intermittent stream following removal of cattle. Pp. 217-221 in Proceedings of the California riparian systems conference: Protection, management, and restoration for the 1990's. D. L. Abell (tech. coord.), Davis, CA. Sept 22-24, 1988. USDA For. Serv. Gen. Tech. Rep. PSW 110. Berkeley, CA.

Spear, M. J. 1985. Position paper: Activities and views of the U.S. Fish and Wildlife Service on riparian ecosystems. Pp. 27-29 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Steinblums, I. J., and A. A. Leven. 1985. Riparian area management in the Pacific Southwest Region, USDA Forest Service. Pp. 507-509 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Stevens, L. E., B. T. Brown, J. M. Simpson, and R. R. Johnson. 1977. The importance of riparian habitat to migrating birds. Pp. 156-164 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Swanson, S. 1989. Using stream classification to prioritize riparian rehabilitation after extreme events. Pp. 96-101 in Proceedings of the California riparian systems conference: Protection, management, and restoration for the 1990's. D. L. Abell (tech. coord.), Davis, CA. Sept 22-24, 1988. USDA For. Serv. Gen. Tech. Rep. PSW 110. Berkeley, CA.

Sweep, D. H., J. M. Zilincar, B. H. Smith, and R. V. Hardy. 1985. Integration of riparian systems management strategies within the context of multiple use land management programs in Southwestern Wyoming. Pp. 371-373 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Szaro, R. C. 1989. Riparian forest and scrubland community types of Arizona and New Mexico. Desert Plants vol 9, no. 3-4. 138 pp.

Vanderheyden, J. 1985. Managing multiple resources in western Cascades forest riparian areas: An example. Pp. 448-452 in Riparian ecosystems and their management: Reconciling conflicting uses - First N. Am. Riparian Conference (proceedings), R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre (tech. coords.), Tucson, Ariz. April 16-18. USDA For. Serv. Gen. Tech. Rep. RM 120.

Wauer, R. H. 1977. Significance of Rio Grande riparian systems upon the avifauna. Pp. 165-174 in Importance, preservation and management of riparian habitat: A symposium (proceedings), R. R. Johnson and D. A. Jones (tech. coords.), Tucson, Ariz. July 9. USDA For. Serv. Gen. Tech. Rep. RM 43.

Zube, E. H., and D. E. Simcox. 1987. Arid lands, riparian landscapes, and management conflicts. Environmental Management vol.11 (4):529-535.

Appendix 1. — Migrant landbirds for *Partners In Flight* Neotropical Migratory Bird Conservation Program (Gauthreaux 1992) which migrate, winter or breed in riparian-associated habitats west of the 100th meridian of the United States and Canada.

Turkey vulture (*Cathartes aura)*
Mississippi kite (*Ictinia mississippiensis)*
Northern harrier (*Circus cyaneus)*
Sharp-shinned hawk (*Accipiter striatus)*
Cooper's hawk (*Accipiter cooperii)*
Common black-hawk (*Buteogallus anthracinus)*
Gray hawk (*Buteo nitidus)*
Red-shouldered hawk (*Buteo lineatus)*
Broad-winged hawk (*Buteo platypterus)*
Zone-tailed hawk (*Buteo albonotatus)*
Red-tailed hawk (*Buteo jamaicensis)*
Golden eagle (*Aquila chrysaetos)*
American kestrel (*Falco sparverius)*
Merlin (*Falco columbarius)*
Peregrine falcon (*Falco peregrinus)*
Prairie falcon (*Falco mexicanus)*
Killdeer (*Charadrius vociferus)*
Long-billed curlew (*Numenius americanus)*
White-winged dove (*Zenaida asiatica)*
Mourning dove (*Zenaida macroura)*
Black-billed cuckoo (*Coccyzus erythropthalmus)*
Yellow-billed cuckoo (*Coccyzus americanus)*
Elf owl (*Micrathene whitneyi)*
Long-eared owl (*Asio otus)*
Buff-collared nightjar (*Caprimulgus ridgwayi)*
Black swift (*Cypseloides niger)*
Chimney swift (*Chaetura pelagica)*
Vaux's swift (*Chaetura vauxi)*
Ruby-throated hummingbird (*Archilocus colubris)*
Broad-billed hummingbird (*Cynanthus latirostris)*
Violet-crowned hummingbird (*Amazilia violiceps)*
Blue-throated hummingbird (*Lampornis clemenciae)*
Magnificent hummingbird (*Eugenes fulgens)*
Black-chinned hummingbird (*Archilocus alexandri)*
Anna's hummingbird (*Calypte anna)*
Calliope hummingbird (*Stellula calliope)*
Broad-tailed hummingbird (*Selaphorus platycercus)*
Rufous hummingbird (*Selasphorus rufus)*
Allen's hummingbird (Selasphorus sasin)
Elegant trogon (*Trogon elegans)*
Belted kingfisher (*Ceryle alcyon)*
Green kingfisher (*Chloroceryle americana)*
Lewis' woodpecker (*Melanerpes lewis)*
Yellow-bellied sapsucker (*Sphyrapicus varius)*
Red-naped sapsucker (*Sphyrapicus nuchalis)*
Red-breasted sapsucker (*Sphyrapicus ruber)*
Williamson's sapsucker (*Sphyrapicus thyroideus)*
Northern flicker (*Colaptes auratus)*
Northern beardless-tyrannulet (*Camptostoma imberbe)*
Olive-sided flycatcher (*Contopus borealis)*
Greater pewee (*Contopus pertinax)*
Western wood-pewee (*Contopus sordidus)*
Yellow-bellied flycatcher (*Empidonax flaviventris)*
Alder flycatcher (*Empidonax alnorum)*
Willow flycatcher (*Empidonax traillii)*
Least flycatcher (*Empidonax minimus)*
Hammond's flycatcher (*Empidonax hammondii)*
Dusky flycatcher (*Empidonax oberholseri)*
Gray flycatcher (*Empidonax wrightii)*
Pacific-slope flycatcher (*Empidonax difficilis)*
Cordilleran flycatcher (*Empidonax occidentalis)*
Buff-breasted flycatcher (*Empidonax fulvifrons)*
Eastern phoebe (*Sayornis phoebe)*
Say's phoebe (*Sayornis saya)*
Vermilion flycatcher (*Pyrocephalus* rubinus)
Dusky-capped flycatcher (*Myiarchus tuberculifer)*
Ash-throated flycatcher (*Myiarchus cinerascens)*
Brown-crested flycatcher (*Myiarchus tyrannulus)*
Sulphur-bellied flycatcher (*Myiodynastes luteiventris)*
Tropical kingbird (*Tyrannus melancholicus)*
Cassin's kingbird (*Tyrannus vociferans)*
Thick-billed kingbird (*Tyrannus crassirostris)*
Western kingbird (*Tyrannus verticalis)*
Eastern kingbird (*Tyrannus tyrannus)*
Rose-throated becard (*Pachyramphus aglaiae)*
Purple martin (*Progne subis)*
Tree swallow (*Tachycineta bicolor)*
Violet-green swallow (*Tachycineta thalassina)*
N. Rough-winged swallow (*Stelgidopteryx serripennis)*
Bank swallow (*Riparia riparia)*
Cliff swallow (*Hirundo pyrrhonota)*
Cave swallow (*Hirundo fulva)*
Barn swallow (*Hirundo rustica)*
House wren (*Troglodytes aedon)*
Sedge wren (*Cistothorus platensis)*
Marsh wren (*Cistothorus palustris)*
Ruby-crowned kinglet (*Regulus calendula)*
Blue-gray gnatcatcher (*Polioptila caerulea)*
Veery (*Catharus fuscescens)*
Gray-cheeked thrush (*Catharus minimus)*
Swainson's thrush (*Catharus ustulatus)*
Hermit thrush (*Catharus guttatus)*
American robin (*Turdus migratorius)*
Gray catbird (*Dumetella carolinensis)*
American pipit (*Anthus spinoletta)*
Phainopepla (*Phanopepla nitens)*
Bell's vireo (*Vireo bellii)*
Black-capped vireo (*Vireo atricapillus)*
Gray vireo (*Vireo vicinior)*
Solitary vireo (*Vireo solitarius)*
Warbling vireo (*Vireo gilvus)*
Philadelphia vireo (*Vireo philadelphicus)*
Red-eyed vireo (*Vireo olivaceus)*
Tennessee warbler (*Vermivora peregrina)*
Orange-crowned warbler (*Vermivora celata)*
Nashville warbler (*Vermivora ruficapilla)*

Virginia's warbler (*Vermivora virginiae*)
Lucy's warbler (*Vermivora luciae*)
Yellow warbler (*Dendroica petechia*)
Magnolia warbler (*Dendroica magnolia*)
Cape May warbler (*Dendroica tigrina*)
Yellow-rumped warbler (*Dendroica coronata*)
Black-throated gray warbler (*Dendroica nigrescens*)
Townsend's warbler (*Dendroica townsendi*)
Hermit warbler (*Dendroica occidentalis*)
Golden-cheeked warbler (*Dendroica chrysoparia*)
Grace's warbler (*Dendroica graciae*)
Palm warbler (*Dendroica palmarum*)
Bay-breasted warbler (*Dendroica castanea*)
Blackpoll warbler (*Dendroica striata*)
American redstart (*Setaphaga ruticilla*)
Ovenbird (*Seiurus aurocapillus*)
Northern waterthrush (*Seiurus noveboracensis*)
Connecticut warbler (*Oporornis agilis*)
Mourning warbler (*Oporornis philadelphia*)
MacGillivray's warbler (*Oporornis tolmiei*)
Common yellowthroat (*Geothlypis trichas*)
Wilson's warbler (*Wilsonia pusilla*)
Red-faced warbler (*Cardellina rubrifrons*)
Painted redstart (*Myioborus pictus*)
Yellow-breasted chat (*Icteria virens*)
Hepatic tanager (*Piranga flava*)
Summer tanager (*Piranga rubra*)
Western tanager (*Piranga ludoviciana*)
Black-headed grosbeak (*Pheucticus melanocephalus*)
Blue grosbeak (*Guiraca caerulea*)
Lazuli bunting (*Passerina amoena*)
Indigo bunting (*Passerina cyanea*)
Painted bunting (*Passerina ciris*)
Green-tailed towhee (*Pipilo chlorurus*)
Rufous-sided towhee (*Pipilo erythrophthalmus*)
Vesper sparrow (*Pooecetes gramineus*)
Chipping sparrow (*Spizella passerina*)
Clay-colored sparrow (*Spizella pallida*)
Brewer's sparrow (*Spizella breweri*)
Black-chinned sparrow (*Spizella atrogularis*)
Fox sparrow (*Passerella iliaca*)
Song sparrow (*Melospiza melodia*)
Lincoln's sparrow (*Melospiza lincolnii*)
Swamp sparrow (*Melospiza georgiana*)
White-throated sparrow (*Zonotrichia albicollis*)
White-crowned sparrow (*Zonotrichia leucophrys*)
Dark-eyed junco (*Junco hyemalis*)
Red-winged blackbird (*Agelaius phoeniceus*)
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)
Brewer's blackbird (*Euphagus cyanocephalus*)
Brown-headed cowbird (*Molothrus ater*)
Hooded oriole (*Icterus cucullatus*)
Northern oriole (*Icterus galbula*)
Scott's oriole (*Icterus parisorum*)
Purple finch (*Carpodacus purpureus*)
Cassin's finch (*Carpodacus cassinii*)
Pine siskin (*Carduelis pinus*)
Lesser goldfinch (*Carduelis psaltria*)
Lawrence's goldfinch (*Carduelis lawrencei*)
American goldfinch (*Carduelis tristis*)

Habitat Fragmentation in the Temperate Zone: A Perspective for Managers

John Faaborg[1], Margaret Brittingham[2], Therese Donovan[1], and John Blake[3]

Abstract — Habitat fragmentation occurs when a large, fairly continuous tract of vegetation is converted to other vegetation types such that only scattered fragments of the original type remain. Problems associated with habitat fragmentation include overall habitat loss, increase in edge habitat and edge effects (particularly higher parasitism and nest predation rates), and isolation effects. Birds show variable responses to fragmentation, with the most conservation concern focused on so-called "area sensitive" species that remain only on large habitat fragments. Management responses to fragmentation include preservation of large tracts of habitat with minimal amounts of edge.

INTRODUCTION

The term "habitat fragmentation" has become a buzzword among conservationists and managers in recent years. Although new to some, researchers have been investigating this area extensively during the last 25 years. One can argue that modern approaches to habitat fragmentation began with the MacArthur-Wilson theory of island biogeography (1963, 1967). Since then, reviewers have noted over 700 publications dealing with some form of habitat fragmentation (Robinson, unpub.). Among these are several recent reviews of the role of fragmentation in declines of Neotropical migrant landbirds (Wilcove et al. 1986, Wilcove and Robinson 1990, Askins et al. 1990, Finch 1991, Robinson and Wilcove, in press). Here, we give a brief overview of what fragmentation is and why it can be detrimental, with a focus on Neotropical migrant landbirds. We suggest general management guidelines for fragmented regions, noting when further research is necessary for more quantitative guidelines for managers.

What Is Habitat Fragmentation?

Habitat fragmentation occurs when a large, fairly continuous tract of a vegetation type is converted to other vegetation types such that only scattered fragments of the original type remain. These remnants (also called isolates, habitat islands, fragments, patches, etc.) obviously occupy less area than the initial condition, are of variable size, shape, and location, and are separated by habitats different from the original condition. The classic example of fragmentation (fig. 1) shows how large, uniform tracts of forest and prairie were broken into small isolates through farm development; the analogy of conversion of a large "mainland" of habitat to an archipelago of habitat islands is certainly apparent.

In this paper, we are focusing on permanent fragmentation that has resulted in islands of habitat surrounded by dissimilar habitat types. Temporary fragmentation occurs through timber harvest practices which create holes of young forest within a matrix of mature forest. Although effects of this type of fragmentation are generally less severe than permanent

[1]Division of Biological Sciences, University of Missouri-Columbia, Columbia, MO 65211.

[2]School of Forest Resources, Pennsylvania State University, University Park, PA 16802.

[3]Department of Biology, University of Missouri-St. Louis, St. Louis, MO 63121.

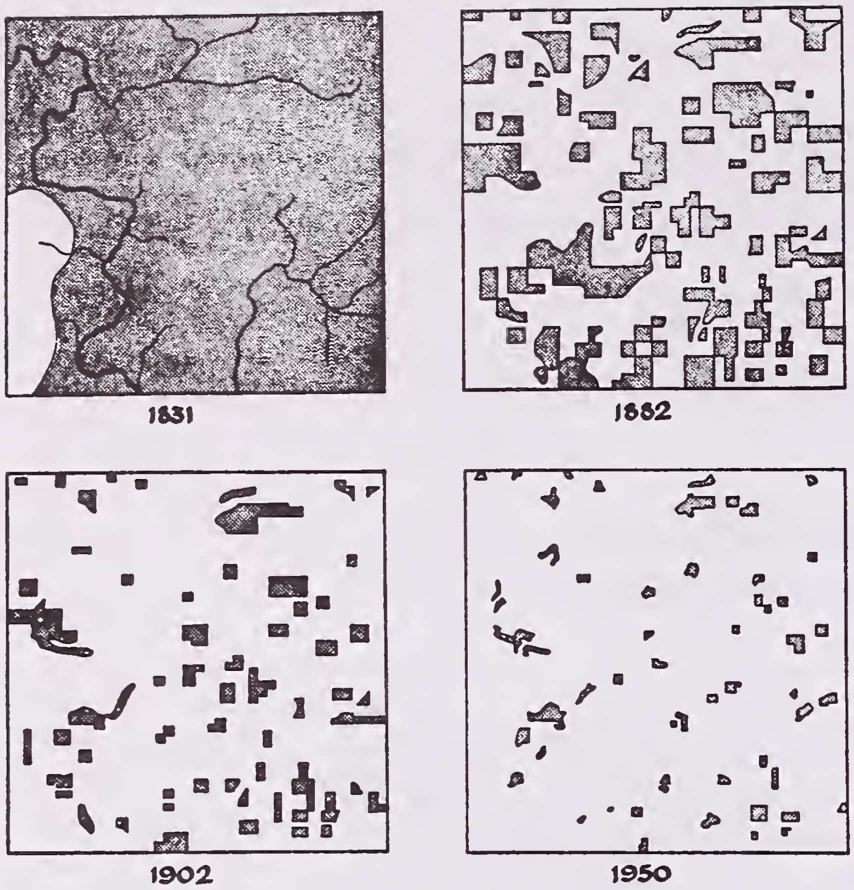


Figure 1. — Fragmentation of forest habitat in Cadiz Township, Wisconsin, over time. After Curtis 1956.

fragmentation, detrimental effects still exist. See the chapter on silviculture (Thompson et al., this volume) for information on temporary fragmentation.

PROBLEMS ASSOCIATED WITH HABITAT FRAGMENTATION

Habitat fragmentation results in both a quantititative and qualitative loss of habitat for species originally dependent on that habitat type (Temple and Wilcox 1986). As a consequence, the abundance and diversity of species originally present often declines, and losses are most noticeable in smallest fragments. Below we discuss mechanisms responsible for these changes, focusing on forest fragmentation because most work has been done in this habitat.

Habitat Loss

The most obvious effect of fragmentation is an outright quantitative loss of habitat for species dependent on the original habitat type in a region. Groups of species directly impacted by habitat loss through fragmentation include those with large home range requirements, very specific microhabitat requirements, and poor dispersal abilities (Wilcove et al. 1986, Wilcove 1988). For example, when home range or territory requirements of a species are greater than fragment size, the species often disappears. However, the factors listed above are usually not sufficient to explain why most Neotropical migrants decline in numbers or disappear from small fragments.

Increase in Edge Habitat and Edge Effects

Most Neotropical migrants utilize small territories (<2 ha), but may disappear from fragments tens or hundreds of times territory size. For these species, fragmentation results in qualitative changes in the remaining habitat (Temple and Wilcox 1986). As an area is fragmented, there is an increase in amount of edge relative to interior area and an increase in "edge effects" (Temple 1986). For our purposes, edge is defined as the junction between two dissimilar habitat types or successional stages. "Edge effects" are ecological characteristics associated with this junction that affect any number of biological traits (Harris 1988, Yahner 1988, Saunders et al. 1991) and which may extend great distances into a forest. These edge effects reduce quality of habitat for Neotropical migrant birds.

Why Is Edge Bad for Neotropical migrants? Traditionally, edge effect has been defined as an increase in abundance and diversity of wildlife found along the boundary between two habitat types (Leopold 1933). Because many game species are more abundant near edges, wildlife managers were generally taught that "edge" was good for wildlife and, in many cases, wildlife management was considered synonymous with creating edge habitat (Harris 1988).

Our concept of edge and edge effect has changed for a number of reasons. First, our definition of wildlife has expanded to include non-game species, many of which evolved within extensive areas of unfragmented habitat away from edges (Temple and Cary 1988). In addition, our way of defining edge effect has changed; instead of merely looking at number and abundance of species, we are using demographic parameters such as reproductive success. This is important because misleading conclusions can be reached by using only abundance as a measure of habitat quality (Van Horne 1983). For example, an apparent consequence of the increase in abundance and diversity of wildlife along edges is an increase in biotic interactions, such as predation, brood parasitism, and competition. Below, we discuss specifically how these changes often negatively affect Neotropical migrants.

1) **High Rates of Nest Predation.** Several species of mammalian and avian nest predators are more abundant along forest edge than in forest interior (Bider 1968, Forsyth and Smith 1973, Robbins 1979, Whitcomb et al. 1981). Studies using both artificial and natural nests have found that predation rates often are higher in small fragments than in larger ones and higher near edge in large forested areas than in the interior (e.g. Gates and Gysel 1978, Wilcove 1985, Small and Hunter 1988, Yahner and Scott 1988; fig. 2). A similar trend occurs on prairie fragments (Burger 1988, Johnson and Temple 1986).
2) **High Rates of Brood Parasitism.** The Brown-headed Cowbird (*Molothrus ater*) is also often more abundant along forest edges than in forest interior and

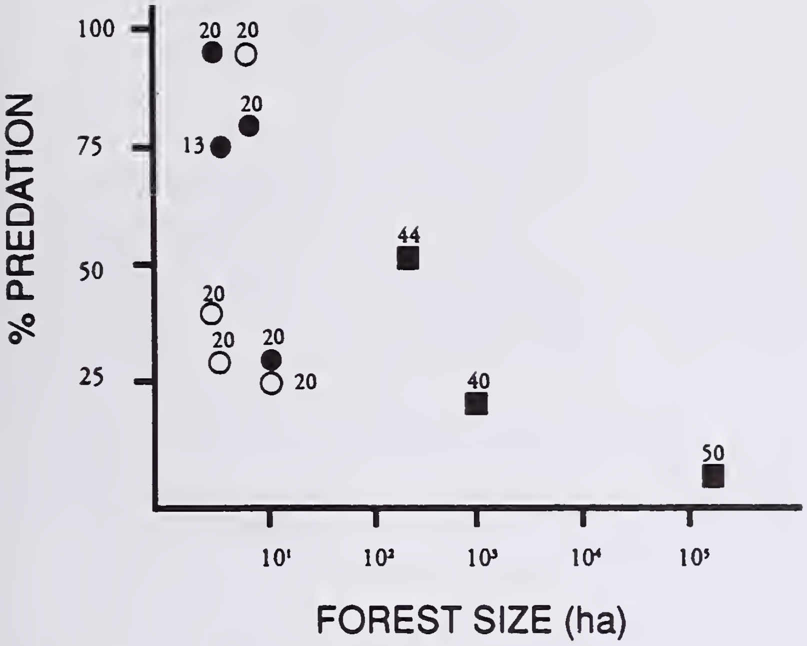


Figure 2. — Relationship between forest area and predation rates on artificial nests. Numbers above the points are sample sizes for each forest site. From Wilcove 1985.

parasitism rates are usually higher near forest edges (see Robinson et al., this volume). This is also true for prairie fragments (Johnson and Temple 1986).

3) **High Rates of Interspecific Competition.** Ambuel and Temple (1983) hypothesized that an increase in interspecific competition associated with increased abundance and diversity of potential competing edge species may adversely affect forest interior songbirds. However, no quantitative data exist to support this hypothesis at present.

4) **Reductions in Pairing Success.** Ovenbirds (*Seiurus aurocapillus*) living in forest fragments in Missouri were found to have lower chances of attracting a mate on smaller fragments (Gibbs and Faaborg 1990, Gentry 1989) and near edge of larger forests (Van Horn 1990). A similar pattern was found for this species in Ontario (Villard et al., 1992) and Minnesota (Donovan, unpub.). Lower pairing success was found in Wood Thrush (*Hylocichla mustelina*) and Red-eyed Vireo (*Vireo olivaceus*) where selective cutting had created clearings in a formerly continuous forest (Ziehmer, unpub.).

5) **Reductions in Nesting Success.** The above factors can have devastating demographic effects on Neotropical migrant birds. Temple and Cary (1988) found that only 18% of nests within 100 m of forest edge in Wisconsin were successful, while 70% of nests > 200 m from an edge were successful. Work by Hoover (1992) on Pennsylvania forest fragments ranging in size from 9.2 to > 500 ha found the probability of nest success correlated with forest area. Studies currently underway in the Shawnee Forest of southern Illinois and central Missouri also are finding that reproductive rates in many fragments are far below those needed to balance mortality.

How Far Do Edge Effects Extend? Unfortunately, we cannot give an exact distance for extent of edge effects. Vegetative changes may extend less than 30 m into a forest (Wilcove et al. 1986, Saunders et al. 1991), but edge-related predation rates have been suggested to extend 600 m into the forest (Wilcove et al. 1986), although other studies have suggested 50 to 100 m as a threshold (Gates and Gysel 1978, Burger 1988). Edge effects may vary with the regional landscape (see Freemark et al., this volume). In locations where cowbird densities are extremely high, parasitism rates may be high throughout the forest (Robinson et al., this volume), and in other areas where cowbird densities are low, parasitism rates may be low enough that no edge effects are apparent (Hoover 1992).

Isolation Effects With Habitat Fragmentation

To the extent that dispersal capabilities and the character of habitat separating fragments limit movement, relative isolation of a fragment may be detrimental to population survival. All other things being equal, theory suggests that isolated fragments might support fewer species or lower densities than less isolated fragments (MacArthur and Wilson 1967, Shafer 1990). Few data examining these patterns exist (Askins et al., 1990, Opdam 1991). Lynch and Whigham (1984) found that more isolated woodlots had fewer Neotropical migrant species than less isolated woodlots of comparable size and vegetation. On the other hand, Robinson (1992) found that extremely isolated woodlots in Illinois contained more forest-interior migrants than expected. Ongoing studies at the Connecticut Arboretum (Askins and Philbrick 1987, Askins et al. 1987) found recent increases in Neotropical migrant numbers, presumably because old fields that had isolated this site had grown into forests.

Neotropical migrants might be the vertebrate group least sensitive to isolation due to their long distance travel abilities. A recent study (Arguedes 1992) using DNA fingerprinting of Ovenbirds (*Seiurus aurocapillus*) found essentially no genetic differences between isolated populations as much as 150 km apart, suggesting high dispersal rates in mid-Missouri forest fragments. A better understanding of dispersal is needed to appreciate the role of isolation in fragmented regions. In particular, sexual variation in dispersal capabilities needs examination.

AVIAN RESPONSES TO HABITAT FRAGMENTATION

Although all of the above problems associated with habitat fragmentation do not paint a favorable picture for reproductive success of Neotropical migrants on fragments, it is not surprising that different species respond to fragmentation in different ways. Here, we briefly examine patterns by which different species respond to fragmentation to gain insight into how habitat management might minimize fragmentation effects.

Species-area Relationships. Recognizing the relationship between species-area patterns on oceanic islands and the equilibrium model, early researchers in habitat fragmentation censused birds on habitat fragments of varying size within a region (Bond 1957, Galli et al. 1976, Whitcomb et al. 1976, Robbins 1979, Hayden et al. 1985, and others). They found the number of species on a habitat island increased with increasing habitat size. A number of studies (reviewed by Askins et al. 1990) verified that area *per se* has the greatest influence on species number in a given area. Factors such as habitat heterogeneity, degree of isolation, and vegetation structure were relatively unimportant compared to habitat size. The slope of the species-area curve for a particular habitat may vary regionally, perhaps depending upon where the study was done in relation to the centers of ranges of species involved. This variation is considered in the landscape ecology chapter (Freemark et al., this volume).

Area Sensitive Species. A large number of studies in many areas, including Illinois (Blake and Karr 1984), Missouri (Hayden et al. 1985), Wisconsin (Ambuel and Temple 1983), Maryland (Robbins et al. 1989), New Jersey (Galli et al. 1976), and Ontario (Freemark and Merriam 1986), have shown that individual species are not randomly distributed with regard to habitat size.

By separating the component species found on fragments into several migration and habitat categories, it was shown that, as a group, long distance (Neotropical) migrants have steeper responses to fragment size than short distance migrants or permanent residents (fig. 3; Whitcomb et al. 1981 and others). Those species categorized as requiring forest interior habitat were also more area sensitive than edge or interior/edge species.

On a species-by-species basis, use of either an incidence function approach (Diamond 1975b) or analysis of "nested subsets" of species (Blake 1991) has shown very non-random distributions of species with respect to fragment size. Most importantly, these studies have noted "area sensitive" species, species which tend to occur in or achieve their highest densities only on large fragments. These patterns suggest the possibility of regional extinctions without preservation of large enough habitats.

Minimum Area Requirements and Source/sink Dynamics. With recognition that some species seemed to "require" large areas to exist, attempts were made to determine minimum area requirement (MAR) of each species within a region. MAR was defined in a variety of ways, ranging from "size class of habitat at which the frequency of occurrence undergoes a sharp decline" (Robbins 1979) to "the area in which young can be produced in sufficient numbers to replace adult attrition under the poorest conditions of weather, food availability, competition from other wildlife, and other disturbances" (Robbins et al. 1989).

Most early published estimates of minimum area requirements were based on presence-absence data from bird censusing. These did not anticipate the devastating effect of predation, parasitism, and other factors on nesting success of some species in habitat fragments. Biologists also did not appreciate the ability of species to continually colonize fragments where production was low or non-existent. To understand the regional dynamics of populations in fragments, a variety of source-sink models have been developed (Brown and Kodric-Brown 1977, Pulliam 1988). A sink population is one that does not produce enough young to replace adult mortality, and which exists because of continued colonization from elsewhere (the "rescue effect" of Brown and Kodric-Brown [1977]). A source produces enough young to replace breeding adults, and perhaps even enough to populate other fragments through dispersal.

Unfortunately, the theory of source-sink dynamics is well ahead of our empirical knowledge; further insight requires both an understanding of population demography in a wide variety of habitats and knowledge of dispersal characteristics for each species. Suffice it to say that we are a long way from estimating true minimum area requirements for species in any region, let alone all regions.

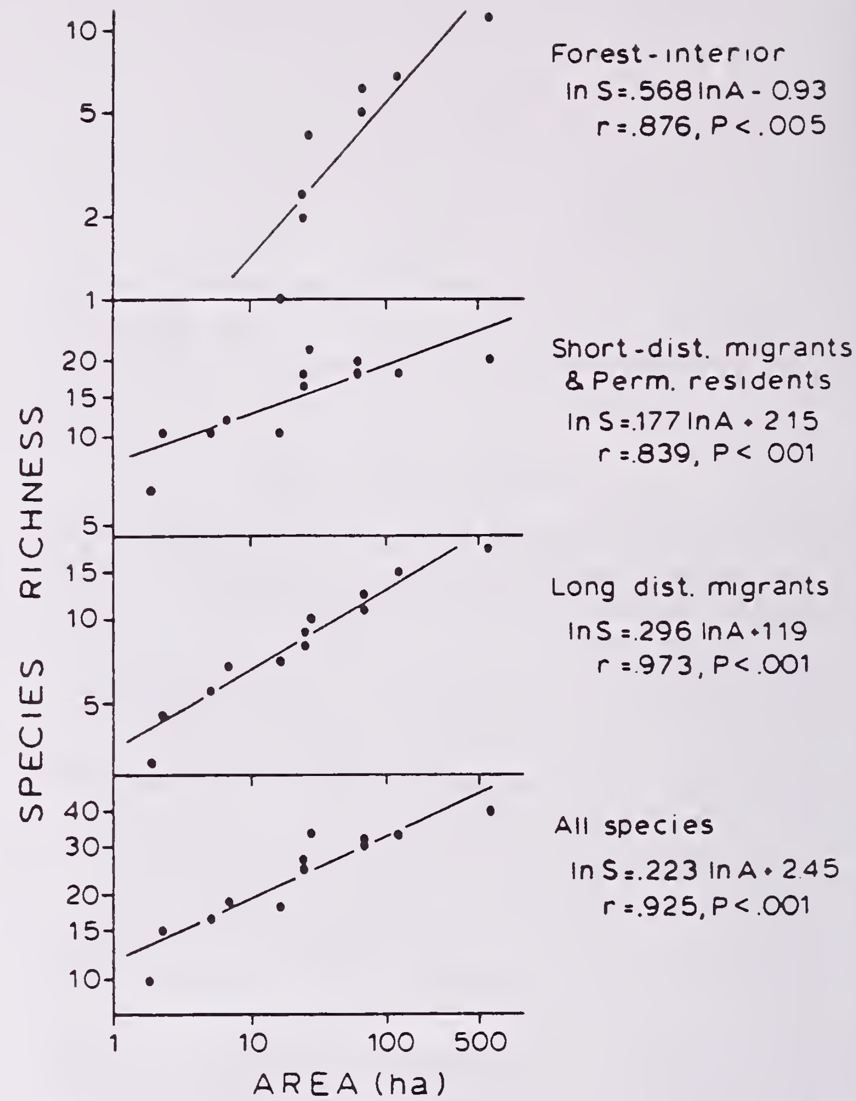


Figure 3. — Species richness (ln) within different ecological groups plotted as a function of area (ln) of forest tracts in east-central Illinois. From Blake and Karr 1984.

HABITAT FRAGMENTATION: MANAGEMENT GUIDELINES

Selecting Fragments to Protect

Despite lack of knowledge about details of avian demography necessary to provide quantitative management strategies, we can provide general guidelines for assigning priorities when the goal is to provide quality breeding habitat for Neotropical migrant songbirds.

Single Large or Several Small (SLOSS). One of the first questions that arises and has been debated in the literature for over a decade (Simberloff and Abele 1976) is whether, given the choice, it is better to protect one large reserve or several small reserves whose total area equals the large reserve. The SLOSS debate initially focused on total number of species preserved and found, in theory, that more species might be preserved on several small reserves than one large one given certain assumptions about species distributions (Simberloff 1986). However, occurrence of area sensitive species only in habitats of large size makes most of these arguments invalid for Neotropical migrants. Rather, the general concensus when managing for breeding Neotropical migrants is that a single large reserve is better than several small reserves.

Reserve Size. Once a manager has decided to direct conservation efforts towards preserving large fragments that will provide quality breeding habitat, the next question is how large do fragments need to be. In a region that still contains large amounts of habitat, knowledge of fragment size that supports source populations would allow a manager to protect most important fragments. In a situation where few large fragments exist, that knowledge may be essential in choosing a fragment of proper size or, in the worst case, managing to make a fragment big enough to support source, or at least stable, populations.

Published minimum area requirements might serve as guidelines to determine fragment size required. As noted above, these are based on presence/absence data. In analyzing a set of 14 area sensitive species, Robbins et al. (1989) determined that 3,000 ha fragments were the minimum size that would retain all species of area sensitive forest birds in the Mid-Atlantic states. Fragments of 1,000 ha in mid-Missouri contain all expected species of Neotropical migrants found in that region (J. Faaborg, pers. obs.). To truly understand the minimum area required to support a stable or source population necessitates examining fitness components such as reproduction or survival in relation to habitat area (Martin et al., this volume; Maurer et al., this volume). Fragments of at least 3,000 ha may be needed in most regions to retain viable breeding populations of all species (Robbins et al. 1989). Perhaps even larger areas currently serve to maintain regional populations. In Missouri, the relatively vast Ozark forests support large Neotropical migrant breeding populations with low parasitism and nest predation rates; this area may be the source for many migrant populations occupying fragmented parts of Missouri. Once again, an understanding of details of demography and dispersal are needed to truly understand population dynamics.

It must be noted that, although large areas may be needed for maintenance of all species, smaller reserves are not without value. Some migrant species can successfully breed at least occasionally on small fragments, and edge and edge/interior species make extensive use of these fragments. If movement of individual birds between source and sink areas occurs between years, fragments may serve as important reservoirs for that part of the population that may not be able to find space to breed within source habitats in a given year. For the goals of many nature reserves, presence of particular Neotropical migrant species may be of value even if successful reproduction is not occurring. In these cases, areas equalling previously published values of minimum area requirements may serve to promote local biodiversity, even if the area is a population sink and not of value in long-term species preservation. It is possible that habitat fragments may be of critical importance to migrants moving through a heavily disturbed region.

Shape of Reserve. Fragment shape determines the ratio of edge to interior, with the ratio largest for long narrow fragments and smallest for circular or square fragments. Because reproductive success of Neotropical migrants is highest within forest interior away from edges, quality of habitat can be strongly influenced by fragment shape. Temple (1986) compared distribution of area sensitive migrants in forest fragments of different sizes and shapes. For each area, he recorded total area and core area (area 100 m from a forest edge) and compared species distribution as a function of these two variables. He found that core area was a better predictor of species occurrence than area alone. Hoover (1992), using Temple's definition of core area, found that core area was also a better predictor of Wood Thrush nest success than area alone. Consequently, compact shapes that maximize core area are favored over narrow shapes where edge habitat predominates, and management favoring too much edge may result in no acceptable core habitat within a fragment (fig. 4).

Location of Reserve. Birds on fragments are not isolated populations, but interact through dispersal with other populations. Therefore, it is also necessary to examine the question at a landscape level to determine how fragment location and isolation affect species distribution.

Our limited knowledge on influence of isolation on distributional patterns is hard to convert to conservation priorities. For example, fragments close to other fragments may support more species than isolated fragments, but in terms of maintaining local populations, isolated fragments may be extremely important because they are all that is left in the region. As is frequently the case when dealing with complex management issues, there is no cookbook solution, but by understanding the processes, a manager can better evaluate options.

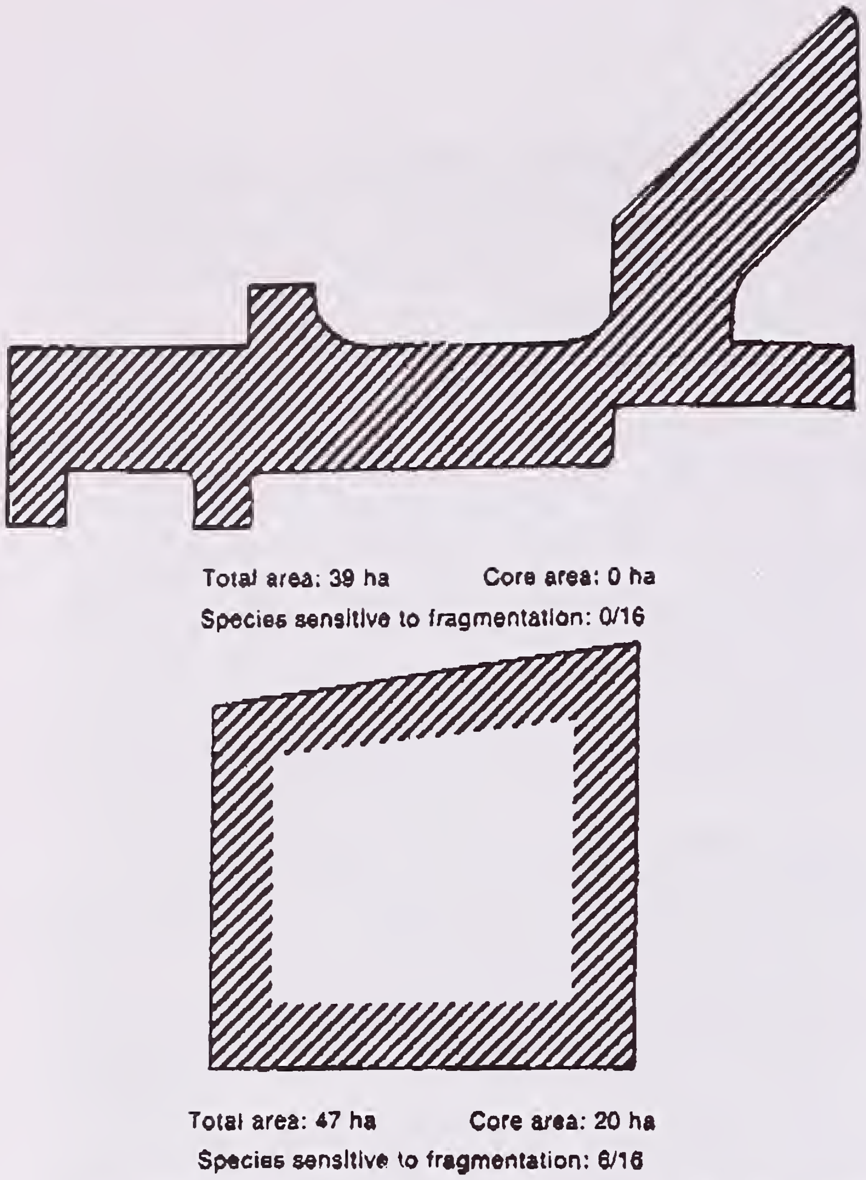


Figure 4. — Amount of edge and interior habitat on two forest patches of similar size but different shapes. From Temple 1986.

Corridors. One technique to minimize isolation of fragments is use of corridors-connecting strips of habitat that reduce fragment isolation. Although much theory about value of corridors exists (Simberloff and Cox 1987, Noss 1987), little data are available on actual value of corridors in the temperate zone (but see Saunders and Hobbs [1991]). Certainly, corridors are of more importance to small mammals or other organisms with limited dispersal capabilities than to Neotropical migrants. For breeding purposes, corridors are just long strips of edge, with associated problems. However, they may be important to migrants or to facilitate post-breeding dispersal, but more information is needed.

Managing Fragments

In many cases, managers will not be able to choose the size, shape, or location of fragments being managed. Instead, the concern may be how to best manage existing fragments. Guidelines for managing large fragments are similar to the guidelines used for managing contiguous forest (see Thompson et al., this volume). In general, a manager should minimize disturbance within forest interior. Openings, including roads and power lines, should be concentrated along existing habitat edges.

Small fragments, particularly those in suburban areas, will probably never provide quality breeding habitat for most area sensitive species. However, these small woodlots are frequently used as stop-over and foraging sites during migration, provide breeding habitat for short distance migrants and permanent residents, and may support non-breeding populations of Neotropical migrants. Although these fragments may not be important to long-term survival of Neotropical migrant bird populations, they may be of great importance in maintaining popular interest in Neotropical migrants, as most people see these migrants in small fragments or residential areas, not in major reserves.

We hope the above material helps managers understand why management guidelines that provide exact area requirements and such are not presently available. The general guidelines for nature reserve design provided by Diamond (1975a; fig. 5) still best summarize the qualitative approach managers should take in selecting and managing habitat remnants in fragmented environments. All other things being equal, bigger is better than smaller, compact shapes are better than narrow shapes, and reserves closer together or close to a source area are better than widely spaced reserves. As researchers discover details of Neotropical migrant demography and ecology, they will be able

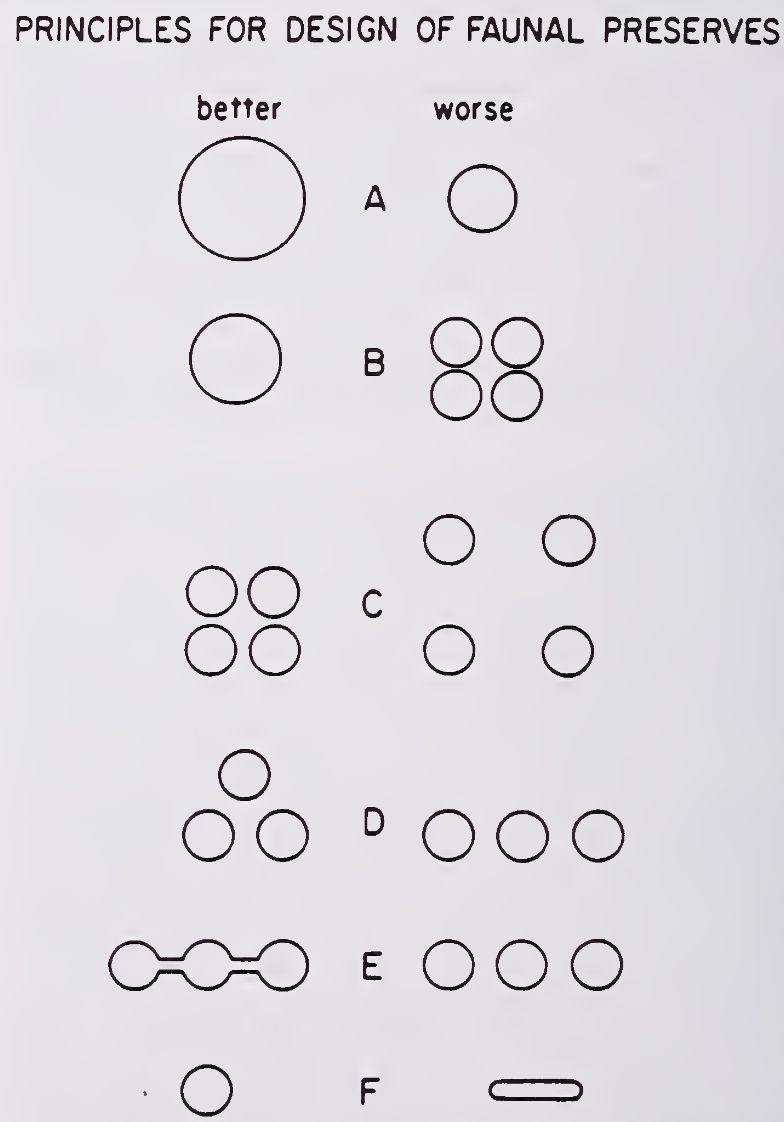


Figure 5. — Suggested qualitative principles for the selection and management of nature reserves, showing better and worse options with regard to extinction rates. From Diamond 1975a.

to provide more quantitative suggestions about details of minimum area requirements and extent of edge effects, but this will probably have to be done on a regional basis.

ACKNOWLEDGMENTS

The authors would like to thank the many students and colleagues who have reviewed this manuscript, including Dirk Burhans, Don Dearborn, Wendy Gram, Paul Porneluzi, and George Wallace. We also thank Scott Robinson for access to his accumulation of fragmentation references.

LITERATURE CITED

Ambuel, B. and S.A. Temple. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. Ecol. 64:1057-1068.

Arguedes, N. 1992. Genetic variation and differentiation in the Ovenbird (*Seirurus aurocapillus*) in central Missouri and Puerto Rico. Unpubl. M.A. Thesis, University of Missouri-Columbia, Columbia, MO.

Askins, R.A., and M.J. Philbrick. 1987. Effects of changes in regional forest abundance on the decline and recovery of a forest bird community. Wilson Bull. 99:7-21.

Askins, R.A., M.J. Philbrick, and D. Sugeno. 1987. Relationship between the regional abundance of forest and the composition of forest bird communities. Biol. Conserv. 39:129-152.

Askins, R.A., J.F. Lynch, and R. Greenburg. 1990. Population declines in migratory birds in eastern North America. Pp. 1-58 in D.M. Power, ed. Current Ornithology Vol. 7. New York: Plenum Press.

Bider, J.R. 1968. Animal activity in uncontrolled tgerrestrial communities as determined by a sand transect technique. Ecol. Monogr. 38:269-308.

Blake, J. 1991. Nested subsets and the distribution of birds on isolated woodlots. Cons. Biol. 5:58-66.

Blake, J. and J.R. Karr. 1984. Species composition of bird communities and the conservation benefit of large versus small forests. Biol. Conserv. 30:173-187.

Blake, J. and J.R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68:1724-1734.

Bond, R.R. 1957. Ecological distribution of breeding birds in the upland forests of southern Wisconsin. Ecol. Monogr. 27:351-384.

Brown, J.H., and A. Kodric-Brown. 1977. Turnover rates in insular biogeography: effects of immigration on extinction. Ecology 58:445-449.

Burger, L.D. 1988. Relations between forest and prairie fragmentation and depredation of artificial nests in Missouri. M.A. Thesis, University of Missouri-Columbia, Columbia, MO.

Diamond, J.M. 1975a. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Bio. Conserv. 7:129-146.

Diamond, J.M. 1975b. Assembly of species communities. Pp. 342-444 in M.L. Cody and J.M. Diamond (eds.) Ecology and Evolution of Communities. Harvard Univ. Press, Cambridge, MA.

Finch, D.M. 1991. Population ecology, habitat requirements, and conservation of neotropical migratory birds. Gen. Tech. Report RM-205. Ft. Collins, CO: US Dept. Ag., Forest Service, Rocky Mt. Forest and Range Expt. Station. 26 pp.

Forsyth, D.J., and D.A. Smith. 1973. Temporal variability in home ranges of eastern chipmunks (*Tamiaus striatus*) in a southeastern Ontario woodlot. American Midland Naturalist 90:107-117.

Freemark, K.E., and H.G. Merriam. 1986. Importance of area and habitat heterogeneity to bird assemblages in temperate forest fragments. Biol. Conserv. 36:115-141.

Freemark, K., J.B. Dunning, S. Hejl, and J. Probst. In press. Landscape ecology of Neotropical migrant birds. In Finch, D.M. and P.W. Stangel (eds.), Status and Management of Neotropical Migratory Birds. U.S.D.A., Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report , RM- .

Galli, A.E., C.F. Leck, and R.T. Forman. 1976. Avian distribution in forest islands of different sizes in central New Jersey. Auk 93:356-364.

Gates, J.E. and L.W. Gysel. 1978. Avian nest dispersion and fledgling success in field-forest ecotones. Ecology 59:871-883.

Gentry, R.M. 1989. Variable mating success of the Ovenbird (*Seiurus aurocapillus*) within remnant forest tracts of central Missouri. M.A. Thesis, University of Missouri-Columbia, Columbia, MO.

Gibbs, J.P. and J. Faaborg. 1990. Estimating the viability of Ovenbird and Kentucky Warbler populations in forest fragments. Conserv. Biol. 4:193-196.

Harris, L.D. 1988. Edge effects and conservation of biotic diversity. Conserv. Biol. 2:330-332.

Hayden, T.J., J. Faaborg, and R.L. Clawson. 1985. Estimates of minimum area requirements for Missouri forest birds. Trans. Mo. Acad. Sci. 19:11-22.

Hoover, J.P. 1992. Nesting success of Wood Thrush in a fragmented forest. M.S. Thesis, The Pennsylvania State University, University Park, PA. 147 pp.

Johnson, R.G. and S.A. Temple. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairie. Pp. 245-250 in J. Verner, M.L. Morrison, and C.J. Ralph, eds. Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. Madison WI: University of Wisconsin Press.

Leopold, A. 1933. Game Management. New York: Scribners.

Lynch, J.F. and D.F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. Biol. Conserv. 28:287-324.

MacArthur, R.H. and E.O. Wilson. 1963. An equilibrium theory of insular biogeography. Evolution 17:373-387.

MacArthur, R.H. and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, NJ.

Noss, R.F. 1991. Corridors in real landscapes: a reply to Simberloff and Cox. Conserv. Biol. 1:159-164.

Opdam, P. 1991. Metapopulation theory and habitat fragmentation: a review of holarctic breeding bird studies. Landscape Ecology 5:93-106.

Pulliam, H.R. 1988. Sources, sinks, and population regulation. Amer. Natur. 132:652-661.

Robbins, C.S. 1979. Effect of forest fragmentation on bird populations. Pp. 198-212 in R.M. DeGraaf and K.E. Evans, eds. Management of north-central and northeastern forests for nongame birds. Gen. Tech. Rep. NC-51, St. Paul, MN: US Dept. Ag., Forest Service, North Central Forest Expt. Station.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildl. Monogr. 103, Washington D.C.: The Wildlife Society.

Robinson, S.K. 1992. Population dynamics of breeding birds in a fragmented Illinois landscape. Pp. 408-418 in J.M. Hagan and D.W. Johnston, eds. Ecology and conservation of Neotropical Migrant Landbirds. Washington D.C.: Smithsonian Institution Press.

Robinson, S.K. and D. S. Wilcove. In press. Forest fragmentation in the temperate zone and its effects on migratory songbirds. Symposium from Neotropical Ornithology Congress.

Robinson, S.K., J.A. Grzybowski, S.I. Rothstein, M.C. Brittingham, L.J. Pettit, and F. Thompson. In these proceedings.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conserv. Biol. 5:18-32.

Saunders, D.A. and R.J. Hobbs, eds. 1991. Nature Conservation 2: The role of corridors. Surrey: Beatty and Sons.

Shafer, C.L. 1990. Nature reserves: island theory and conservation practice. Smithsonian Institution Press, Washington, D.C.

Simberloff, D. 1986. Are we on the verge of a mass extginction in tropical rain forests? Pp. 165-180 in D.K. Elliot, ed. Dynamics of Extinction. New York: John Wiley and Sons.

Simberloff, D. and L.G. Abele. 1976. Island biogeography theory and conservation practice. Science 191:285-286.

Simberloff, D. and J. Cox. 1987. Consequences and costs of conservation corridors. Conserv. Biol. 1:63-71.

Small, M.F. and M.L. Hunter. 1988. Forest fragmentation and avian nest predation in forested landscapes. Oecologia 76:62-64.

Temple, S.A. 1986. The problem of avian extinctions. Current Ornithol. 3:453-485.

Temple, S.A. and B Wilcox. 1986. Predicting effects of habitat patchiness and fragmentation. Pp. 261-262 in Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. J. Verner, M.L Morrison, and C.J. Ralph (eds.). University of Wisconsin Press, Madison, WI.

Temple, S.A. and J.R. Cary. 1988. Modeling dynamics of habitat-interior bird populations in fragmented landscapes. Conserv. Biol. 2:340-347.

Thompson, F.R. III, J.R. Probst., and M.G. Raphael. In these proceedings.

Van Horn, M.A. 1990. The relationship between edge and the pairing success of the Ovenbird. M.A. Thesis, University of Missouri-Columbia, Columbia, MO.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. of Wildl. Mgmt. 47:893-901.

Villard, M.A., K. Freemark, and G. Merriam. 1992. Metapopulation dynamics as a conceptual model for neotropical migrant birds: an empirical investigation. Pp. 474-482 in J.M. Hagan and D.W. Johnston, eds. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, D.C.

Whitcomb, R.F., J.F. Lynch, P.A. Opler, and C.S. Robbins. 1976. Island biogeography and conservation: strategy and limitations. Science 193:1030-1032.

Whitcomb, R.F., C.S. Robbins, J.F. Lynch, B.L. Whitcomb, K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pp. 125-205 in R.L. Burgess and D.M. Sharpe, eds. Forest island dynamics in man-dominated landscapes. New York: Springer-Verlag.

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1214.

Wilcove, D.S. 1988. Changes in the avifauna of the Great Smoky Mountains: 1947-1983. Wilson Bull. 100:256-271.

Wilcove, D.S., C.H. McClellan, and A.P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pp. 237-256 in M.E. Soule, ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, MA.

Wilcove, D.S. and S.K. Robinson. 1990. The impact of forest fragmentation on bird communities in eastern North America. Pp. 319-331 in A. Keast, ed. Biogeography and ecology of forest bird communities. SPBAcademic Publishing, The Hague, The Netherlands.

Yahner, R. 1988. Changes in wildlife communities near edges. Conserv. Biol. 2:333-339.

Yahner, R. and D.P. Scott. 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Manage. 52:158-161.

Migrant Songbirds, Habitat Change, and Conservation Prospects in Northern Petén, Guatemala: Some Initial Results

David F. Whitacre[1], Julio Madrid M.[2], Ciriaco Marroquín[3], Mark Schulze[4], Laurin Jones[5], Jason Sutter[5], and Aaron J. Baker[4]

Abstract — A recently-created complex of reserves spanning the Guatemala, México, Belize borders in the southern Yucatán Peninsula constitutes 5.5 million acres of contiguous, protected lowland forest. Information is needed on compatibility of various land-uses and biodiversity protection in multiple-use zones of these reserves. To address these and other needs related to conservation of migrant songbirds, Peregrine Fund collaborators (6 Guatemalans and 5 North Americans) in 1992 began studies of songbirds wintering in and near the Guatemalan portion of the Maya/Calakmul/Rio Bravo reserve complex. Research consists of two parts. The "intensive" portion involves detailed study on 25-ha plots; goals are to produce long-term monitoring of migrant populations and new information on their winter ecology. The goal of the "extensive" portion is to generate relative abundance indices for migrant species in a variety of pristine and human-altered habitats. Results are presented from a 7680 mist net-hour comparison of 10 sites in slash-and-burn regeneration (3 to 16 years of age) and 10 sites in primary forest of two types. Wood Thrushes were far more common in primary forest than in second-growth. Yellow-breasted Chats, Gray Catbirds, and Ovenbirds were all more abundant in second-growth than in primary forest, and in low, dense-understoried "bajo" forest than in tall, closed-canopy upland forest. Among second-growth sites, capture rates of Kentucky Warblers and Ovenbirds showed significant positive correlations with age of second growth; they appeared to prefer more mature sites. A hypothesis is presented concerning the structural similarity of some types of naturally-occurring "bajo" forest and successional forest, and bird use of the same. Land use patterns in northern Petén are briefly described, with emphasis on conservation challenges and opportunities.

INTRODUCTION

Recent establishment of the Maya/Calakmul/Rio Bravo reserve complex spanning the Guatemala, Mexico, Belize borders has created the largest enclave of protected lowland forest in Central America and Mexico. The Guatemalan portion, Maya Biosphere Reserve, includes large multiple-use areas. Management plans for these areas are still being developed. To aid in decisions about permissible uses of these areas, managers

[1]*The Peregrine Fund, Inc., 5666 West Flying Hawk Lane, Boise, Idaho 83709.*

[2]*Centro de Estudios Conservacionistas, Universidad de San Carlos de Guatemala, Parque Nacional tikal, Petén, Guatemala.*

[3]*The Peregrine Fund, Inc., Parque Nacional tikal, Petén, Guatemala.*

[4]*The Evergreen State College, Olympia, Washington 98505.*

[5]*22582 Veronica Dr., Salinas, California 93908.*

require information concerning compatibility of various land uses with conservation of biological diversity, including populations of migrant and resident songbirds. Migrant songbird research begun in winter 1992 as part of The Peregrine Fund's long-term "Maya Project" helps meet these needs, and complements a program of ecological monitoring of these forest ecosystems developed over the past five years. All aspects of the project provide training and experience in conservation field research for Latin American personnel, who conduct a great deal of the field work. Some results of the first year of migrant songbird research are presented here.

DESCRIPTION AND CONSERVATION OPPORTUNITIES OF NORTHERN PETEN

Project Area Description

The 3.45 million acre Maya Biosphere Reserve was created in January 1990 by Guatemalan law. The 1.8 million acre Calakmul Biosphere Reserve in Campeche, Mexico was created in 1989, and Rio Bravo Resource Management and Conservation Area (202,000 acres) in adjacent Belize was created in 1988. Taken together, this reserve complex encompasses 5.5 million acres, and is the largest contiguous area of legally protected lowland forest in Central America and Mexico.

The Petén Department, 35,800 square km in area, constitutes slightly more than a third of Guatemala's surface, and 60 per cent of the country's forest cover (Heinzman and Reining 1990). The Petén forms the basal part of the Yucatán Peninsula, abutting in the south the mountain ranges that form the backbone of Central America. Elevation of the Petén is mostly 100 to 300 m amsl; the climate is lowland tropical, with mean annual temperature of 26.6 degrees C. A marked precipitation gradient exists over the Yucatán Peninsula, from 3000 mm annual rainfall along the mountains in the south, to 1000 mm and less in the northwest corner of the peninsula near Merida, Yucatán; yearly rainfall in most of the Petén is between 1500 mm (northern Petén) and 2000 mm (southern Petén) (Secretaria de Programación y Presupuesto 1981). A pronounced dry season is typical, from January or February through May.

The forest types represented in the area are classified by Pennington and Sarukhan (1968) as selva alta-mediana subperennifolia (tall to mid-height subperennial forest) and selva baja subperennifolia (low subperennial forest). The nature of undisturbed forest in northern Petén is strongly determined by a topographic and soil type gradient, probably mainly through their effects on soil moisture. Though relief is often no more than tens of meters, the effect on vegetation and soil is marked. Hill tops and slopes have shallow, well-drained, rocky, sandy-loamy soils with relatively low clay content (and presumably limited water-holding capacity, due in part to limestone bedrock a few tens of cm below surface). In contrast, low-lying areas have deep soils (often > 140 cm) with very high clay content; these areas are often seasonally inundated.

Along this topographic/soil gradient is a largely predictable continuum in forest "types". Schulze and Whitacre (in prep.) recognize the following series of forest types: Upland Forest, Upland Dry Forest, Hill-base Forest, Sabal Forest, Transitional Forest, and Bajo Forest (including "Tintal"). Vegetation of upland areas is normally tall, closed-canopy forest with high tree species diversity, complex subcanopy foliage structure, open to moderately open shrub/sapling layer, and sparse ground cover. Forests in low-lying ("bajo") areas are highly variable. In the extreme case, they are "tintales", of very low (3-6 m) stature, and dominated by Tinto (*Haematoxylum campechianum*) and a few other tree species, but more often they have greater tree species diversity, moderately low stature (5-15 m), open canopy structure, very dense shrub/sapling layer, and ground cover which may be sparse or heavy (Schulze and Whitacre, in prep.). While some tree species occur over a wide range of the community continuum described above, their abundances typically vary with position on this gradient. Several tree species are restricted to one or a few of the forest types listed above.

Conservation Needs and Opportunities in the Area

Traditional forest-based industries which thrive in the northern Petén make this area especially interesting due to the potential confluence of sustainable development and conservation goals. Reserves may provide for both biotic conservation and human livelihoods much as rubber-based extractive reserves in Amazonia (Gradwohl and Greenberg 1988). Products extracted from the Petén's forests in potentially sustainable fashion produce a few to several million dollars annually as exports. Currently the economically dominant product is foliage of the Xate (pronounced *shah-tay*) palms (*Chamaedorea* spp.), used in floral arrangements in the U.S. and Europe. This industry employs some 7000 individuals; the value of 1987 exports was nearly $2 million (Heinzman and Reining 1990).

Chicle, the sap of the chicozapote (*Manilkara zapota*) has been harvested from intact Petén forests at least since the 1880's and has been a dominant influence in the areas social and economic evolution (Schwartz 1990). Peak production of ca 2.2 million kg/yr was reached during the 1920's to 1940's. During the 1980's, production ranged from 136,000 to 273,000 kg/year (Heinzman and Reining 1990), with a price on the order of $4.15 per kg. At least 900 people are employed in the chicle industry, with this figure rising as high as two or three thousand during years of high demand, when production may reach .9 to 1.4 million kg/yr (Heinzman and Reining 1990).

Another forest product of the Petén is allspice--the fruit of pimienta gorda (*Pimenta dioica*). Fruit-laden limbs of this common understory species are lopped off during July through

September. In 1986, Guatemalan exports amounted to 394,000 kg valued at $230,000 (Heinzman and Reining 1990). Other forest products exploited in smaller quantities include Bayal (*Desmoncus ferox*), a climbing palm which yields rattan-like fiber used in basketry and furniture, and a yam, *Dioscorea* sp. which provides steroid building blocks for birth control pills (Heinzman and Reining 1990).

Commercial logging of Mahogany and Cedro in the Petén can be traced back to the 1820's, and reached much greater importance beginning in the 1860's and 1870's (Schwartz 1990). Commercial logging is monetarily the dominant extractive industry in the Petén, employing thousands of seasonal loggers and about 1,200 sawmill workers. Contrary to what might be assumed, logging as practiced in this area does not lead to the immediate and outright elimination of forest, though its impact on forest biodiversity is largely unstudied. Logging in this region has traditionally been selective, mainly for two species--Mahogany or "Caoba" (*Swietenia macrophylla*) and Cedro (the "cigar box tree")(*Cedrela odorata*), though perhaps a dozen additional species are also taken at times (S. Gretsinger, pers. comm.).

Southern Petén is more heavily deforested than is northern Petén (pers. obs.). The "agricultural frontier", where slash-and-burn farmers and cattle-ranchers make inroads into fringes of remaining large blocks of forest, runs east-west across the Petén at roughly the latitude of the southern boundary of Tikal National Park and the Maya Biosphere Reserve. However, where a few major roads penetrate farther north, significant deforestation has in some cases occurred along these roads within the Biosphere Reserve; further immigration along these roads, should it continue, represents a significant threat to the integrity of the reserve.

Based on casual observations, primary proximate mechanism of deforestation in this area is slash-and-burn ("milpa") agriculture. Commercial logging, while not destroying the forest outright, tends to facilitate expansion of the agricultural frontier by creating roads into hitherto roadless areas. Cultural heritage also plays a role in deforestation dynamics; while long-time residents of northern Petén tend to be firmly enmeshed in a "forest culture" based on extraction of chicle, xate, etc., recent immigrants from other parts of Guatemala are much more prone to engage mainly in slash-and-burn farming, for it is the livelihood with which they are experienced (K. Kline, pers. comm., Schwartz 1990).

Cattle ranching claimed much land once forest in southern Petén, and this process, often following on the heels of slash-and-burn farming, also exists along the southern boundary of the Maya Biosphere Reserve. Some rough figures on the rate of expansion of cattle ranching in the Department of Petén are: 1957-1964--6,000 head; 1977--21,000 head; 1979--75,000 head; 1980--150,000 head (Schwartz 1990). Cattle-ranching appears to be one of the predominant threats to remaining forests of the Petén.

Human-induced changes in the Petén have been primarily recent and accelerating. While as recently as 1941, the Petén boasted 5 automobiles and about 11,000 people (Schwartz 1990: pp. 11, 333), the decades since the late 1960's have witnessed a rapid increase in milpa agriculture, cattle ranching, and logging (Schwartz 1990). As late as 1964 the population of Petén was but 25,000 (Schwartz 1990: p. 10); by 1986 it had reached an estimated 300,000 (Schwartz 1990: p. 11). A primary ultimate factor leading to high rates of forest conversion in Petén is a high rate of immigration, primarily from more heavily populated portions of Guatemala's south and east; immigration rates are believed to be on the order of 250 people per day (Heinzman and Reining 1990).

Rather than painting the situation as desperate, we prefer to point out the potential for meeting both conservation goals and human needs by accentuating sustainable forest products industries now thriving in the area. To do so, however, will require limiting the roles of cattle-ranching, slash-and-burn farming, and human immigration.

The Need for Migrant Songbird Research in Northern Petén

The northern Petén supports large numbers of neotropical migrant songbird species and individuals. While the Maya/Calakmul/Rio Bravo reserve complex is large, neither this protected area, nor the sum of all protected areas in the region, can house the majority of the wintering populations of migrant songbirds that utilize the area. Unlike Monarch Butterflies (*Danaus plexippus*), of which the entire eastern U.S./Canada population can be protected in winter by preserving a few key forested mountainsides in central Mexico, wintering songbird populations cannot be adequately protected in biotic reserves as currently construed. Extant reserves do not encompass enough area to achieve this, and it is most unlikely that reserve systems will grow sufficiently to do so.

By their nature, songbird populations are relatively thinly spread over large areas, including much area already used or destined to be used by humans for agriculture, lumbering, and other purposes. Hence, fate of neotropical migrant populations wintering in this region is inextricably linked to patterns of land use outside of reserves. For this reason, it is important to learn how useful many types of human-altered landscapes in this region are to migrant songbirds (and other biota). This is a primary goal of research described here.

PEREGRINE FUND RESEARCH ON NEOTROPICAL MIGRANT LANDBIRDS IN NORTHERN PETEN

Our efforts with migrant songbirds in Guatemala began during winter of 1990/91, with exploratory mist netting and observations. This developed in January 1992 into the research described here, which continues to date. Research goals are: (1) create training opportunities for Latin American personnel, (2) document impact of various land-use practices on migrant songbirds, (3) put in place a program for long-term monitoring of migrant populations wintering in the area, and (4) contribute to knowledge of the winter ecology of neotropical migrants.

Research consists of two parallel programs. An "extensive" component conducts standardized sampling of a number of sites relatively rapidly. The goal of this component is to generate information on relative abundance of migrant species in the predominant natural and human-altered habitats of the area. The "intensive" component studies a few permanent 25 hectare study plots in depth, using color-banding, spot-mapping and ancillary techniques to monitor population density, survival, fat levels, body weight, and to collect other ecological information. Here we report results of "extensive" investigations during late winter/early spring 1992.

Habitats Studied

We compared 10 primary forest sites to 10 slash-and-burn regeneration sites. Five primary forest sites represented predominantly "upland" forest, while five represented "bajo" forest. These forest types are described in more detail above; briefly, upland forest is tall, closed-canopy forest with well-developed subcanopy layers but relatively sparse ground cover and shrub layer, while bajo forest is low in stature, open of canopy, with extremely dense shrub-sapling layer. Time elapsed since last cultivation of the slash-and-burn sites is given in Table 1.

Table 1. — Time since prior cultivation, and overall farming history of 10 slash-and-burn study sites. (All sites are within a radius of ca. 15 km, between Tikal National Park and Ixlu, Petén.)

Site	Time since farmed	Prior history
La Placa (Don Adolfo)	3 years	First cleared from primary forest 6 years ago.
Don Antonio	5 years	Was primary forest 5 years ago.
Don Margarito	6 years	Was first cleared from primary forest 18 years ago; recent farming was second cycle.
Don Francisco	7 years	First cleared from primary forest 9 years ago.
Don Peto (Porvenir Plan B)	7-8 years	Was already second growth when land purchased in 1982.
Don Leno	8 years	Evidently was burned 50-100 years prior; first cultivated 9 or 10 years ago.
Don Emilio (Plan B)	8 years	Tall forest initially felled ca. 15 years ago, farmed once then, and then farmed again recently, to be abandoned 8 years ago. In spring 1992, it was felled and burned in preparation for farming during summer 1992.
Cahui Administración	12 years	Was already second growth 57 years ago; has been farmed off and on since then.
Cahui Barba	12 years	Same as Cahui Administración.
Ixlu (Pedro Castellano)	16 years	First cleared from primary forest 17 years ago.

The accuracy of site histories given in Table 1 depends on that of the memories of individuals (normally land owners) providing information. Ages since cultivation are probably accurate within a couple years. It is important to note the rate and nature of vegetation succession following slash-and-burn farming varied a great deal between sites; some sites appeared more recovered than did sites which had lain fallow for longer periods. This was probably due in large part to local differences in drainage, soil type, surrounding vegetation (and hence seed sources) and to the total history of farming and soil exhaustion on each site.

Birds using a given site may be influenced by the nature of the surrounding habitat matrix. Primary forest sites were all within Tikal National Park, a 576 square km area of primary and lightly-altered forest; all sites were well within park boundaries. Second-growth sites were in an agricultural mosaic typical of that existing along the "agricultural frontier" throughout Latin America. Over many square km, the habitat is a patchwork of mostly 5-7 ha units, comprised of actively farmed milpas, fallow fields mostly 0 to 7 years of age, and small remnants of mature forest. Remaining chunks of mature forest are mostly 1 to 100 ha in area, and are often degraded by periodic passage of fire, and by extraction of guano palm, fire wood, and lumber for local construction.

Methods

At each site, sixteen 36 mm mesh mist nets were operated for eight hours on each of three consecutive days. Nets (ATX, obtained from Association of Field Ornithologists) were 12 m in length and 2.6 m tall, and spaced 12 m apart. In all cases but two, nets were in a single linear array. In two cases nets were placed in two parallel arrays of eight nets each, with 60-100 m between arrays; this was done because these habitat blocks were too small to accommodate a single 484 m array (sixteen nets with 50 m of habitat extending beyond ends of the array).

Nets were opened at sunrise time as determined by the current Nautical Almanac (Secretary of the Navy 1989) and closed eight hours later. All captured birds were banded--North American breeders with U.S. Fish and Wildlife Service bands and others with commercially obtained numbered metal bands--and standard data were taken. Each 3-day netting stint comprised 384 net-hours of sample effort. Because sample effort was equal for all comparison units, data used for analyses were number of distinct individuals captured per 3-day sample.

Use of capture rates as an index of abundance can be problematic for comparisons between habitats if birds show behavioral differences correlated with habitat. For example, birds using mainly canopy are far above nets when in tall forest, but may commonly enter nets in second-growth where canopy dips near ground level. For this reason, we restricted comparisons to species largely active within 2.5 m of the forest floor (see below). We felt the vertical pattern of activity of these species was sufficiently similar in habitats compared here to allow comparison of capture rates between habitats without risk of serious artifacts. While recognizing that abundance and vertical distribution of activity are not the only factors affecting mist net results, we assume that capture rates do in large part reflect relative abundance.

Age of second-growth was determined by questioning local people, primarily farmers who had worked parcels in question. In addition, one author (M. Schulze), a plant ecologist experienced in this region, ranked the degree of plot recuperation. Because factors such as farming history and proximity of seed source affects recuperation rates, age of successional stands does not necessarily indicate degree of recuperation from the standpoint of usefulness to birds. Though rankings were similar, that for age as reported by farmers gave higher correlations with bird results overall, and is used here. Significance of Spearman Rank Correlations were determined after Siegel (1956). For all comparisons of capture rates between habitats, the Mann-Whitney U Test was used.

RESULTS

Results are presented here for eight species whose abundance we felt was reliably revealed by mist netting: Wood Thrush (*Hylocichla mustelina*), Kentucky Warbler (*Oporornis formosus*), Hooded Warbler (*Wilsonia citrina*), Worm-eating Warbler (*Helmitheros vermivorus*), Northern Waterthrush (*Seiurus noveboracensis*), Yellow-breasted Chat (*Icteria virens*), Gray Catbird (*Dumetella carolinensis*), and Ovenbird (*Seiurus aurocapillus*). Results are given in Table 2. Four species had significantly different capture rates (Mann-Whitney U test) in primary forest versus successional vegetation 3 to 16 years in age. Wood Thrushes were far more common in primary forest than in second growth ($p = .02$). Species that were more abundant in successional than in primary forest were Yellow-breasted Chat ($p < .01$), Gray Catbird ($p < .01$), and Ovenbird ($p < .002$). Kentucky, Worm-eating and Hooded Warblers showed nonsignificant trends, and Northern Waterthrush results appeared strongly affected by distribution of standing water; all captured individuals were at inundated sites (Table 2).

Table 2. — Distinct individuals of eight focal species captured per 1,000 net hours in two types of primary forest and slash-and-burn successional vegetation.

	Primary Upland Forest	Primary Bajo Forest	Slash-and-burn Regeneration
Wood Thrush	10.94[1,*]	11.98[1,*]	3.65[2]
Kentucky Warbler	8.85	9.38	6.51
Worm-eating Warbler	5.21	3.65	3.39
Northern Waterthrush	0	6.77	0.26
Hooded Warbler	4.17	6.77	7.55
Yellow-breasted Chat	0	2.08	6.77[**]
Gray Catbird	1.04	7.29	15.36[**]
Ovenbird	0.52	5.73[***]	16.93[**]

[1] For total captures in primary upland and bajo forest, multiply numbers given here by 1.92.
[2] For total captures in slash-and-burn regeneration, multiply numbers given here by 3.84.
[*] Significantly more common in primary forest (upland plus bajo) than in second growth.
[**] Significantly more common in second growth than in primary forest (upland plus bajo).
[***] Significantly more common in primary bajo forest than in primary upland forest.

As discussed above, naturally-occurring "bajo" forest often structurally resembles successional forest in some respects. Due to this similarity, we felt it possible that some species perceive and utilize bajo and successional forest similarly. Hence we tested whether capture rates differed between bajo and high-ground forest. Of three species which were more common in successional than primary forest, the Ovenbird also was more common in bajo than in high-ground forest ($p < .05$), while Gray Catbird ($p < .10$) and Yellow-breasted Chat, ($p = .20$) did not differ significantly in these two habitats in this small sample (5 sites of each type). Results are equivocal due to small sample size, but suggest the value of further attention to this topic.

To investigate whether species occurred more commonly in younger or older second-growth, we calculated Spearman Rank Correlation Coefficients between age rank of slash-and-burn sites and the number of captures per site. This was done for seven species, the Northern Waterthrush omitted because its results appeared dominated by the effect of standing water. Three of seven species showed significant correlations. Kentucky Warblers were caught in greater numbers in older than younger second growth (corrected Rho = .649, one-tailed p .05)(Fig. 1) and the same was true for Ovenbirds (corrected Rho = .732, one-tailed $p < .05$)(Fig. 1). Gray Catbirds showed the opposite result, with more captures in younger second-growth (corrected Rho = -.566, one-tailed $p < .05$) (Fig. 1)

DISCUSSION

Our most robust result was that certain species had higher capture rates (and presumably were more abundant) in primary forest than in successional forest, and other species showed the reverse pattern. The identity of species more abundant in primary forest (Wood Thrush significantly, Kentucky Warbler and Worm-eating Warbler non-significantly) is not a surprise, nor for the most part is that of species occurring more commonly in successional forest (Yellow-breasted Chat, Gray Catbird, and Ovenbird significantly, Hooded Warbler nonsignificantly).

The great excess of Ovenbirds captured in successional habitats may come as somewhat of a surprise. Other workers have often found Ovenbirds occupy a variety of agricultural and successional habitats (Waide 1980, Lynch 1989, Robbins et. al. 1990, Petit et al. 1990, Lynch 1990), and Lynch (1989) characterized this species as lying about halfway between extreme reliance on mature forest and completely general use of mature forest, second-growth forest, and agricultural fields, and as using moist tall, moist medium-height, and dry, medium-height forest with equal facility. We are not aware of any other workers having reported such a preponderance of Ovenbird occurrence in relatively young successional vegetation as that shown in Table 2. However, the fact that Ovenbirds were

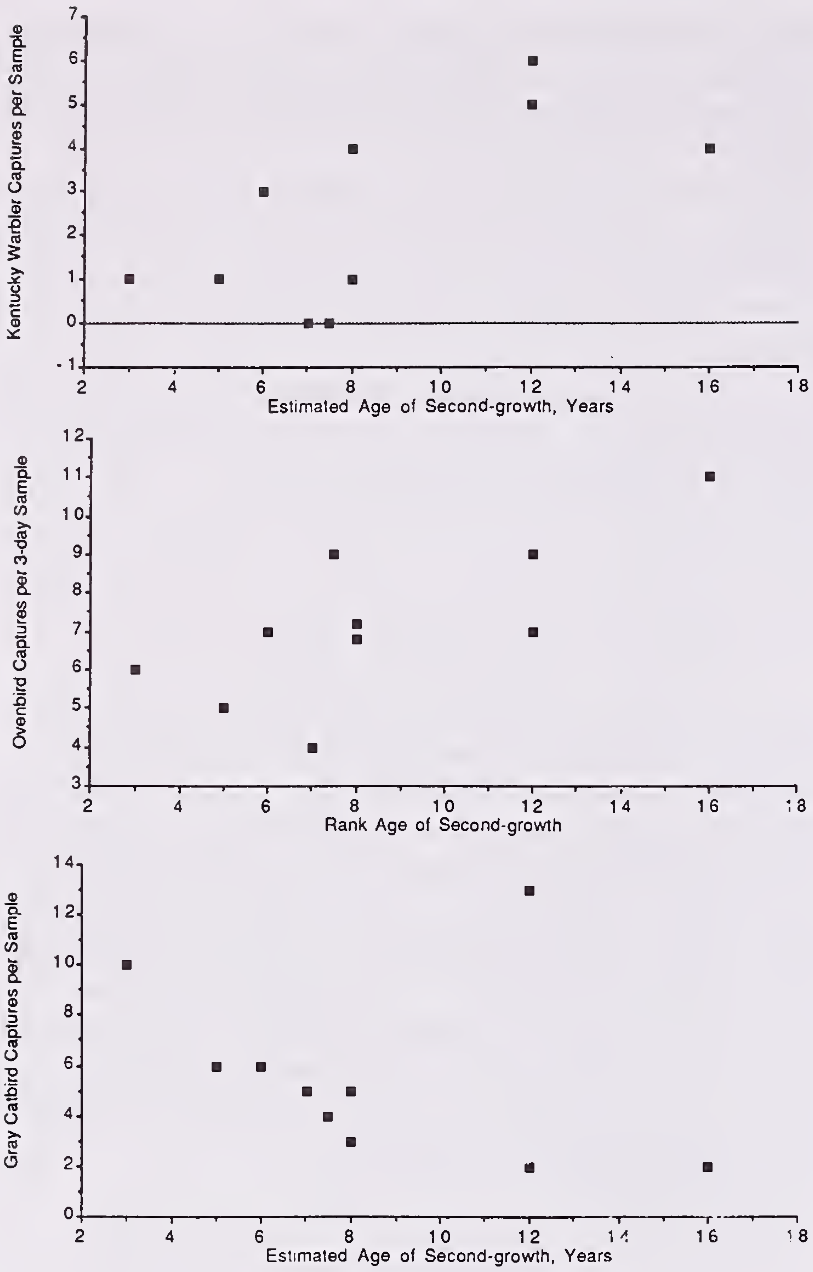


Figure 1. — Scatterplots of capture rates versus age of second-growth vegetation for three species having significant Spearman Rank Correlations among the same.

caught significantly more often in older than in young second growth cautions against the interpretation that the species does quite well in young second growth, and a similar comment may be made about the Kentucky Warbler.

Our results, though admittedly preliminary, lend support to the idea that some bird species perceive some types of "bajo" forest and successional forest in a similar fashion. Bajo forest occupies very extensive portions of the Yucatán Peninsula, and is hence an important forest type for migrant songbirds. It seems likely that some species of migrants are adapted in part to wintering in dense natural vegetation types such as bajo forest. Such species may be preadapted to use of second-growth habitats stemming from slash-and-burn farming, and thus may be relatively immune to effects of milpa agriculture, as compared to species which typically make heavier use of upland forest. If this hypothesized similarity of bajo and second-growth habitats is true, this implies the proliferation of slash-and-burn farming over the past several thousand years in the region may have had less impact on bajo-dwelling species than might otherwise be supposed.

In contrast, the structural difference between upland forest and young second-growth is vast to a human observer. For this reason, any species which typically occur much more commonly in upland than in bajo forest may have a more difficult time making use of second-growth habitats. Interestingly, in our limited sample, none of the eight focal species appeared markedly more common in upland than in bajo forest. The Wood Thrush, for example, was equally abundant in both types of primary forest, and far less common in second growth.

Conservation Prospects

It seems clear that if present rates of human immigration into the region are not reduced, it will be difficult for the conservation potential of this reserve complex to be realized. Direct impacts of non-lumber forest extractive industries (chicle, xate, allspice, guano thatch) on migrant and resident songbirds are likely to be negligible. Of these, only removal of guano thatch and allspice produces noticeable changes in forest structure. These potentially sustainable industries are the most ecologically appropriate extractive industries currently practiced in the area.

While slash-and-burn farming has reportedly declined over the past decade in nearby Quintana Roo (Lynch 1990), this is not the case in the Petén. We cannot give quantitative data, but it is clear that forest destruction by milpa agricultors continues at a fast pace in some parts of the northern Petén and, along with cattle-ranching, has already converted much of the southern Petén into a patchwork of mature forest remnant, successional vegetation, pastures and crops. It is our impression that slash-and-burn agriculture and cattle ranching are the two most potent threats to forest in and near the Maya Biosphere Reserve. While cattle ranching has more devastating impacts on forest biota (pers. obs.), milpa farming seems to be at least as important a source of deforestation at this time in the northern Petén. The two seemed to be linked, moreover, with cattle-ranching often following slash-and burn cultivation (pers. obs., Schwartz 1990).

For species that thrive in successional vegetation, slash-and-burn farming may not present a problem, while for species mostly using mature forest, slash-and-burn appears to be a serious threat in northern Petén. Under pre-Columbian population densities, milpa agriculture may often have maximized regional biodiversity by providing a mosaic of successional stages, with long rotation schedules presumably allowing forest to recuperate mature characteristics. Thus, milpa agriculture in and of itself is probably not inherently "bad" for biological diversity (see also Lynch 1990:192). Rather, the problem is that rotation schedules today are typically so brief, due to human population pressure, that forest rarely if ever is allowed to reach even a moderately mature stage before being felled once more. In our study area, a given patch of ground is farmed 2 years out every 6 to 9 (Heinzman and Conrad 1990, Schwartz 1990). A plot, usually of 5-6 ha, is normally farmed for two years, after which it is fallowed for 4 to 7 years before again being farmed; demographic and economic pressure often leads to fallow periods being further reduced (Schwartz 1990, pp. 269, 274, 276, 286). Hence, the bulk of milpa second-growth is from 0 to 7 years of age. It is difficult to envision, under current human population pressures, how the length of the slash-and-burn rotation may be increased to allow forest to recover more fully. Research on alternatives to slash-and-burn farming, and on ways to increase ability of the slash-and-burn landscape to sustain migrant songbirds and other fauna should be a high priority.

A final thought takes the form of a caution. It is currently popular among international development aid personnel working in the Petén to promote harvesting of more tree species than the two--mahogany (*Swietenia macrophylla*) and Cedro (*Cedrela odorata*)-- traditionally taken. While imparting greater value to the forest is widely recognized as desirable, there is a danger in multi-species harvest, if it is executed without sufficient control. Casual observation suggests the traditional two-species logging practiced today may not necessarily be disastrous for migrant songbirds and other forest biota. The extent of logging damage to the forest appears to vary a great deal, depending on density of the two primary target species as well as other factors (pers. obs., S. Gretsinger, pers. comm.), but in some cases damage appears modest. Our fear is that without controls ensuring a truly long cutting cycle, logging of multiple tree species could lead to a scale and intensity of harvest much worse for migrant birds and other biota, than is the traditional two-species logging practiced today. Promotion of taking more tree species should be contingent upon infrastructure development ensuring the ability to control logging rates over time horizons longer than a human life span.

SUGGESTIONS FOR FUTURE RESEARCH

The success of our inter-habitat comparisons after a single season of study, with limited samples, hinges on strict standardization of methodology which we achieved. If the various researchers conducting similar work in northern Latin America and the Caribbean were to converge on a common methodology, comparisons across a much broader suite of habitats and geographical regions would be facilitated. Such standardization should be a priority in the near future.

ACKNOWLEDGEMENTS

Funding for this research was provided by the National Fish and Wildlife Foundation and Kennetech/U.S. Windpower. We are grateful to the individuals named in Table 1, who allowed us to work on their property. We are thankful to the following government officials who have facilitated our work in Guatemala in many ways: Arq. Claudio Olivares, Lic. L. Leopoldo Colom Molina, and Rogel Chi Ochaeta of the Instituto de Antropología e Historia de Guatemala; Lic. Billy Alquijay Cruz, Lic. Milton Cabrera, and Lic. Ismael Ponciano of (or formerly of) the Centro de Estudios Conservacionistas de la Universidad de San Carlos de Guatemala, and Ing. Milton Sarabia, Lic. Arturo Duarte Ortíz, and Arq. Andreas Lehnhoff, of (or formerly of) the Consejo Nacional de Areas Protegidas.

LITERATURE CITED

Gradwohl, J. and R. Greenberg. 1988. Saving the tropical forests. Island Press, Washington, D. C. 214 pp.

Heinzman, R. and C. Reining. 1990. Sustained rural development: extractive forest reserves in the northern Petén of Guatemala. Tropical Resources Institute Working Paper # 37, Yale University School of Forestry and Environmental Studies, Yale University, New Haven, CT., 104 PP.

Lynch, J. F. 1989. Distribution of overwintering nearctic migrants in the Yucatan Peninsula, I: general patterns of occurrence. Condor 91:515-544.

Lynch, J. F. 1990. Distribution of overwintering Nearctic migrants in the Yucatan Peninsula, II: Use of native and human-modified vegetation. Pp. 178-196 *in* Ecology and conservation of neotropical migrant landbirds. J. M. Hagan III and D. W. Johnston, eds. Smithsonian Institution Press, Washington, D. C.

Pennington, T. D. and J. Sarukhan. 1968. Arboles tropicales de México. México, D. F., México, Instituto Nacional de Investigaciones Forestales.

Petit, D. R., L. J. Petit, and K. G. Smith. 1990. Habitat associations of migratory birds overwintering in Belize, Central America. Pp. 247-256 *in* Ecology and conservation of neotropical migrant landbirds. J. M. Hagan III and D. W. Johnston, eds. Smithsonian Institution Press, Washington, D.C.

Robbins, C. S., B. A. Dowell, D.K. Dawson, J. A. Colon, R. Estrada, A. Sutton, R. Sutton, and D. Weyer. 1990. Comparison of Neotropical migrant landbird populations wintering in tropical forest, isolated fragments, and agricultural habitats. Pp. 207-210 *in* Ecology and conservation of neotropical migrant landbirds. J. M. Hagan III and D. W. Johnston, eds. Smithsonian Institution Press, Washington, D.C.

Schwartz, N. 1990. Forest society: a social history of Petén, Guatemala. University of Pennsylvania Press, Philadelphia. 367 pp.

Secretaria de Programación y Presupuesto. 1981. Carta de climas 1:1,000,000, Merida. Direccion General de Geografia del Territorio Nacional. Mexico, Mexico.

Secretary of the Navy. 1989. The Nautical Almanac for the year 1991. U. S. Gov't. Printing Office, Washington, D.C.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill, New York. 312 pp.

Waide, R. 1980. Resource partitioning between migrant and resident birds: the use of irregular resources. Pp. 337-352 *in* Migrant birds in the neotropics: ecology, behavior, distribution, and conservation. A. Keast and E. S. Morton, eds. Smithsonian Institution Press, Washington, D. C.

Adding a Landscape Ecology Perspective to Conservation and Management Planning

Kathryn E. Freemark[1], John R. Probst[2], John B. Dunning[3], and Sallie J. Hejl[4]

Abstract — We briefly review concepts in landscape ecology and discuss their relevance to the conservation and management of neotropical migrant landbirds. We then integrate a landscape perspective into a spatially-hierarchical framework for conservation and management planning for neotropical migrant landbirds (and other biota). The framework outlines a comprehensive approach by which managers can develop plans based on (1) assessing the composition and interspersion of habitats important to species of current or future concern at a variety of spatial and temporal scales by generating and using data with different levels of resolution, and (2) assessing and modeling population dynamics and related ecological processes. We reference our paper throughout with selected studies of birds on temperate breeding areas, and to a more limited extent, on migration and neotropical wintering areas.

INTRODUCTION

Landscape ecology is the study of spatial patterns: what they are, how they develop through natural or anthropogenic influences, how they change over time, how they affect biological systems and ecological processes, and how spatial heterogeneity can be managed for societal benefits and survival (see Risser et al. 1984, Turner 1989, Turner and Gardner 1991, Barrett 1992, Hansen and diCastri 1992, Karr 1993, and the journal *Landscape Ecology*). It is a synthetic intersection of many disciplines including ecology, geography, sociology, and economics. The explicit consideration of spatial heterogeneity and human influences, and the emphasis on spatial and temporal dynamics distinguishes landscape ecology from traditional ecological studies which, until recently, have focused on pristine environments and have assumed that systems are spatially homogeneous or at equilibrium.

In this paper, we briefly review concepts in landscape ecology and discuss their relevance to the conservation and management of neotropical migrant landbirds. We then outline a framework which integrates a landscape perspective into a spatially-hierarchial approach to conservation and management planning for neotropical migrant landbirds (and other biota). We illustrate our paper throughout by reference to the most pertinent scientific literature. At present, our knowledge of landscape-level relationships for neotropical migrant landbirds is limited by the lack of research in more extensively forested temperate landscapes (especially northern conifer, southeastern and western forests), in nonforested temperate habitats (e.g. cropland), and during the nonbreeding season.

Landscape Defined

A landscape is comprised of a mosaic of habitat elements (e.g. patches, corridors and the intervening matrix) and resources generated at various scales (Kotliar and Wiens 1990, Barrett 1992, Dunning et al. 1992). The spatial extent of a landscape and the way it is perceived varies among organisms and ecological processes (Turner 1989, Wiens 1989, Karr 1993,

[1] *Environment Canada, Canadian Wildlife Service c/o U.S. Environmental Protection Agency, Environmental Research Laboratory, 200 SW 35th St., Corvallis, OR 97333*

[2] *USDA Forest Service, North Central Forest Experiment Station, Forestry Sciences Laboratory, P.O. Box 898, Rhinelander, WI 54501*

[3] *University of Georgia, Institute of Ecology, 724 Biological Sciences Building, Athens, GA 30602*

[4] *USDA Forest Service, Intermountain Research Station, P.O. Box 8089, Missoula, MT 59807*

Pearson et al. in press). For neotropical migrant landbird species, a landscape occupies the spatial scales intermediate between an individual's territory or home range and a species' regional distribution (e.g. 1-100 km^2). By focussing on intermediate spatial scales, the study of landscape-level patterns and processes may form a bridge between local habitat studies that have been commonly done, and larger scale regional and biogeographical studies.

Landscape Structure

Landscape structure can be characterized by the composition and relative availability of habitat elements, and their spatial arrangement or geometry. When particular or combinations of habitat elements are rare or absent from a landscape, bird species that depend on them are also rare or absent (Dunning and Watts 1990, Thomas et al. 1990, Herkert 1991, Probst and Weinrich in press). The richness, composition and abundance of species within a given habitat element are also affected by patch size, amount of edge, the quantity and quality of resources, and how individuals and their resources are affected by natural and anthropogenic disturbances (Stauffer and Best 1980; Karr and Freemark 1983, 1985; Brown and Dinsmore 1986; Freemark and Merriam 1986; Gotfryd and Hansell 1986; Robbins et al. 1989; Askins et al. 1990; Best et al. 1990; Johnson and Temple 1990; Gibbs et al. 1991; Hejl and Woods 1991; Bollinger and Gavin 1992).

Neotropical migrant landbirds are also significantly affected by the spatial arrangement or geometry of habitat elements in the landscape. For example, less isolated habitat patches support more area-sensitive species than more isolated patches (Askins et al. 1987, Robbins et al. 1989, Gibbs et al. 1991, Freemark and Collins 1992). The orientation of habitat patches within the landscape may also influence their relative importance to neotropical migrant landbirds during migration and the subsequent breeding season (Gutzwiller and Anderson 1992). The nature and extent of the intervening habitat matrix, the nature of boundaries created by the juxtapostion of different habitats, and the presence of corridors that facilitate the movement of individuals across the habitat matrix or boundaries can also significantly affect the species richness, composition and abundance of neotropical migrant landbirds (Wegner and Merriam 1979, Szaro and Jakle 1985, Temple and Cary 1988, Wilcove and Robinson 1990, Hansen and diCastri 1992).

Metapopulations

Populations within individual habitat patches can decline, go extinct, and become re-established by the dispersal of individuals from other patches. Sets of local populations which interact through the dispersal of individuals have been termed metapopulations (Merriam 1988, Opdam 1991). Because of spatial and temporal dynamics in local populations, the distribution pattern of a metapopulation shifts over time (Opdam 1991, Villard et al. 1992). Landscape structure coupled with a species' life-history characteristics (e.g. dispersal capability, productivity, adult/juvenile survival), affects the number of patch populations that can interact, the size of those patch populations, their temporal variability, and ultimately, the survival of the metapopulation (Merriam 1988, Opdam 1991).

There is some evidence that forest bird populations function as metapopulations within landscapes (Freemark 1989, Stacey and Taper 1992, Villard et al. 1992, Probst and Weinrich in press) and regions (Temple and Cary 1988, Robinson 1992). Within a landscape, the probability of local extinction within a habitat patch is inversely related to the size of the patch population which in turn is proportional to patch size and quality. The probability of recolonisation is proportional to proximity and connectedness to similar habitat patches and the permeability of the intervening matrix.

Some authors have suggested that metapopulations exist in a "source-sink" fashion (Pulliam 1988, Howe et al. 1991). Offspring disperse from populations in source areas where productivity exceeds mortality to populations in sink areas which, in the absence of immigration, would go locally extinct. A given area may oscillate between acting as a source or a sink with environmental variation. Computer-simulation models show that sink areas can be occupied by a large fraction of the metapopulation and can make a significant contribution to the size and longevity of the metapopulation (Pulliam 1988, Howe et al. 1991 but see McKelvey et al. 1993). Field data in support of "source-sink" metapopulation structure for neotropical migrant landbirds are currently limited to temperate forests in the east (Villard et al. 1992, Villard et al. in press) and midwest (Temple and Cary 1988, Gibbs and Faaborg 1990, Robinson 1992, Probst and Weinrich in press).

CONSERVATION AND MANAGEMENT IMPLICATIONS

It is becoming increasingly clear that the species richness, composition, abundance and population dynamics of neotropical migrant landbirds cannot be understood solely from processes occurring within individual habitat patches. Effects from the surrounding landscape also have to be considered. Understanding the relationship between landscape structure, management practices, species' distributions and probabilities of local extinction is an important prerequisite for developing and implementing effective conservation and management plans for neotropical migrant landbirds. The need for a landscape-level perspective in land management has been recognized in the "New Forestry" being developed and evaluated in the Pacific Northwest (Franklin 1989, Hansen et al. 1991) and in the "New Perspectives" (now Ecosystem Management) initiatives of the USDA Forest Service (Kessler et al. 1992 and related papers in the same issue).

Metapopulation theory provides an important context for developing conservation and management strategies based on nodes and networks of breeding habitat within and among landscapes (Dyer and Holland 1991, Hudson 1991, Murphy and Noon 1992). For at least some neotropical migrant landbird species, understanding metapopulation dynamics may be essential if viable regional populations are to be maintained (Temple and Cary 1988, Robinson 1992, Probst and Weinrich in press). Without considering metapopulation dynamics, land managers may misinterpret immigration to and local extinction in sink areas as a population response to management actions. Cumulative impacts of habitat alterations may be underestimated, particularly for productive, source areas. For example, actions that reduce the abundance and size of suitable habitat below extinction thresholds for the metapopulation may lead to the regional extirpation of a species even if some habitat of suitable quality remains (Lamberson et al. 1992). The failure of existing bird-habitat models to adequately predict population density among different locations and times is related, at least in part, to such landscape-level effects (Van Horne and Wiens 1991).

Effective conservation of neotropical migrant landbirds may require the preservation of suitable but intermittently unoccupied habitat. Efforts to identify critical habitat areas and landscapes need to consider differences in population demography and variability, and species-specific dispersal characteristics as well as population density (Van Horne 1983, Pulliam 1988, Murphy and Noon 1992, Probst and Weinrich in press). In the absence of such information, management plans should protect the diversity of habitats and landscapes used by a species, not just where the species is most common. In some situations, a diversity of habitats and landscapes may be maintained by attempting to mimic the composition and geometry of presettlement landscapes (Thomas et al. 1990, Hejl in press).

A Comprehensive Framework for Conservation and Management Planning

In the remainder of this paper, we outline a framework for conservation and management planning for neotropical migrant landbirds (and other taxa) which incorporates a landscape perspective. Our objective is to provide managers with a more comprehensive approach to planning based on (1) assessing the composition and interspersion of habitats important to species of current or future concern at a variety of spatial and temporal scales by generating and using data with different levels of resolution, and (2) assessing and modeling population dynamics and related ecological processes.

The framework (Figure 1) evolved from guidelines in Probst and Crow (1991). It includes assessments of spatial relationships and population demographics of neotropical migrant landbirds measured by extensive and intensive methods at continental to local spatial scales within and between breeding seasons. Initial activities (Figure 1: Activity 1-3) assess species distributions and population trends relative to different geographic areas, physiographic regions, landforms (sensu Swanson et al. 1988), habitats and land ownerships, in order to target species or their habitats because of concerns about limited distribution, insufficient protection of important areas, sensitivity to habitat fragmentation or other landscape alteration, or recent or long-term declines. Existing breeding bird inventory and monitoring data can be used if available and, if necesary, supplemented by specific field surveys. Otherwise, targetted field surveys are required to generate input data. This approach is similar but more comprehensive than that being used in gap analysis to assess the adequacy of habitat protection for maintaining biodiversity (Scott et al. 1987), and by the Partners in Flight program to prioritize species and habitats of concern.

Activities to examine aspects of landscape structure (Figure 1: Activity 4-6) are used to understand spatial distributions of neotropical migrant landbirds in terms of population demographics and metapopulation dynamics. Field studies contrasting existing landscapes need to be done (cf. Freemark and Collins 1992, Pearson et al. in press), and in some circumstances, may be conducted by altering landscape structure experimentally (cf. Franklin 1989, Rodenhouse et al. 1992).

Differences in bird species patterns among landscapes should be measured by population density, productivity and survivorship. Indirect measures of productivity such as population variability within and between years (Villard et al. 1992, Probst and Weinrich in press), mating status of males (Probst and Hayes 1987, Gibbs and Faaborg 1990, Villard et al. in press), and adult:young ratios are most easily used for more extensive surveys, but need to be supplemented with direct measures of nesting success. Juvenile survival rates, while important, are notoriously difficult to measure because juveniles disperse from their natal areas and birds that disappear from a study area may survive elsewhere (Pulliam et al. 1992). Estimating adult survival is easy because most (but not all) adults which nest successfully usually return year after year to the same breeding site. Better field data are needed on dispersal, especially for juveniles (Pulliam et al. 1992, Villard et al. 1992). By understanding the mechanisms underlying population distribution and dynamics, problems associated with nonbreeding habitats (resulting in poor survival) can begin to be separated from problems associated with alteration of breeding habitats (resulting in poor productivity). The information can be used to evaluate, modify or design sampling schemes for population or demographic monitoring of specific neotropical migrant landbird species, habitats, geographical areas or latitudes.

The use of spatially explicit computer models is recommended (Figure 1: Activity 5-7) to simulate metapopulation dynamics (e.g. Howe et al. 1991, Lamberson et al. 1992, Pulliam et al. 1992, McKelvey et al. 1993, Thompson in press, also see review by Merriam et al. 1991). Models can be used to help focus research, monitoring, and conservation and management efforts, and to simulate short- and long-term impacts on neotropical migrant landbird populations of current

FRAMEWORK FOR CONSERVATION AND MANAGEMENT PLANNING

Activity	Application
1. Overlay: - Breeding range/abundance maps - Landform/physiographic/habitat maps - Ownership maps	Determine centers of breeding distribution ***Continental Scale***
2. Evaluate species by habitat breadth (from existing data, if available)	Field surveys: - Fill data gaps - Compare observed vs. expected habitat distribution ***Regional Scale***
3. Target habitats/species ° Low frequency - Rare habitat? - Range border? - Poor habitat definition? - Patch area effects? - Isolation/edge effects ° High frequency -Declines in abundance	Field surveys: Improve distribution data ***Landscape-Regional Scales***
4. Test contrasting landscape structures	Field studies: ° Density Differences ° Contrast productivity indirectly (Population σ, % Mated, etc.) ° Perform landscape alteration ***Landscape-Local Scales***
5. Develop Landscape/regional habitat map incorporating metapopulation dynamics (e.g. source vs. sink)	° Model metapopulation dynamics ° Relate to monitoring ° Relate to habitat alterations ***Landscape-Regional Scales***
6. Measure directly: - Habitat productivity (# nests, nest success, etc.) - Survivorship of selected species or within selected habitats - Juvenile/adult dispersal	Calibrate/refine metapopulation models ***Local Scale***
7. Model for desired future condition - Habitat type/interspersion objectives - Succession: abandonment vs. regeneration - Cropping/rotation patterns - Land management practices (e.g. pesticides) - Predicting/planning for global change	
8. Develop/implement/monitor conservation and management plans	
9. Extend to migration and Neotropical areas	
10. Extend to Integrated Resource Management	

Figure 1. — A comprehensive, spatially-hierarchical framework for developing conservation and management plans for neotropical migrant landbird species (and other biota). Relevant spatial scales are indicated in bold.

and alternative management strategies for a landscape (Pulliam et al. 1992, Murphy and Noon 1992). For the greatest accuracy in developing conservationa and management strategies, models should reflect local landscape structure(s) and if possible, use local, habitat-specific information about population demography and bird dispersal behavior (Hansen et al. 1992, Pulliam et al. 1992).

Toward this end, a major innovation is the linkage of computer simulation models with geographic information systems (GIS). Management agencies are increasingly turning to GIS technology to map their holdings. These databases are ideal for generating current and future landscape maps. By linking these maps to a population simulation model, the impact of a change in management strategy (e.g. habitat type/interspersion objectives, cropping/rotation patterns, pesticide use) can be observed for the actual landscapes where the changes have been proposed (Pulliam et al. 1992, McKelvey et al. 1993). If demographic and habitat variation can be linked, then spatially explicit models could also be used to simulate impacts of global change on neotropical migrant landbirds, and to help focus related research, monitoring and conservation activities.

The development, implementation and monitoring of such comprehensive conservation and management plans (Figure 1: Activity 8) will require cooperative efforts among many researchers and land managers from many different organizations. Initially, plans will be superficial because of insufficient data but they will become increasingly more detailed and complex as additional information is generated. Use of landscape-level experiments, demonstration areas and adaptive management strategies should facilitate implementation and refinement of conservation and management plans.

At present, our approach is best developed for temperate breeding areas. However, we recognize that it needs to be extended to stopover areas and neotropical areas (Figure 1: Activity 9) if conservation planning for neotropical migrant landbirds is to be truly effective. Eventually, conservation and management plans for neotropical migrant landbirds need to be incorporated into integrated resource management strategies (Wilcove 1989, Probst and Crow 1991; Figure 1: Activity 10). Mechanisms for doing need to be developed.

Efforts to conserve neotropical migrant landbirds (and other biota) must occur on lands having a variety of uses and ownerships. Consequently, approaches for regional decision-making and cross-boundary management (both administratively and on the ground) need to be developed (Headley 1980, Schonewald-Cox et al. 1992). To be effective, approaches will have to include ecological, socio-economic, legal, cultural, ethical and aesthetic considerations (Nassauer and Westmacott 1987, Dearden 1988, Hansen et al. 1991, Kessler et al. 1992, Schonewald-Cox et al. 1992). The resolution of conflicts will require effective education and communication, and carefully designed mechanisms for planning, co-operation and co-ordination (Grumbine 1992, Schonewald-Cox et al. 1992). In this regard, the Partners in Flight program and this workshop have been important first steps.

ACKNOWLEDGMENTS

We thank R.A. Askins, B.R. Noon, S.M. Pearson, and the editors for helpful comments on an earlier draft. Funding for K.Freemark was provided by an Interagency Agreement (DWCN935524) between Environment Canada and the U.S. Environmental Protection Agency. This paper has been subject to the agency's peer and administrative review, and has been approved for publication. Funding for J.Dunning was provided in part by the U.S. Environmental Protection Agency, the Biodiversity Research Program of the U.S. Department of Energy, and USDA Forest Service Southeast Forest Experiment Station.

LITERATURE CITED

Askins, R.A., J.F. Lynch and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7:1-57.

Askins, R.A., M.J. Philbrick and D.S. Sugeno. 1987. Relationship between the regional abundance of forest and the composition of forest bird communities. Biol. Conserv. 39:129-152.

Barrett, G. 1992. Landscape ecology: Designing sustainable agricultural landscapes. J. Sustainable Agr. 2:83-103.

Best, L.B., R.C. Whitmore and G.M. Booth. 1990. Use of cornfields by birds during the breeding season: The importance of edge habitat. Am. Midl. Nat. 123:84-99.

Bollinger, E.K. and T.A. Gavin. 1992. Eastern Bobolink populations: Ecology and conservation in an agricultural landscape. Pp. 483-496 IN: J.M. Hagan and D.W. Johnston (eds.). Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, DC, USA. 609 pp.

Brown, M., and J.J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. J. Wildl. Manage. 50:392-397.

Dearden, P. 1988. Landscape aesthetics, tourism and landscape management in British Columbia. Pp. 183-190 IN: M.R. Moss (ed.). Landscape Ecology and Management. Polyscience Publ., Montreal, Quebec, Canada. 240 pp.

Dunning, J.B. Jr., B.J. Danielson and H.R. Pulliam. 1992. Ecological processes that affect populations in complex landscapes. Oikos 65:169-175.

Dunning, J.B. and B.D. Watts. 1990. Regional differences in habitat occupancy by Bachman's Sparrow. Auk 107:463-472.

Dyer, M.I. and M.M. Holland. 1991. The biosphere-reserve concept: Needs for a network design. BioScience 41:319-325.

Franklin, J. 1989. Toward a new forestry. Am. For. Nov/Dec.:37-44.

Freemark, K.E. 1989. Landscape ecology of forest birds in the northeast. Pp. 7-12 IN: R.M. DeGraaf and W.M. Healy (compil.). Is Forest Fragmentation a Management Issue in the Northeast? USDA Forest Service, Northeastern Forest Experiment Station Gen. Tech. Rep. NE-140. 32 pp.

Freemark, K.E. and B. Collins. 1992. Landscape ecology of birds breeding in temperate forest fragments. Pp. 443-454 IN: J.M. Hagan and D.W. Johnston (eds.). Ecology & Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, DC, USA. 609 pp.

Freemark, K.E. and H.G. Merriam. 1986. Importance of area and habitat heterogeneity to bird assemblages in temperate forest fragments. Biol. Conserv. 36:115-141.

Gibbs, J.P. and J. Faaborg. 1990. Estimating the viability of Ovenbird and Kentucky Warbler populations in forest fragments. Conserv. Biol. 4:193-196.

Gibbs, J.P., J.R. Longcore, D.G. McAuley and J.K. Ringelman. 1991. Use of Wetland Habitats by Selected Nongame Water Birds in Maine. U.S. Fish Wildl. Serv., Fish and Wildlife Research 9, Washington, DC. 57 pp.

Gotfryd, A. and R.I.C. Hansell. 1986. Prediction of bird-community metrics in urban woodlots. Pp. 321-326. IN: J. Verner, M.L. Morrison and C.J. Ralph (eds.). Modeling Habitat Relationships of Terrestrial Vertebrates. University of Wisconsin Press, Madison, WI, USA. 470 pp.

Grumbine, R.E. 1991. Co-operation or conflict? Interagency relationships and the future of biodiversity of US parks and forests. Environ. Manage. 15:27-37.

Gutzwiller, K.J. and S.H. Anderson. 1992. Interception of moving organisms: influences of patch shape, size, and orientation on community structure. Landscape Ecology 6:293-303.

Hansen, A.J. and F. diCastri (eds.). 1992. Landscape Boundaries: Consequences for Biotic Diversity and Ecological Flows. Ecological Studies 92, Springer-Verlag, New York, NY, USA. 452 pp.

Hansen, A.J., T.A. Spies, F.J. Swanson and J.L. Ohmann. 1991. Conserving biodiversity in managed forests. BioScience 41:382-392.

Hansen, A.J., D.L. Urban and B. Marks. 1992. Avian community dynamics: The interplay of landscape trajectories and species life histories. pp. 170-195 IN: A.J. Hansen and F. diCastri (eds.). Landscape Boundaries: Consequences for Biotic Diversity and Ecological Flows. Springer-Verlag, New York, NY, USA. 452 pp. Headley, J.C. 1980. The economic milieu of pest control: Have past priorities changed? Pp. 81-97 IN: D. Pimentel and J.H. Perkins (eds.). Pest Control: Cultural and Environmental Aspects. Westview Press, Boulder, CO, USA. 243 pp.

Hejl, S.J. In press. The importance of landscape patterns to bird diversity: A perspective from the Northern Rocky Mountains. Northwest Environmental Journal.

Hejl, S.J. and R.E. Woods. 1991. Bird assemblages in old-growth and rotation-aged Douglas-fir/ponderosa pine stands in the northern Rocky Mountains: A preliminary assessment. Pp. 93-100 IN: D.M. Baumgartner and J.E. Lotan (eds.). Proc. of the Symposium on Interior Douglas-fir: The Species and Its Management. Washington State Univ., Pullman, WA, USA.

Herkert, J.R. 1991. Prairie birds of Illinois: Population response to two centuries of habitat change. Ill. Nat. Hist. Surv. Bull. 34: 393-399.

Howe, R.W., G.J. Davis and V. Mosca. 1991. Demographic significance of sink populations. Biol. Cons. 57:239-255.

Hudson, W. (ed.). 1991. Landscape linkages and biodiversity. Island Press, Washington, DC, USA.

Johnson, R.G., and S.A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. J. Wildl. Manage. 54:106-111.

Karr, J.R. 1993. Landscapes and management for ecological integrity. IN: K.C. Kim and R.D. Weaver (eds.). Biodiversity and Landscape: A Paradox for Humanity. Cambridge University Press, New York. In press.

Karr, J.R. and K.E. Freemark. 1983. Habitat selection and environmental gradients: Dynamics in the "stable" tropics. Ecology 64:1481-1494.

Karr, J.R. and K.E. Freemark. 1985. Disturbance and vertebrates: An integrative perspective. Pp. 153-168 IN: S.T.A. Pickett and P.S. White (eds.). The Ecology of Natural Disturbance and Patch Dynamics. Academic Press, New York, NY, USA. 472 pp.

Kessler, W.B., H. Salwasser, C.W. Cartwright Jr. and J.A. Caplan. 1992. New perspectives for sustainable natural resources management. Ecol. Appl. 2:221-225.

Kotliar, N.B. and J.A. Wiens. 1990. Multiple scales of patchiness and patch structure: a hierarchical framework for the study of heterogeneity. Oikos 59: 253-260.

Lamberson, R.H., R. McKelvey, B.R. Noon and C. Voss. 1992. The effects of varying dispersal capabilities on the population dynamics of the northern spotted owl. Conserv. Biol. 6: 1-8.

McKelvey, K., B.R. Noon and R.H. Lamberson. 1993. Conservation planning for species occupying fragmented landscapes: The case of the northern spotted owl. IN: P.M. Kareiva, J.G. Kingslover and R.B. Huey (eds.). Biotic Interactions and Global Change. Sinauer Assoc., Sunderland, MA, USA. In press.

Merriam, G. 1988. Landscape dynamics in farmland. Trends Ecol. Evol. 3:16-20.

Merriam, G., K. Henein and K. Stuart-Smith. 1991. Landscape dynamics models. Pp. 399-416 IN: M.G. Turner and R. H. Gardner. Quantitative Methods in Landscape Ecology. Ecological Studies 82, Springer-Verlag, New York, NY, USA. 536 pp.

Murphy, D.D. and B.R. Noon. 1992. Integrating scientific methods with habitat conservation planning: Reserve design for Northern Spotted Owls. Ecol. Appl. 2:3-17.

Nassauer, J.I and R. Westmacott. 1987. Progressiveness among farmers as a factor in heterogeneity of farmed landscapes. Pp. 199-210 IN: M.G. Turner (ed.). Landscape heterogeneity and Disturbance. Springer-Verlag, New York, NY, USA. 241 pp.

Opdam, P. 1991. Metapopulation theory and habitat fragmentation: a review of holarctic breeding bird studies. Landscape Ecology 5:93-106.

Pearson, S.M., M.G. Turner, R.H. Gardner and R.V. O'Neill. In press. An organism-based perspective of habitat fragmentation. IN: R.C. Szaro (ed.). Biodiversity in Managed Landscapes: Theory and Practice. Oxford University Press.

Probst, J.R. and T.R. Crow. 1991. Integrating biological diversity and resource management: an essential approach to productive, sustainable ecosystems. J.Forestry 89(2):12-17.

Probst, J.R. and J.P. Hayes. 1987. Pairing success of Kirtland's warblers in marginal versus suitable habitat. Auk 104:234-241.

Probst, J.R. and J. Weinrich. In press. Relating Kirtland's warbler population to changing landscape composition and structure. Landscape Ecology.

Pulliam, H.R. 1988. Sources, sinks, and population regulation. Am. Nat. 132:652-661.

Pulliam, H.R., J.B. Dunning, and J. Liu. 1992. Population dynamics in complex landscapes: A case study. Ecol. Appl. 2:165-177.

Risser, P.G., J.R. Karr and R.T.T. Forman. 1984. Landscape Ecology: Directions and Approaches. Ill. Nat. Hist. Surv. Spec. Publ. 2, Champaign, IL, USA. 18 pp.

Robbins, C.S., D.K. Dawson and B.A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildl. Monogr. 103:1-34.

Robinson, S.K. 1992. Population dynamics of breeding Neotropical migrants in a fragmented Illinois landscape. Pp. 408-418 IN: J.M. Hagan and D.W. Johnston (eds.). Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, DC, USA. 609 pp.

Rodenhouse, N.L., G.W. Barrett, D.M. Zimmerman and J.C. Kemp. 1992. Effects of uncultivated corridors on arthropod abundances and crop yields in soybean agroecosystems. Agr. Ecosyst. Environ. 38:179-191.

Schonewald-Cox, C., M. Buechner, R. Sauvajot, and B.A. Wilcox. 1992. Cross-boundary management between national parks and surrounding lands: A review and discussion. Environ. Manage. 16:273-282.

Scott, J.M., B. Csuti, J.D. Jacobi, and J.E. Estes. 1987. Species richness: A geographic approach to protecting future biological diversity. BioScience 37:782-788.

Stacey, P.B. and M. Taper. 1992. Environmental variation and the persistence of small populations. Ecol. Appl. 2:18-29.

Stauffer, D.F., and L.B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 44:1-15.

Swanson, F.J., T.K. Kratz, N. Caine and R.B. Woodmansee. 1988. Landform effects on ecosystem patterns and processes. BioScience 38:92-98.

Szaro, R.C., and M.D. Jakle. 1985. Avian use of a desert riparian island and its adjacent scrub habitat. Condor 87:511-519.

Temple, S.A. and J.R. Cary. 1988. Modeling dynamics of habitat-interior bird populations in fragmented landscapes. Conservation Biol. 2:340-347.

Thomas, J.W., E.D. Forsman, J.B. Lint, E.C. Meslow, B.R. Noon, and J. Verner. 1990. A Conservation Strategy for the Northern Spotted Owl. Report of the Interagency Scientific Committee to address the conservation of the Northern Spotted Owl. United States Government Printing Office 1990-791-171/20026, Washington, DC, USA.

Thompson, F. In Press. Simulation response of a forest-interior bird population to forest management options in the Central Hardwoods of the United States. Conservation Biology.

Turner, M.G. 1989. Landscape ecology: the effect of pattern on process. Annu. Rev. Ecol. Syst. 20:171-197.

Turner, M.G., and R.H. Gardner. 1991. Quantitative Methods in Landscape Ecology. Ecological Studies 82, Springer-Verlag, New York, NY, USA. 536 pp.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:89-101.

Van Horne, B. and J.A. Wiens. 1991. Forest Bird Habitat Suitability Models and the Development of General Habitat Models. U.S. Fish and Wildlife Service, Fish Wildl. Research 8, Washington, D.C. 31 pp.

Villard, M.-A., K.E. Freemark and H.G. Merriam. 1992. Metapopulation theory and neotropical migrant birds in temperate forests: An empirical investigation. Pp. 474-482 IN: J.M. Hagan and D.W. Johnston (eds.). Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, DC, USA. 609 pp.

Villard, M.A., P.R. Martin and C.G. Drummond. In press. Habitat fragmentation and pairing success in the Ovenbird. Auk

Wegner, J.F. and G. Merriam. 1979. Movements by birds and small mammals between a wood and adjoining farmland habitats. J. Appl. Ecol. 16:349-357.

Wiens, J. A. 1989. Spatial scaling in ecology. Funct. Ecol. 3: 385-397.

Wilcove, D.S. 1989. Protecting biodiversity in multiple-use lands: Lessons from the US Forest Service. Trends Ecol. Evol. 4:385-388.

Wilcove, D.S. and S.K. Robinson. 1990. The impact of forest fragmentation on bird communities in eastern North America. Pp. 319-331 IN: A. Keast (ed.). Biogeography and Ecology of Forest Bird Communities. SPB Academic Publ., The Hague, The Netherlands. 410 pp.

Silvicultural Options for Neotropical Migratory Birds

Frank R. Thompson III[1], John R. Probst[2], and Martin G. Raphael[3]

Abstract — We review: factors that affect forest bird populations; basic concepts of silvicultural systems; potential impacts of these systems on neotropical migratory birds (NTMBs); and conclude with management recommendations for integrating NTMB conservation with forest management. We approach this topic from a regional-landscape scale to a forest stand-habitat scale, rather than the traditional stand-level approach. Populations are determined by interactions between local habitat factors such as vegetation structure and regional or landscape features such as total habitat area, amount of edge, habitat context, and biogeography. The four silvicultural systems commonly used in North America are selection, shelterwood, seed tree, and clearcutting systems. Clearcutting, seed tree, and shelterwood systems create a mosaic of evenaged stands; the selection system maintains an unevenaged forest or stand. Evenaged management creates an age-class distribution of forest stands that may differ from landscapes with no timber harvest. Juxtaposition of different aged stands results in increased amounts of edge in the forest which may affect the reproductive success of NTMB, but consequences of this may not be significant compared to alteration of forest age-class structure. Regeneration or harvest cuts result in replacement of a mature forest bird community with a young forest bird community. Selection cutting retains much of the mature forest bird community within a stand as well as providing habitat for some early successional species that use the shrub-sapling layer. Edge effects around group selection cuts may be a concern because these openings, although small, may be numerous and widespread.

NTMBs have diverse requirements for nesting and foraging. We believe the only way to incorporate their diverse needs with other forest resources is a hierarchial, top down, approach that begins at a continental scale, identifies opportunities at regional scales, sets composition and structure goals at a landscape scale and management unit scale, and matches management prescriptions to goals at a habitat-stand scale. We make NTMB management recommendations at each of these scales.

[1]*North Central Forest Experiment Station, 1-26 Agriculture Bldg., Univ. of Missouri, Columbia, Missouri 65211.*

[2]*North Central Forest Experiment Station, P. O. Box 898, Rhinelander, Wisconsin 54501-0898.*

[3]*Pacific Northwest Forest and Range Experiment Station, 3625 93rd Avenue, SW, Olympia, Washington 98502.*

INTRODUCTION

We review common silvicultural systems used in North America and their impacts on forest-dwelling NTMBs. Other papers in this symposia address silvicultural impacts in specific forest types in different regions of the continent; we focus more generally on silvicultural systems and their effects on landscape pattern and structure, stand structure, and processes that affect populations of NTMB. We review habitat factors that affect breeding forest birds, basic concepts of silviculture, and potential impacts of these systems with emphasis on harvest and regeneration methods. We do not provide a complete review of literature on this topic, but identify what we believe are major impacts and processes impacting NTMBs in managed forests, and document these with representative citations. Most research on silviculture and its impact on birds has occurred at the stand or habitat level, and only occasionally are large-scale inferences made. Given current emphasis on ecosystem management and application of principles of landscape ecology to forest management, we approach this topic from a regional-landscape scale to a stand-habitat scale, rather than the traditional stand-level approach. We conclude by suggesting an approach for integrating NTMB conservation with other forest resource management and some general guidelines for landscape and habitat composition and structure for different segments of the NTMB community.

LANDSCAPE AND LOCAL FACTORS AFFECTING POPULATIONS

Population levels and viability are determined by interactions between local habitat factors and regional or landscape features such as total habitat area, habitat context and biogeography. A large area of suitable habitat will support a larger population, lower local extinction rates, and greater potential to produce excess individuals for dispersal to remote or less productive areas, than will a small habitat patch. Smaller habitat patches not only have higher local extinction rates, but are less likely to be colonized or re-colonized. Such patterns were originally observed in oceanic islands (MacArthur and Wilson 1967) but have been extended to habitat islands as well. Species requiring large patches of fairly homogeneous habitat are said to be "area-sensitive". Many NTMB in the eastern U. S. are considered area sensitive because they are often absent from small habitat fragments (Whitcomb et al 1981, Ambuel and Temple 1983, Blake & Karr 1984, Hayden et al. 1985, Robbins et al. 1989, Faaborg et al. this proceedings). A major reason for NTMB area-sensitivity is that many NTMB have lower reproductive success near forest edges and in edge-dominated forest fragments due to predation and brood parasitism (Gates & Gysel 1978, Brittingham & Temple 1983, Robinson 1992, Temple & Cary 1988). While edge-related declines in reproductive success in forests fragmented by non-forest habitats are a likely cause of area sensitivity (Temple and Cary 1988) , the effects of edges created by timber harvest in predominately forested landscapes is unclear.

Large scale (regional, landscape) factors may impose important "top down constraints" (Mauer, this proceedings) on the way NTMB respond locally to silvicuture. For instance, the effects of edge and openings created by timber harvest on levels of nest predation and parasitism may depend on the landscape context. Examples of important context considerations for NTMB are the amount of forest versus agricultural land, and the overall level of forest fragmentation. In some fragmented landscapes brood parasitism and predation are extremely high but unrelated to distance to edge. Predator and cowbird numbers may be so high in these landscapes that they saturate forest habitats (Robinson et al. this proceedings). In extensively forested landscapes cowbird and predator numbers may be so low that their influence is limited to forest edges. We discuss edge effects resulting from silviculture later.

At a local or habitat level, birds appear to select nesting and foraging habitats based on an array of factors including vegetation structure; life-forms or presence or volume of vegetative strata; plant or tree species composition; and special features such as snags, streams, or cliffs. Stand or habitat level factors affecting these include forest type, history of disturbance, forest age, and site quality. Forest type and disturbance history determine plant composition and potential vegetation structure. Forest age affects such attributes as tree size, foliage volume, foliage stratification, horizontal patchiness, bark surface area, cavity formation, coarse woody debris, and other special features. Neotropical migrants use forests of all ages, but the importance of different-aged forests to NTMB varies (Fig. 1). Site quality affects forest type composition, successional pathways, the rate of succession, and vegetation structure, especially stature or tree height. Finally, there are cause and effect interactions between vegetation structure and vegetative composition, such as overstory-understory relationships.

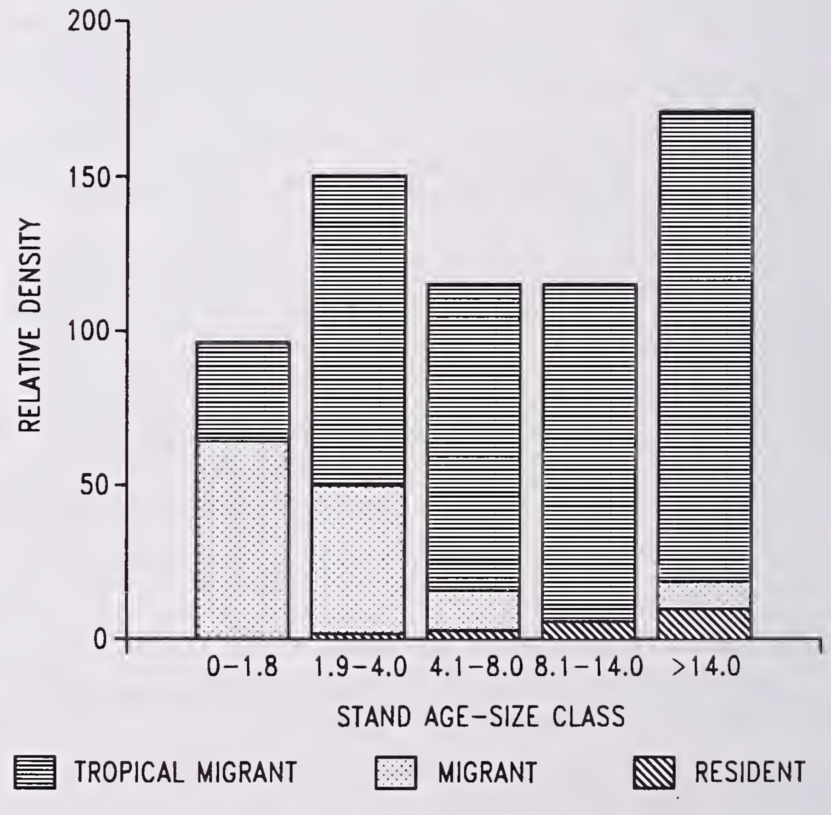


Figure 1. — Comunity compositon by migration status in different age (height) aspen forests. Adapted from Probst et al. (1992).

SILVICULTURE

Silviculture is the theory and practice of controlling forest establishment, composition, structure, and growth (Smith 1962). Silviculture is usually thought of in the context of timber production, though it should be interpreted more broadly to include other possible objectives such as conservation of biological diversity or NTMBs.

Silvicultural treatments are applied at the stand level. A stand is a contiguous group of trees sufficiently uniform in species composition and structure to serve as a management unit. Stands are often equated to animal habitats, communities, or even ecosystems (Hunter 1990). Stands are usually identified by the composition and structure of vegetation currently occupying a site, but sometimes are based on ecological classification systems as well. Management is usually regulated at a larger scale often referred to as the forest, which is a collection of stands administered as a integrated unit (Smith 1962). Often a forest is sub-divided into management compartments.

Silvicultural Systems

A silvicultural system is a program of forest management for an entire rotation of a stand. It includes harvest cutting, regeneration of the stand, and intermediate treatments. Silvicultural systems are often referred to on the basis of the regeneration method used because these practices have such a large impact on the future of a stand. Regeneration methods establish tree reproduction and usually simultaneously harvest timber.

The four silvicultural systems commonly used in North America are the selection, shelterwood, seed tree, and clearcutting systems (USDA Forest Service 1973). An important distinction among silvicultural systems is whether they maintain evenaged or unevenaged stands. In evenaged stands, trees are the same age class although there may vary in diameter. The diameter distribution of these stands is typically a bell-shaped curve. An unevenaged stand contains at least three age classes. Often the height profile of a stand is more characteristic of its age-class distribution than are tree diameters; an evenaged stand tends to have a level canopy while an unevenaged stand is distinctly irregular in height. The selection method is used to maintain unevenaged forests; the clearcut, seed tree, and shelterwood methods maintain evenaged stands. Some alternatives to these traditional evenaged practices maintain two-aged stands.

Evenaged Systems

Under evenaged management harvest and regeneration is regulated by area and is a function of rotation age, that is, age at which a stand is regenerated. Rotation age is based on economic, aesthetic, structural, or ecological management objectives. The goal of regulation is usually to provide a sustained yield of products or other uses and values over time. It is important to recognize that this occurs at the forest, not the stand level. Three methods have traditionally been used to harvest or regenerate stands (Smith 1962):

Clearcutting method--Removal of the entire stand in one cutting. Size of the stand varies from small patches (<1 ha) to extensive (>100 ha).

Seed Tree Method--Removal as in clearcutting except a small proportion of the original stand is left to reseed the harvested area.

Shelterwood Method--Gradual removal of the entire stand in a series of partial cuttings which extend over a fraction of the rotation. Regeneration is established under the protection of a partial overstory before the final removal cut.

A number of alternative regeneration methods have recently been tried in attempt to meet public opposition to clearcutting and to address ecological concerns. *Patch cutting* involves creating small clearcuts (<1 ha). It differs from selection cutting because cutting is regulated by area, as with other evenaged practices, and not stand structure as in selection cutting. *Aesthetic shelterwoods* are similar to traditional shelterwoods except the removal cut is done over widely spaced entries, or a final removal is never made and a portion of the original stand is left. *Two-age silviculture* does not fit neatly into unevenaged or evenaged systems, though it most closely resembles evenaged systems in its application. It is accomplished by removing half the stand every half rotation, which results in two distinct age classes present throughout the rotation (Marquis 1989).

Unevenaged Systems

In unevenaged systems, single trees or small groups of trees are periodically harvested. Trees are selected on the basis of age, diameter, vigor, form, and species with the objective of maintaining a relatively consistent stand structure. Sustained yield can be accomplished within a stand if a balanced size-class distribution is maintained within the stand. The desired size class distribution for a balanced stand is defined by the largest desired tree size and the ratio of the number trees in successive diameter classes (q-value). Thus regulation is by volume and diameter rather than by area under evenaged management. There is tremendous variation in the implementation of the selection system though harvest is classified as one of two methods:

1. **Single-tree selection**--Trees are removed as single scattered trees.
2. **Group selection**--Trees are removed in small groups.

Often single-tree selection and group selection are performed together; this is sometimes refered to as selection with groups (Law and Lorimer 1989). Groups may be harvested to establish regeneration of less tolerant species and single trees removed to balance larger diameter classes or regenerate tolerant species.

Silvicultural Practices

Silvicultural practices can be divided into two broad categories: regeneration practices and intermediate treatments. The objective of regeneration practices is to establish a new stand , whereas the objective of intermediate treatments is to regulate stand composition, structure, and growth, as well as provide some early products (Smith 1962). Many other practices associated with silviculture and forest management may affect NTMB such as pest control, salvage, fire management, and road building, but these are beyond the scope of this paper.

Regeneration Practices

Following or during harvest a stand is treated to create conditions favorable for regeneration of desired species. Site preparation may dispose of slash (debris left from harvest cuts), reduce competition from unharvested vegetation, or prepare the soil for the new trees. Slash may be removed to reduce potential fuel for forest fires or because it creates too much shade or physically impedes the regeneration of the stand. Slash disposal commonly occurs in the western forests in combination with planting. Slash is disposed of by broadcast burning, piling and burning, lopping and scattering, or chopping on site. Seedbeed preparation usually consists of exposing the mineral soil by removing the organic matter. Predominant methods are prescribed burning and scarification, that is, the mechanical removal or mixing of the organic matter with mineral soil. Competing vegetation may be controlled by prescribed burning, mechanical treatment, or herbicides. Presribed burning may also be used to promote desireable species that are adapted to or dependent on fire. Artificial regeneration occurs by planting young trees or seeding before or after removing the old stand. Artificial regeneration is most commonly used for conifers because the probability of success and high financial yield are often greater than for hardwoods. Natural regeneration occurs from natural seeding or from stump and root sprouts. The essential step in natural regeneration is to ensure that there is an adequate seed source, advanced reproduction, or potential for sprouting. Advance reproduction is natural reproduction that is present before a stand is regenerated.

Intermediate Treatments

Intermediate treatments are those done between regeneration periods. Release cuttings are used to free desirable trees in a young stand not past the sapling stage from the competition. Three types of release cuttings are: weeding, which removes all competitors; cleaning, which removes overtopping competitors of the same age; and liberation, which removes overtopping competitors that are older. Because competing vegetation often resprouts if simply cut or girdled, herbicides are often used alone or in combination with cutting or girdling.

Thinnings are selective removal of trees in stands past sapling stage. They harvest some trees that normally die from competition in immature stands and perhaps more importantly, they redirect and accelerate growth on selected trees that are released. There are two general types of thinnings. Low thinning removes trees from lower crown classes, salvaging trees that would normally die, and possibly reducing root competition. Crown thinning removes trees from middle and upper portion of the canopy to favor development of selected trees.

IMPACTS ON HABITAT AND BIRDS

Evenaged Systems

Landscape Composition

Evenaged management creates a specific age-class distribution of forest habitats that usually differs from forests with no timber harvest. Assuming timber harvest is regulated to provide sustained yield over time, rotation age will determine the amount of forest in any given age class and overall proportion of forest stands in young versus older age-classes. Forests managed by evenaged management could have more or less early successional forest than natural landscapes depending on rotation age and frequency of natural disturbances. For instance, an oak-hickory forest managed by regulated clearcutting on a 100-year rotation would be comprised of approximately 10% regeneration (stands 1-10 years old). Managed forests often contain more early successional forests and NTMB than historically before logging (Fig. 2), or than unmanaged forests. For example, Raphael et al. (1988) modeled large scale changes in bird populations in Douglas-fir forests of

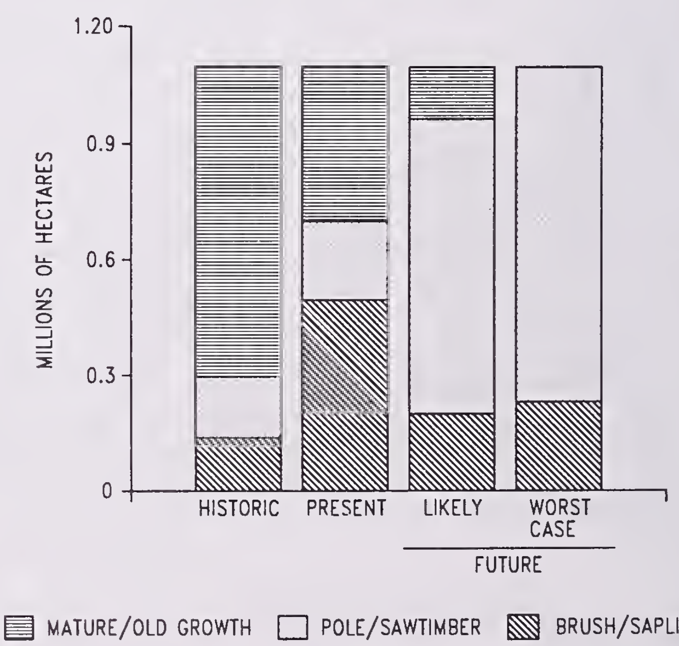


Figure 2. — Forest area occupied by three seral stages of Douglas-fir forest in northwestern California in historic times, at present, and under two projected trends (Raphael et al. 1988).

Northwestern California based on the impacts of forest management on landscape composition. They compared presettlement, present day, and future bird populations given current management trends. They concluded that early seral species were currently at a peak compared to historic levels, and that mature forest species had declined and would continue to do so. Thompson et al. (1992) compared NTMB in landscapes managed by clearcutting to those in wilderness areas with no timber harvest. Total density of early successional NTMBs were much greater, and forest interior NTMBs slightly lower in landscapes managed by clearcutting (Figure 3).

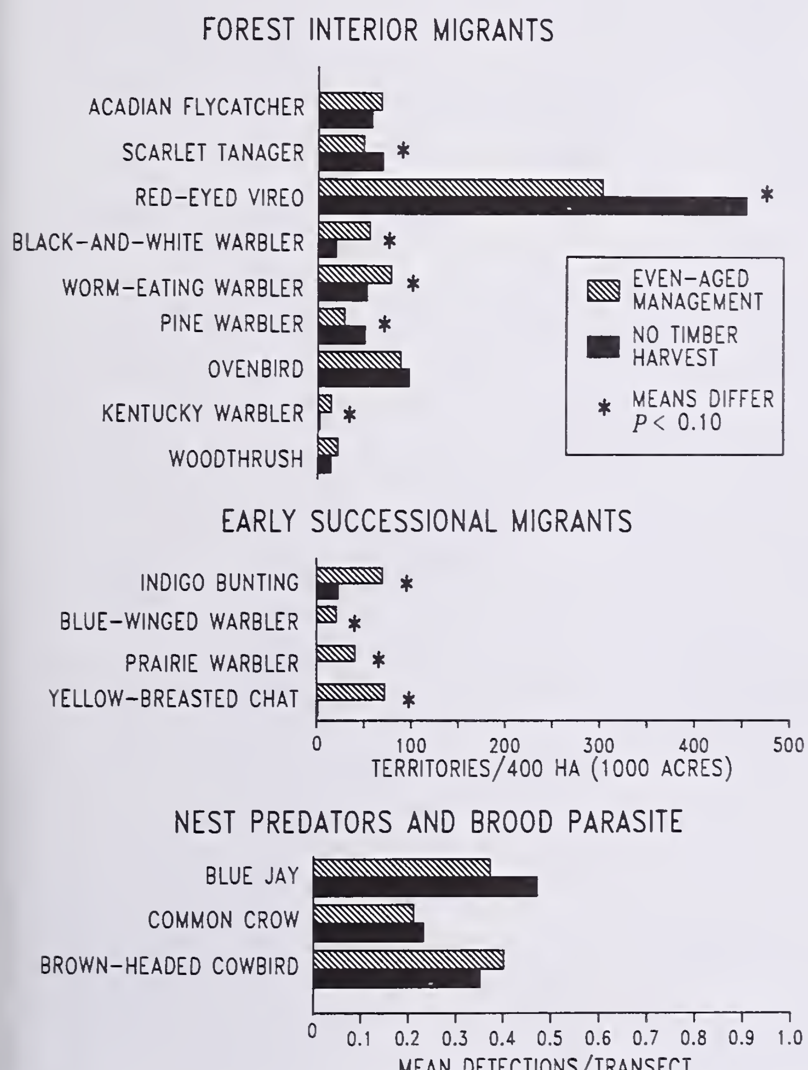


Figure 3. — Numbers of forest interior neotropical migrants and early successional neotropical migrants in forested landscapes managed by clearcutting and landscapes with no timber harvest (Thompson et al. 1992).

Spatial Distribution and Edge Effects

The spatial distribution of different aged stands also may impact NTMB. Stand size determines size of habitat patches created by regeneration cuts, and is usually 5-20 ha. Natural disturbances and openings occur much more frequently at small scales than at large scales, but have a wide range of sizes (Hunter 1990). Without special considerations, evenaged management results in a unnatural uniformity of habitat patch size, excluding small and very large patches.

Juxtaposition of different aged stands in managed forests may result in increased forest edge, which may effect reproductive success of NTMB (Wilcove 1988). It is not clear, however, how edges created by timber harvest affect NTMB. Several studies have found higher nest parasitism or predation near openings created by timber harvest (Brittingham and Temple 1983, Yahner and Scott 1988, D. Whitehead unpubl.data), while others have not (Ratti and Reese 1988). In highly fragmented forests in agricultural landscapes parasitism and predation rates may be high throughout the forest, with no relation to edges of clearcuts or wildlife openings, because cowbirds and predators may be so abundant they saturate the forest (Robinson et al. this proceedings). While many forest interior species remain abundant in managed forests (Thompson et al. 1992), it is possible that these are population sinks where reproduction is insufficient to compensate for adult mortality (Pulliam 1988, Robinson 1992). Simulation modeling suggests a forest interior bird population that occupies mature forest could decline up to 60% in landscapes managed by clearcutting. However, most of this decline was due to conversion of older stands to younger stands and not edge effects (Thompson In Press). The extent to which silvicultural practices exacerbate cowbird parasitism and nest predation will depend on the landscape context and whether edges created by these practices function as true ecological traps (Robinson et al. this proceedings, and Freemark et al. this proceedings).

Temporal Distribution of Forest Age-Classes

Management for sustained and constant yield of timber requires the maintenance of a balanced stand age-class distribution. This also provides a relatively constant availability of habitats. However, on lands with an unbalanced age class distribution the amount of early versus late successional habitats may vary greatly through time.

Species Turnover Within Stands

Regeneration or harvest cuts remove a mature forest community and replace it with a young forest community. Numerous studies have documented bird species turnover associated with regeneration practices (e.g. Conner and Adkisson 1975, Webb et al. 1977, Conner et al. 1979, Crawford et al. 1981, Franzreb and Ohmart 1978, Thompson and Fritzell 1990, and many others). These changes are largely due to changes in vegetation structure resulting from stand regeneration.

Tree species composition may also change with stand regeneration. The most obvious example is use of artificial regeneration where the composition of the future forest is largely determined by selection of planting stock. Planting stock can potentially be anything a site can support, including exotics. Past practices of converting low quality hardwood stands to pine, and the use of exotic tree species (because of greater potential timber yields), have been largely abandoned on public lands. However, artificially regenerated stands are still usually planted with few species. Changing the forest type or reducing tree species richness may change the NTMB community and reduce species richness. NTMB are often associated with hardwoods in conifer plantations, so control of competing hardwood vegetation may further limit the diversity of NTMB. Closed-canopy plantations often have limited vertical and horizontal vegetative-structural diversity, and as a result low NTMB diversity. Selection of a regeneration method can also affect natural regeneration. Regeneration methods range from clearcutting, which favors shade intolerant trees, to single tree selection which favors shade tolerant species. Small changes in tree species composition in eastern deciduous forests probably have little effect on breeding birds because of high tree species diversity and because similar vegetative-structure or life forms are maintained.

Residual Structure

Regeneration practices could result in felling of all trees (including snags) and disposal of slash. This can result in a stand (and forest over a rotation) deficient in downed dead woody material and snags, and with little variation in tree age and structure. Practices such as retention of snags, woody debris, and some live trees from previous stands will result in a more structurally diverse stand and provide habitat features needed by certain species (Dickson et al. 1983).

Rotation Age

Rotation age greatly affects stand structure. Rotation ages have usually been defined to maximize economic returns from a stand and typically range from 30 to 100 years, which is often shorter than the average frequency of natural disturbances. As a result, evenaged management often truncates succession and prevents development of structural characteristics associated with old stands (Edgerton and Thomas 1978, Bunnell and Kemsater 1990). This includes development of large trees, accumulation of downed and standing dead wood, and development of high vertical foliage density due to canopy layering. This could result in fewer cavity-nesting, bark-foraging, foliage-gleaning, or canopy-nesting species resulting in lower within-stand species diversity (Probst 1979).

Stand Succession

Avian density and diversity generally increase with succession following land abandonment (Johnston and Odum 1956, Karr 1971, Shugart and James 1973, Shugart et al. 1975). Bird response to stand regeneration often differs from natural succession. Breeding bird densities in regenerating forests are often similar to or much greater than those in mature stands, with densities often lowest in mid-successional pole-sized stands (Conner and Adkisson 1975, Conner et al. 1979, Dixon and Selquist 1979, Probst 1979, Horn 1984, Yahner 1986, Thompson and Fritzell 1990). Species richness and diversity may also show an early peak in regenerating stands (Conner and Adkisson 1975, Conner et al. 1979, Dixon and Selquist 1979, Probst 1979, Horn 1984, Yahner 1986, Thompson and Fritzell 1990)(Fig. 4). Early peaks in NTMB density and diversity in regeneration stands may be due to dense foliage of seedling-sapling trees and horizontal patchiness resulting from small patches of failed regeneration that create small herbaceous openings, as well as intruding species from adjacent older stands.

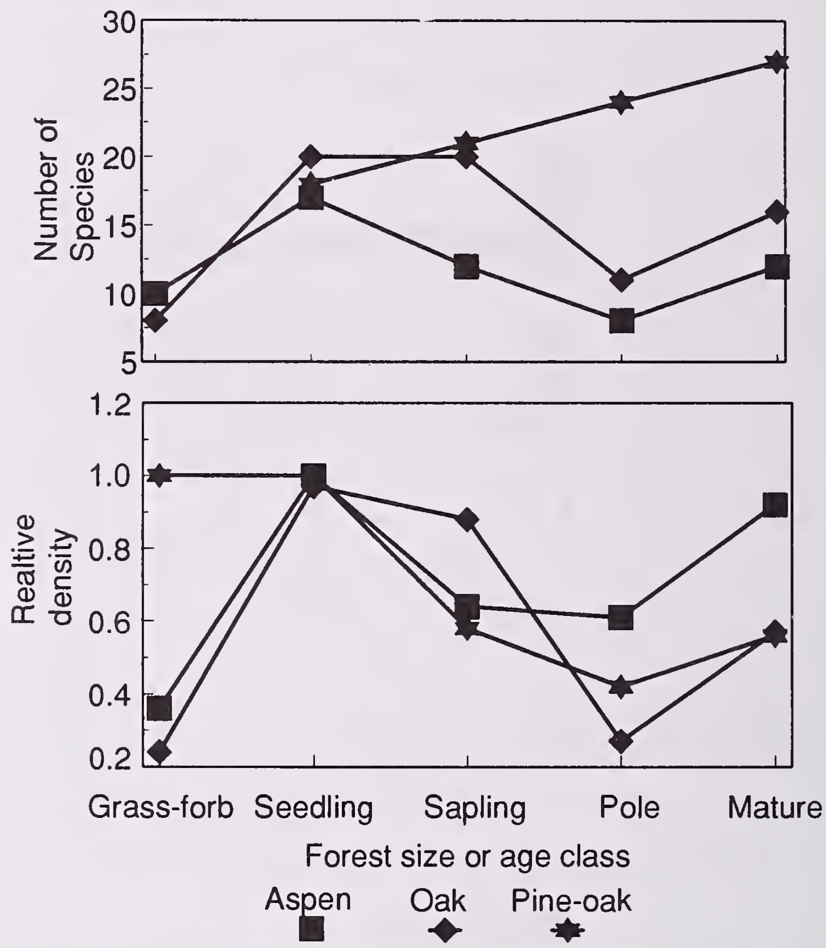


Figure 4. — Numbers of bird species and bird density in different size (age)-class evenaged stands. Results are from studies in aspen forests (Probst et al.1992), mixed oak forests (Conner and Adkisson 1975) and pine-oak forests (Conner et al. 1979). Density values from original papers were rescaled to 0-1.0 to be comparable.

Unevenaged Systems

Comparatively little information exists on forest bird response to unevenaged management or selection cutting. Evenaged regeneration methods result in near complete removal of the previous stand and as a result, a near complete turnover in breeding birds. Selection cutting maintains a specific tree-diameter distribution in the stand through periodic removal of selected trees. Hence, there is less change in vegetation structure and bird communities than under evenaged management. Selectively cut stands typically retain much of the mature forest bird community (although often at lower numbers), and provide habitat for some early successional species that use the ground-shrub-sapling layer. Whereas changes in density of canopy-dwelling species are typically small, they may be significant when summed across the landscape.

Landscape level impacts

Unlike evenaged management, selection cutting maintains a mature tree component at all times and does not create a mosaic of different-aged stands. This may benefit forest interior species because large tracts of forest with mature trees can be maintained. Selection cutting does not provide landscape-level temporal and spatial diversity that evenaged management does. This may benefit area sensitive or forest interior species that prefer mature forests but it will not provide habitat for species that require larger openings, evenaged stands, early seral conditions, or a diversity of evenaged stands.

Single and Multi-tree Gaps

Canopy gaps resulting from harvest of single trees or groups of trees provide habitat for a variety of migrant birds associated with young second-growth forests or gaps. In the Midwest , for example, the hooded warbler, Kentucky warbler, white-eyed vireo, and indigo bunting appear to be able to make use of small gaps created by single-tree and group selection whereas other species such as yellow-breasted chats, blue-winged warblers, and prairie warblers require large openings more typical of clearcuts (S.Robinson, unpubl. data, F. Thompson pers. obsv.). Species such as the Kentucky and hooded warbler are generally considered forest interior, area sensitive species adapted to internal forest disturbances such as tree-fall gaps. There is a dearth of information on the area-sensitivity of species requiring early successional forest or gaps. These canopy gaps may also be attractive to cowbirds and result in higher levels of brood parasitism. Cowbirds occur in greater numbers in selectively cut stands in Illinois and Missouri (S. Robinson unpubl data, Ziehmer 1992) than in uncut mature forest. Brittingham and Temple (1983) found increased brood parasitism near edges of forest openings as small as 0.2 ha, which is comparable to small group-selection openings. Brood parasitism and nest depredation were higher for a few species in selectively cut stands than uncut stands in Illinois (S. Robinson unpubl. data). If edge effects occur around group selection openings they could drive a local population to extinction; because while small, these openings could be much more numerous and widely dispersed than those created by clearcutting (Thompson, In Press).

Change in Stand Structure

Uneven aged stands have a well-developed understory and sub-canopy because of frequent canopy gaps. Presence of several well-developed vegetation levels and more complex habitat structure than in evenaged stands results in higher within-stand bird species diversity than in evenaged stands. Maintenance of a mature tree component at all times should provide habitat for canopy dwelling species at all times. However the loss of some large trees and potential large snags, is likely to result in lower densities of bark foragers, canopy-foliage gleaners, and cavity nesting species (e.g. Raphael et al. 1987). The few studies that have compared selection cutting or partial cuts to unlogged stands have in fact found that some bark foragers and foliage gleaners decrease and some ground and shrub foragers or nesters increase (Medin 1985, Medin and Booth 1989, S.Robinson unpublished data).

Species Composition

Single tree selection will primarily maintain shade tolerant trees and group selection tolerant and intermediate tolerant trees. As previously discussed, tree species composition may impact bird communities.

RECOMMENDATIONS

Populations are determined by an interaction between local habitat factors, the landscape context of habitats, and regional or continental context of habitat biogeography and population levels. We believe the only way to incorporate diverse needs of neotropical migratory birds with other resources, such as timber, is a hierarchial approach that begins at a continental scale, identifies opportunities at regional scales, sets composition and structure goals at a landscape scale and management unit scale, and matches management prescriptions to goals at a habitat-stand scale. Single resource or single species approaches (including indicators) originating at stand or management unit level scales will not yield a holistic, comprehensive management strategy. We present this approach in the context of incorporating NTMB needs into forest management but it is valid for all resources including biodiversity in general.

Step 1: Establish Regional Context. (Scales: multi-state, province, eco-region).

Establish the management area in a regional context by identifying the spatial patterns of ecosystems and NTMB ranges in the region. Locate or prepare a complete list of NTMB for the region with information on their status, habitat associations, and geographic location. Determine desired regional ecosystem-vegetation patterns. Consider historical and current vegetation patterns, trends in vegetation types, and habitat needs of NTMB on the regional list and their status. Finer scale, local level management should occur with knowledge of species or ecosystems status in the region, and should complement regional goals.

Step 2: Determine Desired Landscape Composition and Structure (Scales: landform, watershed, mountain range, national forest or refuge).

Determine the desired amounts and distribution of forest types, forest age classes, and non-forest habitats. These should complement regional goals. Consider natural tendencies such as site capability, natural disturbance frequency and pattern, and successional pathways. Next consider NTMB needs in terms of habitats including spatial relationships (size, shape, juxtaposition).

Because of diverse habitat needs and edge or area sensitivity of NTMB, landscape-level forest planning is extremely important to NTMB conservation. At this level, the simplest approach is a coarse filter approach that assumes that a representative variety of ecosystems will contain the vast majority of species in a region (Hunter et al. 1988, Hunter 1990). For instance, management and restoration efforts might be directed toward regionally rare ecosystems such as bottomland hardwoods, lowland conifers, oldgrowth, and savannahs. This will address needs of regionally rare species, including NTMB. However, concerns for impacts of forest fragmentation and edge on NTMB, population size and viability, as well as source-sink relationships require careful spatial planning for even common habitats such as upland forest. In extensively forested regions or landscapes cowbirds and predator numbers may be sufficiently low that edge effects are not a concern. In these areas, silviculturally sound, regulated harvest that maintains natural forest types should be compatible with NTMB conservation. In highly fragmented, edge dominated landscapes, forest habitats may already be saturated with cowbirds and predators, and edge effects resulting from timber harvest inconsequential. However, in the wide range of landscapes between these extremes careful spatial planning may be required. For instance, some large blocks of unfragmented forest should be reserved from timber harvest and other anthropogenic disturbances to support productive, source populations of forest interior NTMB. Harvest and other activities could be concentrated in more fragmented parts of these landscapes. This planning would produce a diversity of landscapes, some with undisturbed, mature-contiguous forest and others with successional diversity.

On areas where timber is harvested a balance of selection cutting and evenaged systems should be used to create small openings for gap species, large openings for early successional forest migrants, and a balanced age-class distribution to maintain sufficient mature forest habitats. Where late successional or edge-sensitive species are featured single-tree selection or evenaged systems with long rotations should be used. Larger regeneration cuts and longer rotations will increase amount of late successional forest and decrease amount of early successional forest and their edges in the landscape.

Step 3: Establish Management Unit Goals (Scales: An administrative unit, compartment, group of habitats).

Set vegetation composition and structural goals across the management unit including forest age classes, vertical stratification, horizontal pattern and special features. These may be uniform or varied based on species needs and management unit context. Maximizing diversity at this scale could compromise landscape and regional diversity by fragmenting mature forest or homogeneous forest habitats. Instead, manage to meet landscape and regional diversity goals for forest types and ageclasses, and to compliment management in other management units. Maintain natural forest type diversity. Examine spatial relationships of stands based on elements of structure and composition. Group regeneration cuts to minimize impacts on area and edge-sensitive NTMB. In coniferous forest types maintain deciduous components where it is declining. Mix silvicultural options across units unless specific concerns dictate otherwise.

Step 4: Develop Stand-Habitat Level Management Prescriptions (Scale: habitat or stand).

At this level the manager needs to use the best practices to compliment goals established for the management unit and landscape, and to match site capabilities and natural tendencies. Prescriptions should address NTMB diversity and habitat requirements of priority species. Priority species will vary depending on landscape and region as established in steps 1-3. For instance, in many Midwest landscapes forest interior and prairie species will be priority while in some New England landscapes early successional migrants may be more important. We offer the following suggestions for enhancing specific components of the NTMB community as well as diversity at the stand level. However, we reiterate the need to manage stands to address goals set at larger scales.

NTMB Diversity . Do not maximize within-stand diversity at the expense of landscape or regional diversity. For example, selection cutting may produce high within-stand diversity but an entire landscape of selectively cut unevenaged forest would be lacking some NTMB. A better approach might be to use a mix of silvicultural practices (even and unevenaged) and reserve some areas from harvest. Maintain deciduous and coniferous components in mixed stands. Limit control of hardwoods in regenerating conifer plantations. Use variable and wider spacing in conifer plantations.

Area or edge-sensitive NTMB. Increase stand size and regeneration cuts to benefit early and late successional species. Cluster regeneration cuts when possible. Emphasize evenaged systems and single-tree selection cuts. Reserve some of the least fragmented areas from timber harvest.

Cavity nesting and bark foraging NTMB. Lengthen rotation ages in evenaged systems and increase proportion of larger trees (decrease q-values) in unevenaged systems. Retain snags and live residual trees in regeneration cuts.

Canopy gleaners. Lengthen rotation ages in evenaged systems and increase proportion of larger trees (decrease q-values) in unevenaged systems.

Ground foragers and understory gleaners. Mix silvicutural systems to provide regenerating evenaged stands and selectively cut unevenaged stands. Use wide and variable spacing in plantations with minimum hardwood control.

Early successional species. Use evenaged systems . Shorten rotations.

ACKNOWLEDGEMENTS

We thank D. E. Capen, W. D. Dijak, P. S. Johnson, S. R. Shifley, and M. J. Schwalbach for their review of this manuscript.

LITERATURE CITED

Ambuel B. and S. A. Temple. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. Ecology 64:1057-1068.

Blake, J. G., and J. R. Karr. 1984. Species composition of bird communities and the conservation benefit of large versus small forests. Biol. Conserv. 30:173-187.

Brittingham, M. C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? Bioscience 33:31-35.

Bunnell, F. L. and L. L. Kremsater. 1990. Sustaining wildlife in managed forests. Northwest Environmental Journal 6:243-269.

Conner, R. N., and C. S. Adkisson. 1975. Effects of clearcutting on the diversity of breeding birds. J. For. 73:781-785.

-----, J. W. Via, and I. D. Prather. 1979. Effects of pine-oak clearcutting on winter and breeding birds in southwestern Virginia. Wilson Bull. 91(2):301-316.

Crawford, H. S., R. G. Hooper, R. W. Titterington. 1981. Songbird response to silvicultural practices in central Appalachian hardwoods. J. Wildl. Manage. 45:680-692.

Dickson, J. G., and C. A. Segelquist. 1979. Breeding bird populations in pine and pine-hardwood forest in Texas. J. Wildl. Manage. 43(2):549-555._____., R. N. Conner, J. H. Williamson. 1983. Relative abundance of breeding birds in forest stands in the southeast. Southern J. Applied For. 4:174-179.

Edgerton, P. J. and J. W. Thomas. 1978. Silvucultural options and habitat values in coniferous forests. Pages 56-65 in Proceedings of workshop on nongame bird habitat and managment in the coniferous forests of the western United States (R. M. DeGraaf Tech. Coord.). USDA Forest Service Pacific Northwest Forest and Range Experiment Station General Technical Report PNW-64.

Faaborg, J., M. Brittingham, T. Donovan, J. Blake. Habitat fragmentation in the temperate zone. (This symposium).

Franzreb, K. E. and R. D. Ohmart. 1978. The effects of timber harvesting on breeding birds in a mixed-coniferous forest. Condor 80:431-441.

Freemark, K, J. Probst, S. Hejl, B. Dunning. Landscape ecology of neotropical migrant birds. (This symposia).

Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledgling success in field forest ecotones. Ecology 58:871-883.

Hayden, T. J., J. Faaborg, and R. L. Clawson. 1985. Estimates of minimum area requirements for Missouri forest birds. Trans. Mo. Acad. Sci. 19:11-22.

Horn, J. C. 1984. Short-term changes in bird communities after clearcutting in western North Carolina. Wilson Bull. 96:684-689.Hunter, M. L. Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, N.J. 370 p.

_____, G. L. Jacobson Jr., and T. Webb III. 1988. Paleocology and the coarse-filter approach to maintaing biological diversity. Conservation Biology 2:375-385.

Johnston, D. W. and E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology, 37:50-62.

Karr, J. R. 1971. Structure of avian communities in selected Panama and Illinois habitats. Ecol. Monogr. 41:207-233.

Law, J. R. and C. G. Lorimer. 1989. Managing unevenaged stands. Pages 6.08-6.086 in F. B. Clark and J. G. Hutchinson, editors, Central Hardwood Notes. USDA Forest Service North Central Forest Experiment Station, St. Paul, Minnesota.

MacArthur, R. H. and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press. Princeton, N.J. 203pp.

Marquis, D. A. 1989. Alternative silvicultural systems-East. Pages 29-35 in Proceedings of the national silviculture workshop. USDA Forest Service Timber Management, Washington, DC.

Medin, D. E. 1985. Breeding bird responses to diameter-cut logging in west central Idaho. USDA Forest Service Intermountain Research Station Research Paper INT-355. 6p.Medin, D. E. and G. D. Booth. 1989. Responses of birds and small mammals to single-tree selection logging in Idaho. USDA Forest Service Intermountain Research Station Research Paper INT-408. 11p.

Probst, J. R. 1979. Oak forest bird communities. Pages 80-88 in R. M. Degraaf, tech. coor. Proceedings of the workshop management of north central and northeastern forests for nongame birds. USDA Forest Service North Central Forest Experiment Station General Technical Report NC-51, St. Paul, MN.

Probst, J. R., D. S. Rakstad, D. J. Rugg. 1992. Breeding bird communities in regenerating and mature broadleaf forests in the USA Lake States. For. Ecology and Manage. 49:43-60.

Pulliam, H. R. 1988. Sources, sinks, and population regulation. Amer. Nat. 132:652-661.

Raphael, Martin G., Michael L. Morrison, and Michael P. Yoder-Williams. 1987. Breeding bird populations during 25 years of postfire succession. Condor 89(3):614-626.

Raphael, M. G., K. V. Rosenberg, and B. G. Marcot. 1988. Large-scale changes in bird populations of Douglas-Fir forests, Northwest California. Pages 63-83 in Bird Conservation 3 (J.A.Jackson ed.). Univ. Wisconsin Press, Madison, WI.Ratti, J. T., and K. P. Reese. 1988. Preliminary test of the ecological trap hypothesis. J. Wildl. Manage. 52(3):484-491.Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proc. of the Nat. Acad. of Sci., USA. 86:7658-7662.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proc. of the Nat. Acad. of Sci., USA. 86:7658-7662.

Robinson, S. K. 1992. Population dynamics of breeding neotropical migrants in a fragmented Illinois landscape. Pages 408-418 in Ecology and conservation of neotropical migrant landbirds (J. M. Hagan, III and D. W. Johnston eds.). Smithsonian Institution Press, Washington DC.

Robinson, S. K., J. A. Grzybowski, S. I. Rothstein, M. C. Brittingham, L. J. Petit, and F. R. Thompson, III. 199_. Management implications of cowbird parasitism for neotropical migrant songbirds. This Proceedings

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern arkansas. The Auk 90:62-77.

Shugart, H. H., S. H. Anderson, and R. H. Strand. 1975. Dominant patterns in bird populations of the eastern deciduous forest biome. p. 90-95 in The management of forest and range habitats for nongame birds Symp. Proc. USDA Forest Service General Technical Report WO-1, Washington, DC.Smith, D. M. 1962. The practices of silviculture. John Wiley and Sons, Inc., Cary, N.C. 578pp.

Temple, S. A., and J. R. Cary. 1988. Modeling dynamics of habitat-interior bird populations in fragmented landscapes. Conserv. Biol. 2:340-347.

Thompson, F. R.,III., and E. K. Fritzell. 1990. Bird densities and diversity in clearcut and mature oak-hickory forest. USDA For. Serv. Res. Pap. NC-293, St. Paul, Minn. 7pp.

_____. In Press. Simulated responses of a forest interior bird population to forest management options in central hardwood forests of the United States. Consv. Biol.

______, W. D. Dijak, T. G. Kulowiec, and D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. J. Wildl. Manage. 56(1):23-30.

USDA Forest Service. 1973. Silvicultural systems for the major forest types of the United States. Agriculture Handbook 445. 114 pp.

Webb, W. L., D. F. Behrend, and B. Saisorn. 1977. Effect of logging on songbird populations in a northern hardwood forest. Wildlife Monographs 55. 35pp.

Whitcomb, R. F., C. S. Robbins, J. F. Lynch, B. L. Whitcomb, M.K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of eastern deciduous forest. Pages 125-205 in R. L. Burgess and D. M. Sharpe, eds. Forest island dynamics in man dominated landscapes. Springer-Verlag, N.Y.Wilcove, D. S. 1988. Forest fragmentation as a wildlife management issue in the eastern United States. Pages 146-150 in Healthy forests, healthy world: proceedings of the 1988 Society of American Foresters national convention, Rochester, N. Y.

Yahner, R. H. 1986. Structure, seasonal dynamics and habitat relationships of avian communities in small even-aged forest stands. Wilson Bull. 98:61-82

Yahner, R. H.and D. P. Scott. 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Manage. 49:508-513.

Ziehmer, R. L. 1992. Effects of uneven-aged timber management of forest bird communities. M.S. Thesis, Univ. of Mo., Columbia. xxpp

Management of New England Northern Hardwoods, Spruce-Fir, and Eastern White Pine for Neotropical Migratory Birds

Richard M. DeGraaf[1], Mariko Yamasaki[2], and William B. Leak[2]

Abstract — Habitat management for neotropical migratory birds must be based upon land capability, vegetation, successional patterns, response to treatments, landscape diversity, and species/habitat relationships. Neotropical migratory birds use diverse arrays of aquatic, early successional, and forest habitats. Management of neotropical migratory birds involves enhancement of habitat diversity. We describe a process that includes evaluation of potential habitat capability, inventory of existing conditions, and prescriptions for necessary structural features for species diversity. Silvicultural treatments to manipulate vegetation structure are presented for major forest cover types in New England, and applicability to other regions is discussed.

INTRODUCTION

In the northeastern United States, neotropical migratory birds (NTMB) represent up to 75 percent of the breeding avifauna in deciduous forests during summer. Bird communities in coniferous forests are less variable seasonally. In deciduous forests there is a pattern of bird density increasing with plant succession, a manifestation of the ecological requirements of forest birds.

We address extensively forested landscapes in northern New England, not isolated forest patches. Our findings, specific to this area, suggest a general outline for developing procedures in other regions with extensive northern temperate forests. Population trends in large forested tracts do not clearly show widespread declines in forest-dwelling NTMB (see Askins et al., 1990 for review); NTMB utilize all stages of forest development, stand conditions, within-stand features, and types of disturbance.

[1] *U.S. Forest Service, Holdsworth Hall, University of Massachusetts, Amherst, MA 01003.*

[2] *Northeastern Forest Experiment Station, P.O. Box 640, Durham, NH 03824.*

Neotropical Migratory Bird Habitat Concerns

Assessment of NTMB habitat in northern temperate forests include: 1) forest size as a major predictor of bird community composition; 2) species diversity related to habitat scales; 3) vegetative structure; 4) prey base densities; and 5) human-related impacts (from Askins et al., 1990; Terborgh, 1989; Whitcomb et al., 1981). New England landscapes encompass many land types and are much more heterogeneous in site conditions than other parts of the northern temperate forest (Leak, 1982). Larger forest areas have more NTMB; some of these species are absent or less abundant (Askins et al., 1990) in smaller forest patches, surrounded by urban, suburban, or agricultural land uses.

Four factors shape quality and quantity of NTMB habitat: 1) land use history and current trends in forest cover; 2) existing and potential habitat capability; 3) silviculture that creates or alters habitat structure and prey base densities; and 4) management goals and process.

BACKGROUND

Once covered by primeval forest, up to 75 percent of New England was cleared for agriculture by 1840. Farm abandonment allowed forest regrowth. Northern New England is now a rural forest landscape, and southern New England largely a wooded suburban landscape.

Forests now cover 60 to 90 percent of the various New England states; forests comprise a much smaller component of landscapes in regions surrounding New England, ranging from 40 to 60 percent coverage (Woddell, et al. 1989).

Habitat Relationships

NTMB habitat relationships need to be considered hierarchically at different scales of management: landscape level; between stand level; and within stand level.

Landscape Level:

Northern New England is at least 75 percent forested; upland nonforest, wetland, and aquatic habitats are very minor components in most cases (DeGraaf et al. 1992). Urban and suburban sprawl is limited. Isolation of forest fragments does not appear to be a factor at the present time. Interspersion of agricultural land use is minimal. Urban and suburban sprawl, though limited, continues to slowly increase. Increased predation rates by suburban wildlife, cats, and dogs is expected. Year-round bird feeding encourages brown-headed cowbird occurrence, as do some agricultural activities (Yamasaki, unpubl. data). Breeding bird surveys in forest-dominated areas on the White Mountain National Forest reveal few cowbirds away from these food sources.

Upland nonforest, wetland, and aquatic habitats are more abundant components in southern New England. Urban/suburban sprawl is much more pervasive, even though it is up to 60 percent forested.

Most forest-dwelling NTMB have home ranges smaller than 10 acres (Table 1). Large forested properties present more opportunities to concurrently manage seasonal habitats for more NTMB species, resident species with small and large home-ranges, and short distant migrants.

Table 1. — Comparison of home-range area for birds in New England (modified from DeGraaf et al. 1992).

	Average home-range area estimates (acres)				
	None reported/ not applicable	1-10	11-50	>50	Total
Neotropical migrants	3	111	19	15	148
Resident/ Short distance migrants	14	30	11	17	72
Total Species	17	141	30	32	220

Small properties within extensive forest landscapes present opportunties to supply a portion of year-round habitat needs of wide-ranging resident species, if coordinated with surrounding area conditions. These same small properties also present opportunities to manage seasonal habitats for NTMB species and possibly complete habitats for small range residents.

Extensive forests of uniform age provide habitat for a limited number of avian species (Fig. 1). When a variety of nonforest habitats are available within extensive forest areas, a significantly larger number of habitat conditions is available. If a variety of aquatic habitats are also present, the number of available habitats again increases. Finally, the presence of high elevation sites add the krummholz and alpine habitats that complete the range of available habitats in New England. Thus, habitat breadth is useful in examining species / habitat potential.

Figure 1. — Comparison of habitat breadth use by New England birds (NTM=neotropical migratory birds; RES/SDM=residents and short distance migratory birds; F=forest; NF=nonforest; W=aquatic habitats; K=krummholz and alpine habitats).

Between-stand Level:

Size-class combination (after DeGraaf et al., 1992: regeneration, sapling-pole, sawtimber, and large sawtimber stands) also describes habitat relationships at the between-stand level. Large forests of a single size-class limit habitat for birds and other species (Fig. 2). If two size-classes are available within an extensive forest area, the potential number of habitats doubles. With all four size-classes present, potentially available habitats again increase. Size-class combination does not pertain to NTMB that only use nonforest, wetland, and aquatic habitats within the forest.

Within-stand Level:

The distribution of many wildlife species, including NTMB, is related to structural habitat features within cover-type groups (Table 2). Many features are created or altered when forest

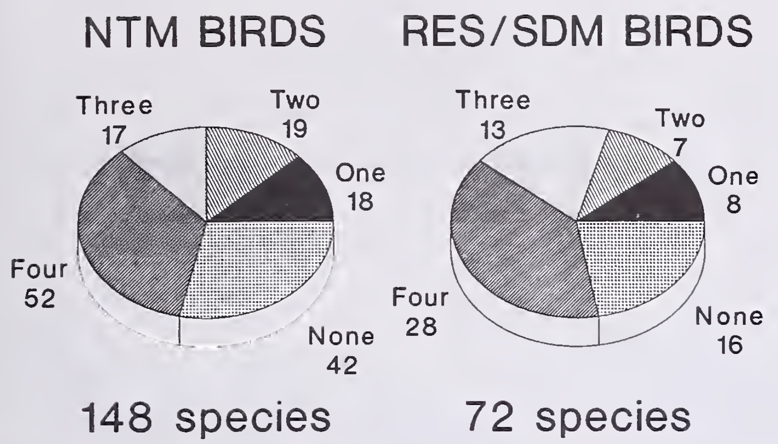


Figure 2. — Comparison of size-class use by New England birds (NTM=neotropical migratory birds; RES/SDM=residents and short distance migratory birds; One=one size-class used; Two=two different size-classes used; Three=three size-classes used; Four=four size-classes used; None=no forest size-classes used).

Table 2. — Comparison of neotropical migratory and all birds combined relationship to structural habitat features in New England by size-class (NTM=neotropical migratory birds; AB=all birds combined). (Modified from DeGraaf et al. 1992).

Feature	Number NTM/AB	Regeneration NTM/AB	Sapling-pole NTM/AB	Sawtimber NTM/AB	Large sawtimber NTM/AB
High perches	7/10	6/ 7	3/ 3	5/ 6	5/ 7
Exposed perches	15/20	9/13	9/12	6/ 9	7/ 9
Minimal canopy	20/25	15/20	12/16	7/12	8/13
Partial canopy	27/41	22/32	20/29	22/34	22/34
Closed canopy	25/32	18/24	21/27	25/31	25/32
Tree boles	12/35	4/19	6/22	8/29	9/32
Midstory layer	18/24	14/18	16/22	15/21	15/21
Shrub layer	56/75	51/70	41/52	32/44	33/45
Ground vegetation	33/52	21/36	10/21	6/15	7/16
Litter	11/12	10/12	10/12	11/11	11/11
Overstory inclusions	40/57	26/42	33/49	37/55	37/55
Mast/fruit	6/39	3/17	3/15	3/18	3/18

stands are treated. No single silvicultural treatment can provide all conditions at any given time, but a range of conditions can be provided over time and space with some planning. No single habitat management practice covers all necessary conditions for all NTMB. A variety of management goals, objectives, silvicultural methods, site conditions, management intensities, and habitat improvement practices is required across landscapes to provide a diversity of habitats for the full range of wildlife species and NTMB potentially inhabiting New England forests.

Silvicultural Methods

Silvicultural cuttings are usually classified as regeneration treatments (Fig. 3) or intermediate treatments (Fig. 4). Four techniques are discussed: two for producing even-aged stands and two for producing uneven-aged stands:

Even-aged:

1. Clearcutting--removal of all stems in the stand includes strip cutting, coppice, coppice with standards, and seed tree cuts.
2. Shelterwood--removal of the understory and lower crown canopy trees to allow the new stand to regenerate under shade. Subsequent cuts remove the overstory.

Uneven-aged:

1. Single-tree selection--removal of trees singly or in groups of 2 or 3, to maintain a continuous crown and uneven-aged or sized mixture. Can be used between groups.
2. Group selection--removal of trees in groups usually 1/10 to 2/3 acre in size, but sometimes up to 2 acres.

Intermediate treatments are applied in the culture of even-aged stands. Quality timber thinnings commonly maintain a closed canopy; however, low-density thinning (50-70% residual crown cover) can be used to hasten diameter growth and stimulate understory development for wildlife purposes.

Single-tree and group selection methods culture uneven-aged stands. Instead of a specified rotation age, a general maximum tree size is chosen, and residual stands are defined by maximum tree size, stand density, and stand structure.

Other intermediate treatments utilized in either even-aged or uneven-aged stands are pruning, prescribed burning, sanitation cutting, or salvaging (after Hunter, 1990).

Even-aged and Uneven-aged Management Comparisons:

Even-age management provides opportunities to regenerate shade intolerant hardwoods by clearcutting, opportunities that uneven-age management does not provide. Indirect effects of harvesting include a flush of herbaceous growth, followed by development of a shrub layer of woody seedlings and sprouts. This shrub layer usually grows into a densely stocked sapling stand within 10 years. Shelterwood techniques with residual canopy closures less than 50 percent provide some of these habitat conditions for several years after harvest. Such regeneration treatments produce distinct forage and shelter opportunities for numerous species that are not usually available under uneven-age management (Fig. 5).

Even-age management provides potential habitat for up to 26% more species than uneven-aged management that regenerates similar cover types. Bird species display greater sensitivity to silvicultural treatment than do other taxa. Forests that contain a distribution of each size-class in distinct even-age

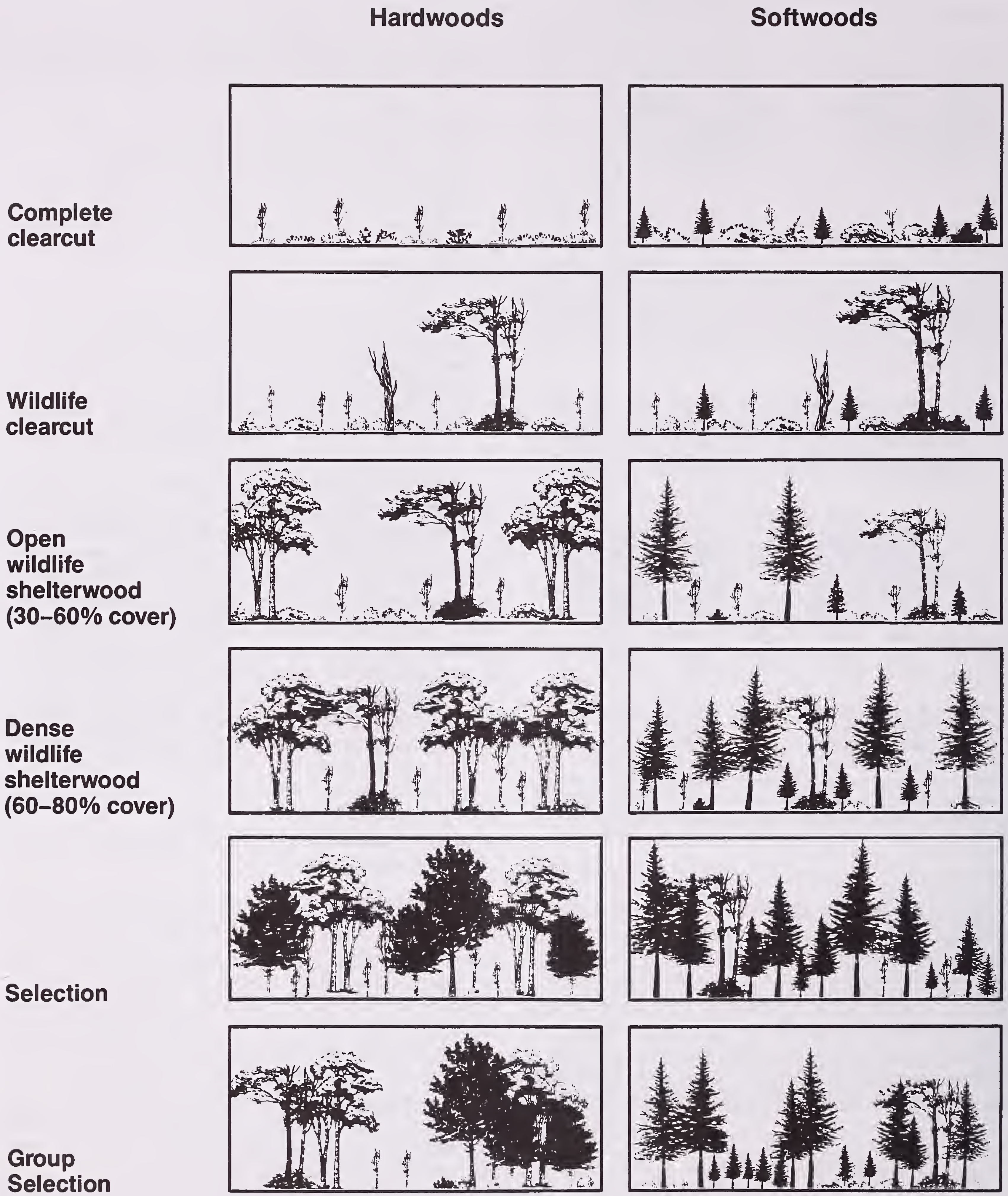


Figure 3. — Comparison of wildlife habitat conditions under several regeneration treatments (taken from DeGraaf et al. 1992).

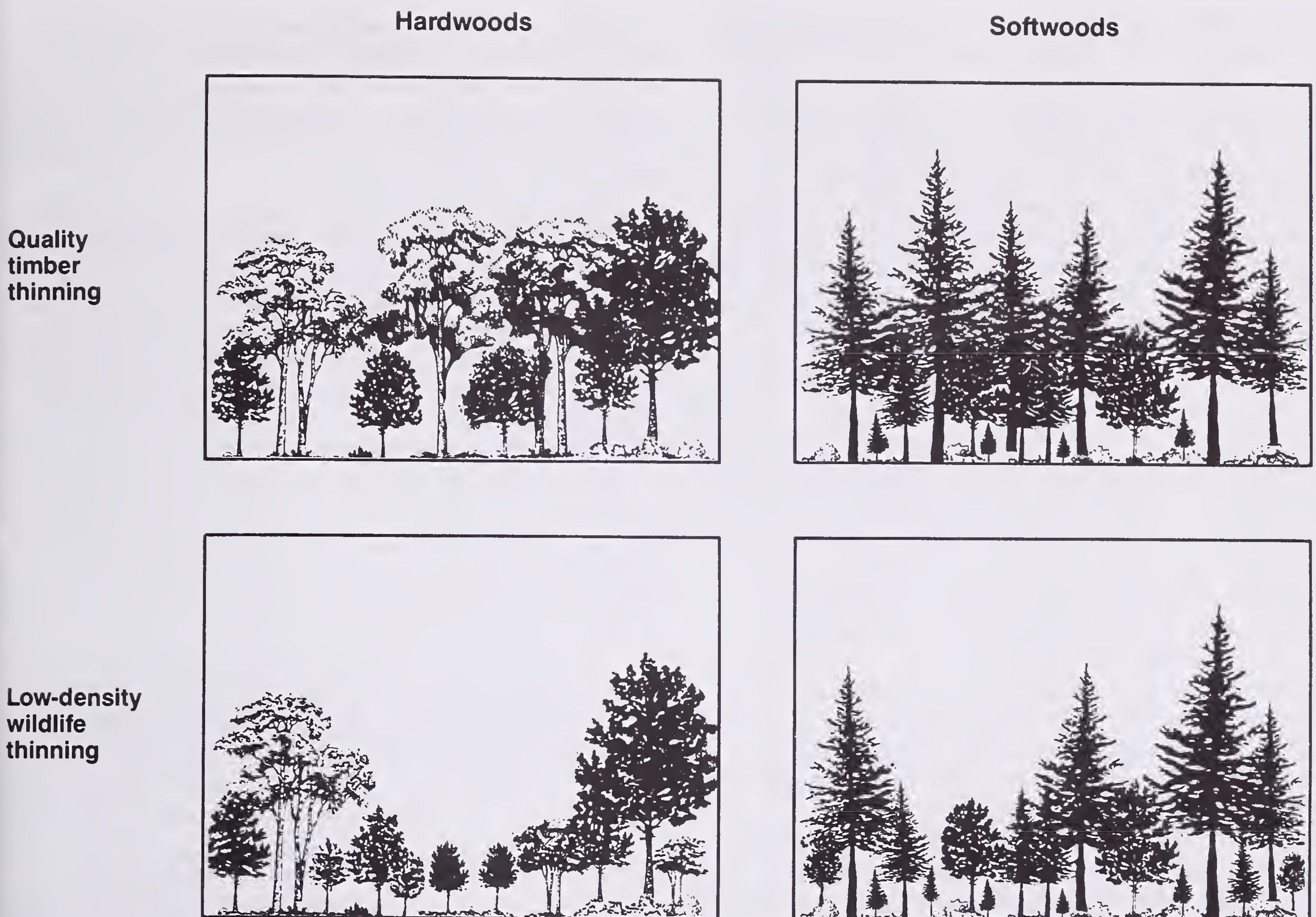


Figure 4. — General comparison of wildiife habitat conditions following quality timber thinning and low-density thinning with reserved wildlife trees (taken from DeGraaf et al. 1992).

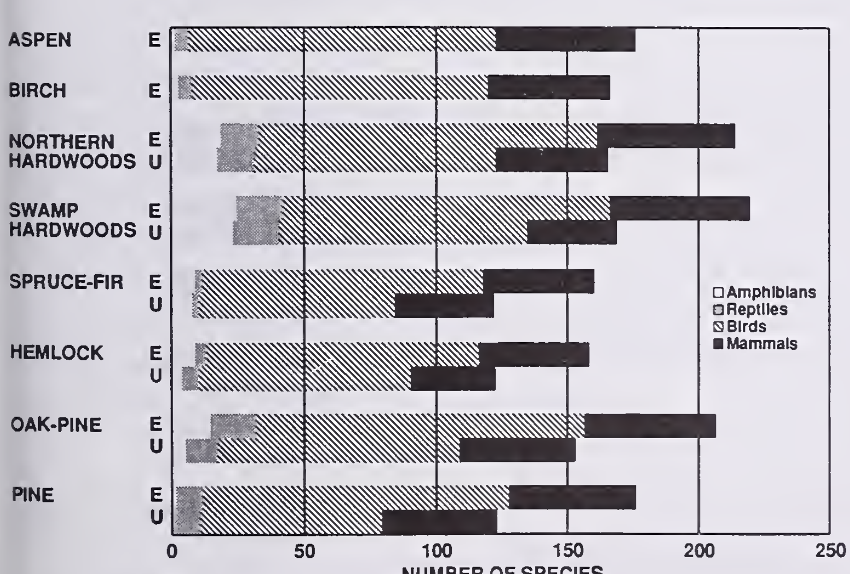


Figure 5. — Potential number of wildlife species by silvicultural system and cover-type group. E=even-age forests containing regeneration, sapling-pole, sawtimber, and large sawtimber stands in distinct units of 5 acres and larger. U=uneven-aged forests with essentially continuous canopies and intermixed size- classes produced by single-tree selection (taken from DeGraaf et al. 1992).

units of 5 acres and larger can provide more potential habitats than uneven-age management, when applied at intervals so entire landscapes are not affected during any one management period.

Uneven-age management can provide continuous overstory canopies and intermixed size-classes of tolerant hardwoods and softwoods by single-tree selection. With residual canopy closures greater than 70 percent, minimal herbaceous ground cover and shrub conditions are expected, and a midstory layer usually develops. Intolerant and midtolerant tree species are few and decrease over time. Uneven-age management applied across large homogeneous areas tends to limit early successional habitat conditions and intolerant cover types. In much of New England, however, large areas are discontinuous in soils, geology, elevation, and drainage patterns. This leads to variation in species composition and response to treatment, indicating use of even-age methods interspersed with the general uneven-age method.

Group selection provides habitat conditions that range between single-tree selection and even-age approaches. At regular intervals (10 to 20 years), up to about 10 percent of the stand is regenerated in groups, while single-tree selection is sometimes applied between openings. Intolerant species regenerate in larger groups, while intermediate and tolerant species dominate small openings. Distinct size-classes are recognizable for a few decades following cutting. The main limitation on wildlife habitat is the small size of the openings. Group selection provides habitat for a potential number of species between that suggested for even-age and typical uneven-age approaches. Combinations of these systems, rather than strict adherence to one, increases the habitat conditions possible through vegetative management. Care taken to provide a range of diverse habitat conditions throughout a forest or property will eventually result in increased use by a wider variety of wildlife species.

PROCESS

Five steps are required to consider NTMB throughout the public and private management planning process.

1. **Goals**--need to identify current and potential habitat opportunities, public concerns, and political or economic issues (local and regional). Goal statements require understanding and agreement by the divergent publics and private landowner.
2. **Inventory**--gather information to address key issues at the appropriate scale. Hierarchical resolution of NTMB habitat management concerns requires placing the planning area within a landscape composition; estimating the likelihood of change/disturbance frequencies (Lorimer 1977) and extent of forest cover; identifying site capability and spatial heterogeneity (after Hunter 1990); and describing existing cover type composition and size-class distribution.
3. **Prescription**--develop working objectives for the management period from goal statements, site capability, and existing vegetative condition. Prescriptions can be written to develop the amount and location of early successional habitats, regeneration quantities, softwood composition, or the types of structural habitat features.
4. **Implementation**--involves a large degree of integration with other resource considerations and activities to do an environmentally sensitive and thorough job.
5. **Monitoring**--should determine what was really done, and how successful was the prescription in getting the desired habitat conditions established.

NTMB MANAGEMENT CONSIDERATIONS

Managed stands of hardwoods and softwoods support different breeding bird communities, and stands can be grouped by type and/or size-class by the similarity of their breeding bird compositions.

The most dramatic differences occur in the smallest size-classes (youngest stands), and breeding bird composition is essentially unchanged in stages beyond the poletimber stage. Even-aged sawtimber, large sawtimber, and uneven-aged stands have similar avifaunas. Species richness is similar in regeneration/seedling, sapling, and mature stands; poletimber stands have the fewest breeding bird species (DeGraaf, 1987). No breeding bird species are unique to old growth or virgin stands (Absalom, 1988).

Northern hardwood and aspen sapling stands have similar breeding bird compositions, as do poletimber stands of paper birch, northern hardwoods, and swamp hardwoods. White pine and red spruce poletimber stands have similar breeding avifaunas, as do poletimber and mature stands of both spruce-fir and balsam fir. Mature white pine stands have distinct breeding avifaunas, and eastern hemlock stands, whether poletimber, mature, or overmature present another (DeGraaf, unpubl. data -- for survey methods see DeGraaf and Chadwick, 1987).

Neotropical migrants comprise a higher proportion of breeding birds in smaller diameter size stands than larger diameter size stands in northern hardwoods (Table 3). The same general pattern holds for even-aged stands of spruce-fir and white pine, but the percentages are slightly lower.

Table 3. — Neotropical migratory bird occurrence in (% of breeding avifauna) northern hardwood, spruce-fir, and eastern white pine cover types and size-classes in New England (from DeGraaf and Rudis, 1986). Spruce-fir and pine types are not managed using uneven-age techniques.

Cover Type	Regen-eration	Sapling-pole	Saw-timber	Large sawtimber	Uneven-age
Northern hardwoods	61(71)	38(70)	44(64)	50(64)	45(62)
Spruce-fir	40(64)	38(65)	42(61)	42(57)	--
Eastern white pine	46(65)	41(74)	43(64)	41(59)	--

These final three sections are unavoidably brief management summaries from DeGraaf et al. (1992), and the following silvicultural guides: *Silvicultural guide for northern hardwood types in the Northeast (revised)* (Leak et al., 1987); *Ecology and management of the northern hardwood forests in New England* (Hornbeck and Leak, 1992); and *A silvicultural guide for spruce-fir in the Northeast* (Frank and Bjorkbom, 1973).

Northern Hardwoods Management

The northern hardwood type occurs at elevations up to 2,500 feet. Three subtypes--sugar maple/white ash, beech/birch/maple and beech/red maple tend to occupy distinct sites with different soil and vegetative features.

These subtypes generally occur on well-drained to moderately well-drained upland soils (Leak and Graber, 1974). Stands of a given subtype vary in size from small to moderate, from a few to 100 acres or so. The subtypes occur throughout New England, though regional shifts in abundance of certain species occur.

Sugar Maple/Ash:

Occurs on well-drained, fine-textured tills derived from limestones and certain metamorphics, as well as moderately drained areas enriched by moving water and organic materials.

Sugar maple is aggressive and abundant on this subtype. Yellow birch and white ash are mid-tolerant common associates. Beech is a minor component. These sites have the capability to grow large trees. Trees larger than 22-24 inches dbh commonly have seams and cavities (Leak, 1985).

The shrub layer (2-10 feet tall) is primarily deciduous. The midstory (10-30 feet tall) is deciduous. In mature undisturbed stands, numbers of stems per acre in the shrub layer range around 2,000; and 300 stems per acre in the midstory layer, a fairly sparse understory (Bormann et al., 1970; Leak, 1959).

A hundred or more plant species can be found in the herbaceous layer (feet) including herbs, shrubs, and tree seedlings. Ground cover occupies about 40 percent of the forest floor in mature hardwood stands, but can attain higher percentages on this subtype due to the richer soils (Siccama et al., 1970).

Beech/Birch/Maple:

This subtype occurs on well and moderately well-drained sandy loams. Beech is as abundant or more so than sugar maple, especially in the understory. Yellow birch is a common mid-tolerant associate; paper birch is more common in this subtype than in the sugar maple/ash subtype. Ash is not abundant. Defect is common in trees larger than 20 inches dbh. The presence and abundance of beech increases proportion of dead and defective trees, at earlier ages than in the sugar maple/ash subtype. Beech usually has cavities at 16-18 inches dbh, and few live trees are found larger than 22 inches dbh (Leak, 1985).

Shrub and midstory layers are deciduous and similar to sugar maple/ash understory layers. In undisturbed mature understories the stem densities are even less than sugar maple/ash. Herbaceous layers in mature stands typically reach 40 percent ground coverage, with lower floral diversity than sugar maple/ash.

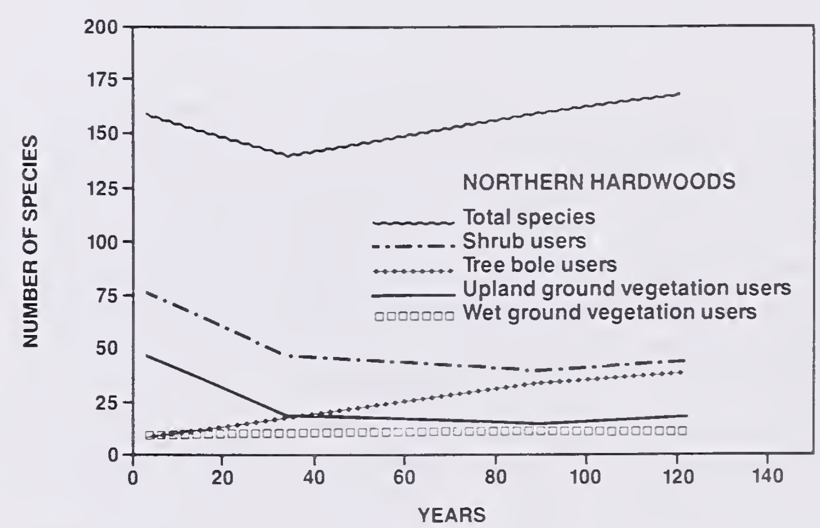
Beech/Red Maple:

Beech is a predominant component and probably the climax species on this subtype. Red maple is more abundant and aggressive than sugar maple. Northern red oak is an associate; a softwood component up to 10-15 percent is often present. Soils are generally sandy, somewhat washed tills. Cavities are common in trees over 14-16 inches dbh (Leak, 1985).

Shrub and midstory layers frequently contain some softwoods admixture, but hardwoods are predominant. Midstory layers are more dense, and herbaceous layers are sparse.

Succession:

Succession in the northern hardwood type consists of a short (2-4 years) herbaceous/shrub stage followed by a hardwood dominated seedling/sapling stage (to 10 years), pole (10-59 years), and sawtimber stages (Fig. 6). During succession, canopies are closed, a range of dbh classes is represented, and the herbaceous layer is sparse. Beech/red maple subtype develops an abundance of cavity trees due to the beech component; and softwood inclusions.



Mean d.b.h. (in)	2–4	4–6	6–8	8–10	10–12	11–13	12–14
Basal area (ft^2)	50–70	90–100	100–110	100–120	100–120	100–130	100–130
No. stems per acre	1000–2000	500–1000	300–500	200–300	150–200	100–150	80–120
Maximum height (ft)	30–40	40–60	50–70	60–80	70–90	80–100	80–100
Maximum d.b.h. (in)	8–10	10–12	12–14	16–18	18–20	20–24	20–26

Figure 6. — Northern hardwoods stand development and wildlife species occurrence (taken from DeGraaf et al.

Numbers of potential species are high in regenerating stands and drop off in the pole stage. Neotropical migrants particularly associated with this habitat structure include alder and willow flycatchers, cedar waxwing, yellow warbler, chestnut-sided warbler, and common yellowthroat.

Numbers of species then increase with stand age to the maximum in mature and overmature stands. Species using tree boles account for some of this increase. Softwood inclusions in the beech/red maple subtype account for increasing use of older stands by hermit thrush, solitary vireo, magnolia warbler, blackburnian warbler, and black-throated green warbler.

Intermediate Treatments:

Quality timber thinning (Fig. 4) tends to maintain a closed canopy, which reduces habitat for open canopy birds; develops a woody understory; and reduces the wildlife tree component. Low-density thinning results in a partial canopy, with cavity trees, and coniferous overstory inclusions if desired, and a dense woody understory. If begun too early, this method results in shorter merchantable tree lengths and lower long-term timber production. Diameter growth is rapid.

Regeneration:

All northern hardwood subtypes can be regenerated by clearcutting mature stands, shelterwood cuts, and single-tree or group selection cuts (Fig. 3). Heavier cutting produces more shade-intolerant to intermediate tree species composition, important to neotropical migrant prey bases. Rapid NTMB composition change occurs during the first few years following clearcutting. **Clearcuts** produce a temporary herbaceous/shrub layer followed by a distinct seedling/sapling class (Fig. 4).

Shelterwood and large group selection cuts can also resemble natural patterns seen in mature and overmature stands as well as those in various intermediate treatments. Open shelterwood cuts create more woody understory than dense cuts.

Group selection cuts mix small patch clearcuts of 0.33 to 2 acres and selection cuts across a stand. Small patch clearcuts can maintain intolerant and mid-tolerant tree species composition; and for 5-10 years after cutting may provide some habitat structure needed by some early successional wildlife species.

Type Conversion:

Converting to aspen/birch is the most feasible option. The beech/red maple subtype probably is easiest to convert to aspen/birch, by a series of short-rotation complete clearcuttings. Cuttings at rotations of 25-30 years will result in most rapid conversion, if costs or markets permit. Conversion is easier if some aspen is available for root-sucker regeneration. Otherwise, consider scarification (and perhaps liming) to encourage aspen and birch seedling regeneration.

Spruce-Fir Management

The red spruce-balsam fir type occurs principally in northern New England and New York, adjacent Canada, and highest elevations of the Appalachians. White spruce is a common associate in the northwest part of this range; hemlock is found in the south at lower elevations. Black spruce and tamarack occur in northern wet areas. Spruce-fir is a climax type and is persistent under light to moderate disturbance. Heavy disturbance results in hardwood-softwood mixtures followed by a predominance of fir. Undisturbed over time, the proportion of red spruce increases due to its longevity.

Two broad types of spruce-fir sites are recognized: primary and secondary according to Frank and Bjorkbom (1973).

Primary Sites:

Primary softwood sites consist of moderately to somewhat poorly drained areas at lower elevations; and shallow-to-bedrock areas at elevations above 1,500 to 2,500 feet in New England. When heavily disturbed, successional hardwoods and shrubs rapidly invade. In time, these stands revert to nearly pure (75%) spruce-fir as the hardwoods die out. Mixedwood stands on primary sites support a layer of deciduous shrubs and small trees in addition to the coniferous understory. Pure softwood stands, often contain sparse herbaceous and shrub layers until canopy is broken by overmaturity, windthrow, or insect damage.

Secondary Sites:

These are well-drained to moderately well-drained side slopes at mid elevations. Soils are better than primary sites, and hardwood competition is greater. Pole and sawtimber stands are mixedwood with less than 50 percent softwoods. Eventually, these sites revert to pure softwoods. If heavily disturbed, the new stand may be nearly pure hardwoods, but will develop a softwood understory. Pole and sawtimber stands contain deciduous shrubs. Herbaceous layers vary greatly in species and density, up to 30 to 40 percent ground coverage. Hardwoods found on secondary sites generally show considerable defect and cavities at 14-16 inches dbh (or earlier in the case of quaking aspen).

Succession:

On wet primary sites, the herbaceous/shrub layer following clearcutting of spruce-fir stands may last up to 10-15 years (Fig. 7). The period is much shorter on drier primary and secondary sites. The main difference is the hardwood component--mainly pure softwoods on primary sites and a mixture of hardwoods and softwoods on secondary sites. Relative abundance of deciduous cavity trees is associated on secondary sites. Both successional trends are towards increasing softwood proportions.

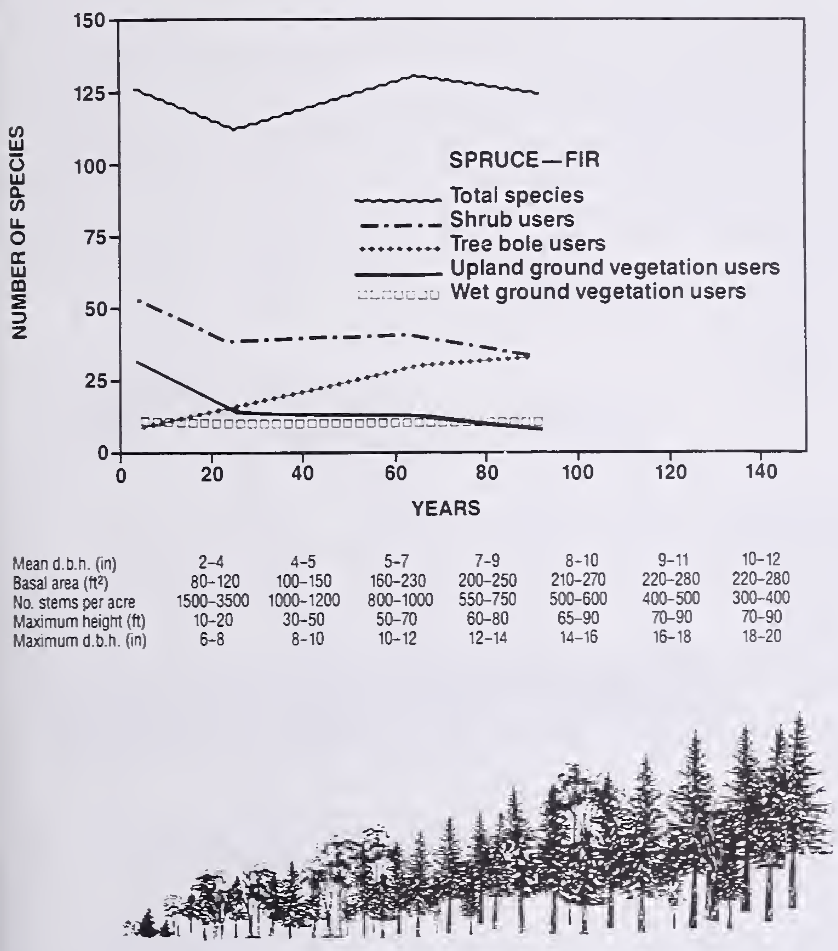


Figure 7. — Spruce-fir stand development and wildlife species occurrence (taken from DeGraaf et al. 1992).

Spruce-fir stands follow several patterns during maturation. Stands comprised primarily of balsam fir reach overmaturity at 60-70 years of age; the canopy quickly dies and the fir understory forms a new sapling stand. This creates "fir waves" at high elevations. Spruce-fir canopies remain closed until the stand is roughly 120-150 years old. Then, areas up to many acres begin to die and regenerate to mixed spruce-fir-hardwood seedling/sapling stands. Canopy openings in overmature spruce-hemlock and spruce-hardwood (secondary sites) are smaller and less apparent. The stands maintain a more uneven-aged character due to differences in species longevity.

Numbers of potential wildlife species are high in the regeneration stage due to the herbaceous/shrub layer response (Fig. 7). Numbers drop and then rise to a maximum in mature and overmature spruce-fir--again due tree-bole users (mainly residents and short-distance migrants). Spruce-fir supports higher potential numbers of species than pure spruce.

Intermediate Treatments:

Quality timber thinning in spruce-fir increases the softwood proportion (especially spruce) and reduces the proportion of hardwood cavity trees. Quality timber thinnings (Fig. 4) can be combined with wildlife tree retention with minimal losses in timber productivity. Low-density (30-50% crown closure) thinning provides a prominent midstory of conifer or mixed hardwood and conifer on secondary sites, and some patchy areas of herbs and shrubs, especially on wet primary sites.

Regeneration:

Spruce-fir is most effectively regenerated with a high-density shelterwood system (Fig. 3). This produces a softwood overstory (with reserved hardwood wildlife trees) and a spruce-fir understory, several hardwoods, and occasional herbs and shrubs on wet sites. Low-density shelterwoods produce a mixed understory and more patches of herbs and shrubs. Single-tree and group selection are both used to maintain spruce-fir stands, usually with a hardwood component. Group selection with openings up to 1 acre is similar to regeneration conditions created by blowdown. Three-cut shelterwoods simulate natural regeneration in old spruce-fir stands. Either method can be used to regenerate spruce-fir.

Type Conversion:

Complete clearcutting on rotations longer than 80 years converts spruce-fir stands to hardwoods, resembling beech-red maple subtype or aspen-birch type, if the stand contains 10-20% aspen before cutting. Repeated clearcutting on short rotations of 15-60 years favor aspen - birch.

Eastern White Pine Management

Eastern white pine occurs throughout the region. Pine types can be organized into two type and site combinations:

1. Oak-pine type on sands, gravel, and sandy tills.
2. Temporary old-field pine on fine-textured soils.

Oak-Pine:

Red oak (with some other oaks) and white pine are associates on outwash soils and sandy tills in central and southern New England. Usually, shrub and herb layers are not dense.

The climax is uncertain, because oak and pine alternate in a series of harvests. Further north, hemlock and spruce seem to be the ultimate climax on dry sandy soils, with oak and pine as persistent associates on south or west exposures.

Old-field Pine:

Old-field pine is prevalent, although a temporary type resulting from farmland abandonment. It commonly develops as pure, dense stands of pine with an occasional wide-crowned hardwood. Woody understories are very sparse unless the stand is opened up (< 70% crown closure) by cutting or windthrow. Old-field pine on sandy soils rapidly assumes the characteristics of oak-pine.

Succession:

On sandy soils, groups of oak often support a pine understory and vice versa. These stands usually exhibit a closed canopy, stratified hardwood-softwood mixtures and a sparse dry-site ground flora.

Old-field pine on fine-textured soils develops dense pure stands once early successional species (like gray birch, aspen, juniper) disappear. Understory and ground flora are almost nonexistent until the canopy is broken by damage, cutting, or overmaturity (150+ years). Then a dense hardwood understory develops.

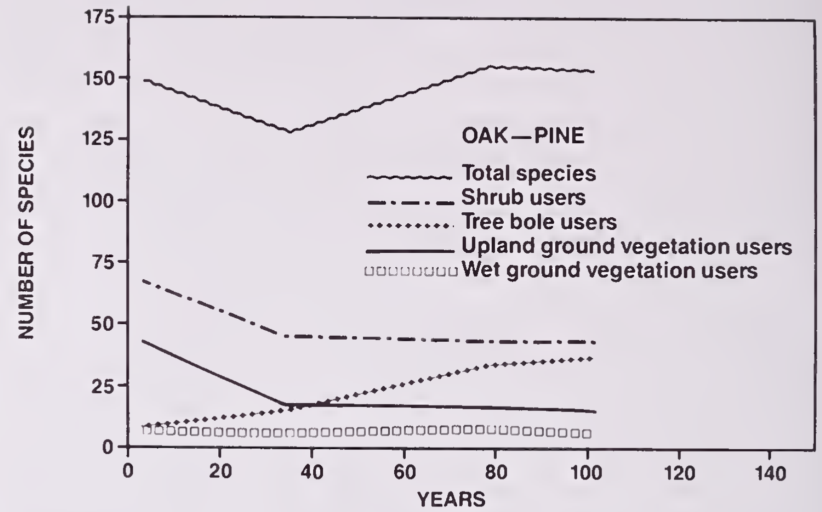
Numbers of wildlife species potentially occurring throughout the successional process tends to be higher in oak-pine than old-field pine. Numbers of potential species are high in regenerating stands (Fig. 8), then drop off in pole stands. Numbers rise in older stands, due to the increasing number of residents and short distance migrants using tree boles.

Several "bull" pines in the supracanopy of the oak-pine group can provide raptor perching and nesting sites. Great-blue heron, osprey, and bald eagle can use these features near open water and other wetlands. The oak-pine type is also managed for production of hard mast for resident wildlife and short distance migrants.

Intermediate Treatments:

Usual treatments in oak-pine on sandy soils are hardwood removals, to favor pine, or thinning of oak stands to improve quality and growth. Low-density thinning in pine is an accepted alternative in some areas. Midstory development is rapid, especially under old-field pine.

Timber thinning with reserved wildlife trees results in habitat potential similar to that in natural succession. Thinnings without reserved wildlife trees eliminates high exposed perches, medium-and large-diameter cavity trees, larger crowned nut-producing trees, and reduces overstory inclusions--important features to many NTMB and resident species.



Mean d.b.h. (in)	2–4	6–8	9–13	12–16	15–20	16–22	18–24
Basal area (ft²)	60–120	180–240	220–280	240–300	250–320	250–320	250–320
No. stems per acre	1400–2000	600–1000	350–550	200–300	150–200	120–150	100–120
Maximum height (ft)	15–30	40–60	60–80	70–100	80–110	80–120	80–120
Maximum d.b.h. (in)	8–10	12–14	16–18	20–24	26–28	30–32	32–34

PINE FOLLOWED BY OAK

Mean d.b.h. (in)	3–4	5–7	7–9	9–11	11–14	12–16	13–17
Basal area (ft²)	60–70	80–90	90–100	100–110	100–120	100–130	100–140
No. stems per acre	800–1200	350–600	250–350	160–250	120–160	95–125	90–100
Maximum height (ft)	30–50	40–70	50–80	65–90	70–100	75–100	80–100
Maximum d.b.h. (in)	8–10	10–14	14–16	16–20	20–24	24–26	24–28

OAK FOLLOWED BY PINE

Figure 8. — Oak-pine stand development and wildlife species occurrence (taken from DeGraaf et al. 1992).

Regeneration:

Pine regenerates best under a moderately dense shelterwood series, especially when coupled with site preparation that eliminates unwanted understory stems and provides a mineral soil seedbed. When regeneration is roughly 4 feet tall, overstory can be removed. With pine, retention of scattered wildlife trees will help prevent weevil damage, as well as add much habitat structure to regenerating stands. First-stage dense shelterwood cuts (Fig. 3) resemble timber thinnings with reserved wildlife trees in the sawtimber-size-class. The final cut in such a shelterwood series could resemble a clearcut with reserved wildlife trees.

CONCLUSION

In the forest dominated rural landscape of northern New England, no one site, cover type, size- class, silvicultural practice, or habitat structure will meet all the needs of NTMB. NTMB habitat management needs to focus on: 1) maintaining a range of forest, nonforest, aquatic, and high elevation habitat; 2) developing and maintaining a variety of cover type compositions and size-class distributions that provide a range of habitat structures, in a mix of area sizes, disturbance scales, and managed and wild conditions; to meet the diverse NTMB habitat needs; and 3) developing ways to offset the consequences of suburbanization of the northeastern forest.

ACKNOWLEDGMENTS

The authors would like to thank the following people for their assistance: C. Costello, R. Cooke, W. Danielson, G. Getchell, and M. Sheremeta. We wish to thank R. Askins and M. Hunter for reviewing the manuscript. Final thanks go to the memory of K. Yamasaki for his quiet encouragement over the years.

LITERATURE CITED

Absalom, S. 1988. Comparison of avian community structure and habitat structure in mature versus old-growth northern hardwood forests. Master's thesis. Amherst, MA: University of Massachusetts. 80 p.

Askins, R.A.; Lynch, J.F.; Greenberg, R. 1990. Population declines migratory birds in eastern North America. In: Power, D.M., ed. Current Ornithology 7. New York: Plenum Press: 1-57.

Bormann, F.H.; Siccama, T.G.; Likens, G.E.; Whittaker, R.H. 1970. The Hubbard Brook ecosystem study: composition and dynamics of the tree stratum. Ecological Monographs. 40:373-388.

DeGraaf, R.M. 1987. Managing northern hardwoods for breeding birds. In: Nyland, R.D., ed. Proceedings of a silvicultural symposium; 1986 June 23-25; Syracuse, NY. Misc. Publ. No. 13. SAF Publ. No. 87-03. Syracuse, NY: State University of New York:348-362.

DeGraaf, R.M.; Chadwick, N.L. 1987. Forest type, timber size-class, and New England breeding birds. J. Wildl. Manage. 51:212-217.

DeGraaf, R.M.; Chadwick, N.L. 1987. Habitat classification: a comparison using avian species and guilds. Environ. Manage. 8(6):511-518.

DeGraaf, R.M.; Rudis, D.D. 1986. New England wildlife: habitat natural history, and distribution. Gen. Tech. Rep. NE-108. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 491 p.

DeGraaf, R.M.; Yamasaki, M.; Leak, W.B.; Lanier, J.W. 1992. New England wildlife: management of forested habitats. Gen. Tech. Rep. NE-144. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 271 p.

Frank, R.M.; Bjorkbom, J.C. 1973. A silivicultural guide forspruce-fir in the Northeast. Gen. Tech. Rep. NE-6. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

Hornbeck, J.W.; Leak, W.B. 1992. Ecology and management of northern hardwood forests in New England. Gen. Tech. Rep. NE-159. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 44 p.

Hunter, M.L., Jr. 1990. Wildlife, forests, and forestry: principlesof managing forests for biological diversity. Englewood Cliffs, New Jersey: Prentice Hall. 370 p.

Leak, W.B. 1959. Progress report: regeneration following cutting of old-growth northern hardwoods on the management intensity plot. Bartlett Experimental Forest, Durham, NH: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 22 p.

Leak, W.B. 1979. Effects of habitat on stand productivity in the White Mountains of New Hampshire. Res. Paper NE-452. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Leak, W.B. 1982. Habitat mapping and interpretation in New England. Res. Pap. NE-496. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 28 p.

Leak, W.B. 1985. Final report: effects of habitat on stand structure in old-growth hardwoods and mixedwoods. Durham, NH: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Leak, W.B.; Graber, R.E. 1974. Forest vegetation related to elevation in the White Mountains of New Hampshire. Res. Pap. NE-299. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Leak, W.B.; Solomon, D.S.; DeBald, P.S. 1987. Silvicultural guide for northern hardwood types in the northeast (revised). Res. Pap. NE-603. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 36 p.

Lorimer, C.G. 1977. The presettlement forest and natural disturbance cycle of northeastern Maine. Ecology 58:139-148.

Siccama, T.G.; Bormann, F.H; Likens, G.E. 1970. The Hubbard Brook Ecosystem Study: productivity, nutrients, and phytosociology of the herbaceous layer. Ecological Monographs. 40:389-402.

Terborgh, J. 1989. Where have all the birds gone? Essays on the biology and conservation of birds that migrate to the American tropics. Princeton, NJ: Princeton University Press. 207 p.

Waddell, K.L.; Oswald, D.D.; and Powell, D.S. 1989. Forest statistics of the United States, 1987. Res. Bull. PNW-RB-168. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 106 p.

Whitcomb, R.F.; Robbins, C.S.; Lynch, J.F.; Whitcomb, B.L.; Klimkiewicz, M.K; Bystrak, D. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. *In:* Burgess, R.L.; Sharpe, D.M., eds. Forest island dynamics in man-dominated landscapes. New York: Springer-Verlag: 125-205.

Effects of Silviculture on Neotropical Migratory Birds in Central and Southeastern Oak Pine Forests

James G. Dickson[1], Frank R. Thompson III[2], Richard N. Conner[1], and Kathleen E. Franzreb[3]

Abstract — Avian communities that are associated with forest habitat attributes are affected by silvicultural and other stand influences. Some species have specific habitat requirements, whereas others occupy a broad range of vegetative conditions. In general, bird species richness and density are positively related to stand foliage volume and diversity. Bird density and diversity are usually high in young brushy stands, decrease in dense pole stands as canopies close and shade out understories, and are highest in older stands with diverse foliage strata. Tree harvesting generally favors early successional species such as the Indigo Bunting, Prairie Warbler, and Yellow-breasted Chat, but some late successional forest species, such as the Black-and-white Warbler, persist with partial cutting. A few forest interior species, such as the Ovenbird, are less abundant in landscapes with cutting and forest fragmentation. Some species may have elevated nest parasitism and nest predation along forest edges. Recommendations for NTMB include: Maintain some large, old-growth stands; manage forest habitat for NTMB; employ special measures for endangered or sensitive species; implement long-term monitoring; and develop more complete information through research regarding NTMB, population viability, and their forest habitat.

Central hardwood, loblolly-shortleaf pine, longleaf-slash-pine, and bottomland hardwood forests dominate the central and southeastern United States. These forests are managed by both even-aged and uneven-aged silvicultural systems. We review the impacts of silvicultural practices on neotropical migratory birds (NTMB), in forests of this region. We approach this topic by (1) identifying general relationships between birds and forest habitats and landscapes in the region, (2) assessing effects of forest management on the NTMB in each ecosystem, and (3) conclude with some management strategies that extend across forest types.

Bird Habitat

Bird species and communities in forest stands have specific habitat requirements and any changes to stand characteristics influence stand suitability. Avian density and diversity generally increase with plant succession, and vegetation volume and structural diversity (Johnston and Odum 1956, Shugart and James 1973, Shugart et al. 1975). But breeding bird densities in regenerating oak-hickory or pine-hardwood stands are often similar to those in mature stands, with densities often lowest in mid-successional pole-sized stands with little sub-canopy foliage (Conner and Adkisson 1975, Conner et al. 1979, Dickson and Segelquist 1979, Yahner 1986, Thompson and Fritzell 1990).

[1] *USFS, Southern Forest Experiment Station, Nacogdoches, TX.*
[2] *USFS, North Central Forest Experiment Station, Columbia, MO.*
[3] *USFS, Southeast Forest Experiment Station, Clemson, SC.*

Tree harvesting drastically alters bird habitat and thus bird communities. Generally, clearcutting results in a near complete turnover of bird species while partial removal of a forest overstory results in decreases in some species, increases in others, and little change in relative abundance of other species (Webb et al. 1977, Crawford et. al. 1981, McComb et al. 1989, Thompson et al. 1992).

Landscape Level Impacts

NTMB populations are affected by factors at scales larger than habitats or forest stands such as landscape (Freemark et al. this proceedings). For instance many forest interior migrants are absent from small forest fragments, and their absence is likely due to lower reproductive success in edge-dominated forest fragments (Faaborg et al. this proceedings, Robinson et al. this proceedings). While edge-related declines in reproductive success in fragmented forests have been documented, the effects of edges created by timber harvest in predominately forested landscapes is unclear. Yahner and Scott (1988) reported higher nest predation rates of artificial nests in Pennsylvania forest with clearcutting than with no clearcutting. Many forest interior species remain abundant in managed forests (Thompson et al. 1992), but it is possible that such forests are population sinks where reproduction is insufficient to compensate for adult mortality (Pulliam 1988). Simulated populations of forest interior NTMB were lower in cut than in uncut forest landscape (Thompson In Press).

In uneven-aged stands, selection cutting maintains a mature tree component at all times and does not create a mosaic of different aged stands. This may benefit forest interior warblers because large tracts of forest with mature trees can be maintained. However, edge effects may occur in group selection openings which could be detrimental to local populations, since these openings can be widely dispersed throughout forests. Also, selection cutting will not provide habitat for species that require young stands, or a diversity of even-aged stands.

CENTRAL HARDWOOD FORESTS

Oak-hickory forests dominate the central hardwood forests but give way to mixed hardwoods in the east and oak-pine forests to the south (Eyre 1980, Sander and Fischer 1989). These forest have been predominantly managed by clearcutting in the past. However, recently there has been an increase in the use of shelterwood and selection cutting, particularly on public lands.

Effects of Even-aged Management

Regeneration Stands

The first year after harvesting these stands may have abundant herbaceous ground cover, but they quickly become dominated by tree regeneration from sprouting and advance regeneration resulting in as many as 25,000 stems/ha (Gingrich 1971). The first year after clearcutting there is usually a drastic reduction in total bird numbers and a nearly complete turnover in species (Table 1). American Goldfinches and Field Sparrows often prefer cuts at this age because of the abundant grass/forb vegetation. As tree regeneration dominates the site, Yellow-breasted Chats, Indigo Buntings, Prairie Warblers, Blue-winged warblers, Kentucky Warblers, Common Yellowthroats, White-eyed Vireos, Gray Catbirds, and Rufous-sided Towhees occupy the stands. To the east Chestnut-sided Warblers and Hooded Warblers also may be common. In shelterwood and seed-tree cuts, and clearcuts with residual live trees and snags, some mature-forest, canopy-dwelling species may continue to use the stands.

Sapling Stands

During age 10 to 20 the stands are dominated by tree saplings with a closed canopy. At age 20 the number of stems has been reduced through mortality to 3,400-6,200/ha and the larger trees on good sites have reached 18 cm dbh (Gingrich 1971). Many birds typical of regenerating stands persist at lower densities in these stands. Black-and-white Warblers, Worm-eating Warblers, and Kentucky Warblers seem to prefer the high stem densities and closed canopies this age class provides. Ovenbirds, Wood Thrushes, and Red-eyed Vireos may begin using stands at this age.

Poletimber Stands

From age 20 to 60 years 90% of the trees will die due to competition. The canopy remains closed and there is little understory development. As a result, common species tend to be canopy nesters such as Red-eyed-Vireos, Scarlet Tanagers, Eastern Wood Pewees, and Wood Thrushes, or ground nesters such as Ovenbirds and Black-and-white Warblers.

Mature Stands

The structure of mature forests varies widely throughout the region. Depending on soils, geology, climate, and geography; mature stands may have sparse to dense groundcover and understory. Decay and deaths of large trees result in cavities, snags, and tree fall gaps not present in short rotation stands.

Table 1. — Abundance of neotropical migratory birds in central hardwood forests.[1]

Species	Stand Age[2]					
	R	S	P	M	G	T
Whip-poor-will	U[3]	U	U	U	U	U
Ruby-throated hummingbird	C	N	N	N	?	N
Acadian flycatcher	N	N	C	A	N	A
Eastern wood-pewee	N	N	U	A	N	A
Eastern phoebe	N	N	U	U	N	U
Great-crested flycatcher	C	C	C	C	C	C
Carolina wren	C	C	U	N	?	?
Blue-gray gnatcatcher	A	C	C	C	C	C
Eastern bluebird	C	N	N	N	N	N
Wood thrush	U	C	C	C	U	C
Gray catbird	C	C	N	N	?	N
White-eyed vireo	C	C	N	N	?	N
Yellow-throated vireo	N	N	N	U	N	U
Red-eyed vireo	U	U	A	A	U	A
Blue-winged warbler	A	C	N	N	?	N
Golden-winged warbler	C	U	N	N	?	N
Northern parula	N	N	U	C	N	C
Chestnut-sided warbler	C	C	N	N	?	N
Yellow-throated warbler	N	N	U	U	N	U
Pine warbler	N	N	C	C	N	C
Prairie warbler	A	C	N	N	?	N
Black-and-white-warbler	C	C	C	C	C	C
Worm-eating warbler	U	C	C	C	C	C
Ovenbird	U	C	C	C	U	U
Louisiana waterthrush	N	U	C	C	C	C
Common yellowthroat	A	U	N	N	?	N
Kentucky warbler	A	C	U	U	A	C
Hooded warbler	C	C	U	U	C	C
Yellow-breasted chat	A	C	N	N	?	N
Orchard oriole	U	N	N	N	N	N
Summer tanager	C	C	C	A	C	C
Scarlet tanager	U	U	C	A	U	A
Indigo bunting	A	C	U	U	A	C
Rufous-sided towhee	A	U	N	N	C	N
Field sparrow	A	N	N	N	?	N
Brown-headed cowbird	A	C	C	C	C	C
American goldfinch	U	N	N	N	N	N
Blue jay	C	C	C	C	C	C
American crow	U	U	U	U	U	U

[1] *Includes oak-hickory, mixed hardwood, and oak-pine forest types. Habitat associations based on Conner and Adkisson 1975, Conner et al. 1979, Dickson and Segelquist 1979, Dickson et al. 1980, Evans and Kirkman 1981, Yahner 1986, Thompson and Fritzell 1990, Thompson et al. (1992), Whitehead unpubl. data, Robinson unpubl. data.*

[2] *R = regeneration, S = sapling, P = poletimber, M = mature, G = group selection, T = single tree selection.*

[3] *A = abundant, C = common or regular, P = present, U = uncommon, N = not present.*

Rotations for central hardwood stands managed for sawtimber are usually 60-120 years. At age 80 dominant trees will range from 30-46 cm dbh. If left undisturbed these stands will slowly become uneven-aged as they age and individual trees die. However, because of widespread logging, burning, and grazing of this region in the late 1800s and early 1900s much of the mature forest in the region is even-aged ranging from 60-100 years old. There are no known obligate old-growth NTMB in these forests. The most abundant species throughout the region in mature forests is the Red-eyed Vireo. Other abundant or common species in this age class include Eastern Wood Pewee, Acadian Flycatcher, Blue-gray Gnatcatcher, Ovenbird, Worm-eating Warbler, Scarlet and Summer tanager, and Blue Jay. In oak-pine stands Pine Warblers and Yellow-throated Warblers are common.

Changes in Stand Composition

Regeneration cuts do not usually greatly alter tree species composition in central hardwood stands because they are naturally regenerated largely from advance reproduction and stump sprouts. Small changes in tree species composition have little effect on breeding birds because it is generally believed most birds select breeding habitat by vegetation structure. Past practices of converting low quality hardwood stands to pine have been largely abandoned on public lands but may persist on some private lands. Pine plantations generally support a lower density and diversity of breeding birds because of their structural simplicity.

Uneven-aged Management

Single and Multi-tree Gaps

Canopy gaps resulting from the harvest of single trees or groups of trees provide habitat for a variety of migrant birds. Species such as the Hooded Warbler and Indigo Bunting appear to be able to make use of small gaps typical of single tree selection while other species such as Yellow-breasted Chats, Blue-winged Warblers, and Prairie Warblers require large openings more typical of clearcuts (F. Thompson pers. obsv.). There is a dearth of information on the area sensitivity of species requiring early successional forest or gaps. These canopy gaps also may be attractive to cowbirds and predators.

Change in Stand Structure

Uneven-aged stands have a well developed understory and sub-canopy because of frequent canopy gaps. The presence of several well developed vegetation levels and more complex habitat structure than similar aged even-aged stands could result in higher within-stand bird species diversity. For instance, in Illinois selectively cut stands contained NTMB associated with mature forest habitats as well as some young second growth species.

There are indications that uneven-aged stands may be poor habitat for some mature forest species. There were fewer ovenbirds in mature uneven-aged than in even-aged forests; and all red-eyed vireo males in a selectively cut stand in Missouri were unmated, compared to 80% mated in a nearby uncut mature forest (Ziehmer 1992).

LOBLOLLY-SHORTLEAF PINE FORESTS

he loblolly-shortleaf pine ecosystem of the rolling portions of the Gulf Coastal Plains, the Piedmont, and portions of Appalachian, Ouachita, and Ozark Mountains, is characterized by a species composition of at least 50 percent pines (either loblolly, shortleaf, or a mix). Associated species include oaks, hickories, sweetgum, blackgum, winged elm, and red maple (Garrison et al. 1977). The degree of hardwood inclusion in these forests is largely determined by past frequency and intensity of natural and prescribed fire.

Harvesting of loblolly and shortleaf pines and subsequent stand regeneration can be successfully accomplished with both even- and uneven-aged silvicultural techniques (Baker and Balmer 1983, Lawson and Kitchens 1983), In modern managed forests prescribed fire, intensive mechanical site preparation, pine seedling planting, and herbicides are used to enhance or maintain the pine component.

Bird Communities

The loblolly-shortleaf pine ecosystem provides habitat for a very diverse array of birds, many of which are neotropical migrants. Stand structure and the proportion of pines and hardwoods are important determinants of avian communities.

Even-aged Management

Early succession stands are structurally simple with little vertical foliage diversity. As stands develop different stages of stand development are attractive to different species of birds.

Seedling and Sapling Stands

Breeding season--Clearcutting today and over the past several decades has produced habitat conditions very similar to those created by large landscape level disturbances. An array of neotropical migrants (e.g., Prairie Warblers, Field Sparrows, Blue Grosbeaks,) are attracted to the youngest stands during the breeding season (Noble and Hamilton 1976; Meyers and Johnson 1978; Conner et al. 1979, 1983; Dickson and Segelquist 1979; Dickson et al. 1980, 1984; Childers et al. 1986). When the stands exceed three years old the number of neotropical migrants using them for breeding sites blooms. Indigo Buntings,

Table 2. — Abundance of neotropical migratory birds in Loblolly-shortleaf pine forests[1].

Species	Stand Age[2]				
	R	S	P	M	O
Whip-poor-will	N[3]	N	N	N	?
Ruby-throated hummingbird	U	U	U	U	U
Acadian flycatcher	N	N	U	C	C
Eastern wood-pewee	N	U	P	C	A
Eastern phoebe	N	N	N	N	?
Great-crested flycatcher	N	N	U	P	C
Blue-gray gnatcatcher	N	N	U	C	A
Eastern bluebird	U	U	N	N	P
Wood thrush	N	N	U	C	A
American robin	N	U	U	U	U
Gray catbird	U	U	N	U	U
White-eyed vireo	U	A	P	U	C
Yellow-throated vireo	N	N	U	A	C
Red-eyed vireo	N	U	C	A	A
Blue-winged warbler	N	N	N	N	N
Golden-winged warbler	N	N	N	N	N
Northern parula	N	N	U	U	C
Chestnut-sided warbler	N	N	N	N	N
Pine warbler	N	N	C	A	A
Prairie warbler	C	A	N	N	U
Black-and-white-warbler	N	U	C	C	C
Worm-eating warbler	N	N	C	C	C
Chuck-will's-widow	U	U	U	U	U
Ovenbird	N	N	U	C	C
Louisiana waterthrush	N	N	N	P	P
Kentucky warbler	N	U	C	P	P
Hooded warbler	N	U	C	A	C
Yellow-breasted chat	C	A	U	N	P
Summer tanager	N	N	U	C	C
Scarlet tanager	N	N	U	U	U
Indigo bunting	N	A	P	U	P
Rufous-sided towhee	N	P	C	C	P
Field sparrow	C	U	N	N	N
Brown-headed cowbird	P	C	P	P	N
American goldfinch	U	U	U	U	U
Blue grosbeak	C	U	N	N	N
Blue jay	U	U	C	A	C
American crow	U	U	P	C	C

[1] Includes oak-hickory, mixed hardwood, and oak-pine forest types. Habitat associations based on Conner and Adkisson (1975), Conner et al. (1979), Crawford et al. (1981), Yahner (1986), Thompson and Fritzell (1990), Thompson et al. (1992), Hammel (in Press), Robinson (unpubl. data), Whitehead (unpubl. data).

[2] R = regeneration, S = sapling, P = poletimber, M = mature, O = oldgrowth.

[3] A = abundant, C = common or regular, P = present, U = uncommon, N = not present.

Painted Buntings, White-eyed Vireos, Yellow-breasted Chats, and Common Yellowthroats are some of the more common species found in the well developed shrubby vegetation of young clearcuts.

As these even-aged stands develop, foliage patchiness in the 0-3 m layer increases and some trees grow to 4-5 m. A few additional species of neotropical migrants begin to occupy the older sapling loblolly-shortleaf stands. In the northern portion of the ecosystem Ovenbirds, Rufous-sided Towhees, Black-and-white Warblers, and American Redstarts begin to appear. Further south, only Black-and-white Warblers are added in any numbers. During this later sapling stage of succession some species, such as Field Sparrows and Blue Grosbeaks, begin to disappear as foliage over-grows bare ground and grasses.

Winter--Many neotropical migrants use young and older sapling aged loblolly-shortleaf pine stands as wintering habitat (Noble and Hamilton 1976, Dickson and Segelquist 1977). Winter Wrens, Brown Thrashers, American Robins, Hermit Thrush, Eastern Bluebirds, Ruby-crowned and Golden-crowned kinglets, Pine and Yellow-rumped warblers, Dark-eyed Juncos, and Field, Song, Lincoln's, and White-throated sparrows all use young pine plantations during winter.

Pole Stands

Breeding season--When young pines and hardwoods reach the pole stage (12-25 years) most of the early succession migrants are no longer found. The taller foliage gradually forms a canopy that reduces light penetration through to the understory. A few White-eyed Vireos and Yellow-breasted Chats remain in open areas, such as wind rows, (Noble and Hamilton 1976; Meyers and Johnson 1978; Conner et al. 1979, 1983; Dickson and Segelquist 1979; Dickson et al. 1980, 1984; Childers et al. 1986). Kentucky and Black-and-white warblers become fairly common. Red-eyed Vireos, Worm-eating, Pine, and Hooded warblers, Yellow-billed Cuckoos, and Summer Tanagers begin to appear. Occasionally, Wood Thrush and Brown Thrashers are detected in such stands.

Winter--Both pine and pine-hardwood pole sized stands are used during winter by neotropical migrants, such as Brown Creepers, Winter Wrens, Hermit Thrush, Eastern Bluebirds, Golden-crowned and Ruby-crowned kinglets, Black-and-white, Pine, and Yellow-rumped warblers, and White-throated Sparrows (Noble and Hamilton 1976, Dickson and Segelquist 1977).

Mature Loblolly-Shortleaf Pine Stands

Breeding season--After 35 to 50 years the developing stand begins to achieve a few characteristics of maturity. An overstory canopy is now present, but midstory and understory foliage can be present also, depending on how much light filters through the canopy. A few White-eyed Vireos and Indigo Buntings are the only early succession species that may persist into the more mature stages of forest growth, depending on the availability of open patches where sufficient light has penetrated to stimulate growth of understory foliage for nesting sites. Wood Thrush, Red-eyed Vireos, Black-and-white Warblers, Eastern Wood Pewees, Great Crested and Acadian flycatchers, Pine, Hooded, Kentucky warblers, Summer Tanagers, and Blue-gray Gnatcatchers are now abundant (Noble and Hamilton 1976; Meyers and Johnson 1978; Conner et al. 1979, 1983; Dickson and Segelquist 1979; Dickson et al. 1980, 1984; Childers et al. 1986). Yellow-throated Warblers, Northern Parulas, and Yellow-billed Cuckoos are also present. Pine Warblers are attracted to the pine foliage, whereas most of the other species are primarily dependant on deciduous foliage that has developed.

Winter--Mature loblolly-shortleaf pine and pine-hardwood forests provide winter cover and food for American Robins, Hermit Thrush, Golden-crowned and Ruby-crowned kinglets, Black-and-white Warblers, and White-throated Sparrows (Noble and Hamilton 1976, Dickson and Segelquist 1977).

Management Activities Affecting Bird Communities

Management activities such as site preparation, herbicide use, and thinning, affect stand structure and impact the avian fauna.

Site preparation--The intensity of mechanical site preparation prior to planting affects the amount of hardwood vegetation that regenerates with the pine seedlings. Intensive K-G blading (bull-dozer blade) and chopping of roots will reduce the amount of hardwood regeneration substantially. Less intensive site preparation, such as prescribed burning, permits more hardwood vegetation to survive and grow along with the pines. Bird species diversity will be reduced as the amount of hardwoods in all pine stands decreases. **Herbicides**--Herbicides sometimes are used to kill hardwoods that compete with pines in young pine plantations. Reduction of hardwood vegetation would set back stand development and associated bird communities.

Thinning--Thinning opens the canopy, releasing the remaining pines for increased diameter growth, and permits more light into the understory which promotes understory vegetation (Blair and Enghardt 1976, Blair 1982).

Thinning is beneficial to some neotropical migrants and has a significant positive influence on bird abundance and species richness during the breeding season (Chritton 1988). Indigo Buntings, Pine Warblers, and Brown-headed Cowbirds increased in abundance following thinning of a loblolly plantation in Texas. White-eyed Vireos, Worm-eating Warblers, and Hooded Warblers were negatively affected, whereas Black-and-white Warblers appeared to be unaffected by thinning.

Thinning also affects migrants that winter in the loblolly-shortleaf pine ecosystem in the South (Chritton 1988). During winter, bird abundance and species richness was higher in thinned pine stands than in unthinned stands. Pine Warblers, Ruby-crowned and Golden-crowned kinglets, and Dark-eyed Juncos increased in numbers following thinning in Texas.

Rotation ages--Longer rotations of 70 to 80 years and longer permit some old-growth attributes to develop and provide habitat for species of neotropical migrants that prefer mature pine forest, such as Red-eyed Vireos, Northern Parulas, and Hooded, Pine, and Yellow-throated warblers. Shorter saw log rotations of 35 to 50 years would provide habitat for some mature forest species but probably at lower densities then the longer rotations. Pulp wood rotations of 20-30 years provide habitat for early successional species when the stands are young, but has limited suitability for neotropical migrants requiring stands beyond the pole timber stage.

Seed-tree and Shelterwood Harvesting

Seed-tree and shelterwood harvesting leave uncut mature pines to serve as seed sources and in shelterwood as shelter for the developing stands. These large residual pines can be of value to early and late successional neotropical migrant birds (Hall 1987).

Breeding Season--Neotropical migrants using seed-tree and shelterwood cuts during the breeding season are: Eastern Kingbirds, Acadian Flycatchers, Pine Warblers, Prairie Warblers, Yellow-breasted Chats, Wilson's Warblers, Hooded Warblers, Orchard Orioles, Indigo Buntings, and Chipping and Field sparrows.

Winter--During winter, seed-tree and shelterwood harvesting again provide habitat for both early and late succession bird species. Neotropical migrants using cuts included American Kestrels, Ruby-crowned Kinglets, Yellow-rumped Warblers, Common Yellowthroats, Red-winged Blackbirds, Purple Finches, Pine Siskins, American Goldfinches, and Grasshopper, Henslow's, Lark, Field, White-crowned, White-throated, Swamp, and Song sparrows (Hall 1987).

Unfortunately, the benefits for bird species richness gained by the presence of the residual pines is lost completely when the residuals are removed following the establishment of the new pine stand.

Uneven-aged Timber Management

There is extremely little published information on the bird communities that inhabit stands managed under single-tree or group selection harvesting, so currently we can only speculate based on data from seed-tree and shelterwood cuts, and heavily thinned stands. Species that use early successional stands, small gaps within forests, and "edge" would probably be favored by single tree selection harvesting. In group selection larger gaps up to 1 ha would have a similar but more pronounced effect on the avian community than single tree selection. Yellow-breasted Chats, Indigo Buntings, and Prairie Warblers, will probably be added to the overall bird community. But, cowbird parasitism may increase and the few mature forest species that prefer a continuous canopy may be negatively impacted.

LONGLEAF, SLASH, AND LONGLEAF-SLASH PINE FORESTS

The longleaf-slash pine ecosystem, a subclimax type maintained by fire, generally occurs along the lower coastal plain of the southeastern U.S. Agricultural conversion, intensive timber management, and substantial declines in frequency and intensity of fires have resulted in drastic reduction in the longleaf pine forests. The natural range of slash pine is more restricted (South Carolina to Central Florida and southeast Louisiana), although it has been planted extensively as far north as North Carolina and west to eastern Texas. Most of the typical longleaf-slash pine cover type is found in the flatwoods of Florida and Georgia. Slash pine seedlings are more shade tolerant than those of longleaf pine; hence, slash pine may begin as an understory and remain subordinate to the longleaf pine overstory. Slash pine regeneration is eliminated by fire and without fire the encroachment of hardwoods will progress until they predominate and exclude the pines. Longleaf pine seedlings in the grass stage can tolerate and benefit from prescribed burning for brownspot control. Both slash and longleaf pine seedlings growing in height are vulnerable to fire, but both species are somewhat immune when they attain a height of about 5m.

Bird Habitat

Younger forests tend to have moderate bird species diversity (BSD), the initial BSD tends to decrease by the time the forests are 16-20 years old, after which it increases to maturity (Childers et al. 1986, Noble and Hamilton 1976, Repenning and Labisky 1985).

Avifauna in pine forests is substantially influenced by the presence and extent of hardwoods (Johnston and Odum 1956, Dickson and Segelquist 1979). Pine stands normally contain numerous hardwood species and removal influences bird community composition. Burning to maintain pine forests can have deleterious effects on birds using the hardwood component for cover, nesting, or foraging. However, for ground foragers, the effects of burning may be beneficial as fire reduces the litter thereby exposing seeds that then become available for food. Slash pine sites in southeastern Georgia that contained hardwoods supported 17 species that either were absent or occurred in low densities in the pure slash pine and, therefore, hardwoods were important in maintaining the BSD (Johnson and Landers 1982).

Several studies have examined longleaf and slash pine stands of various ages to determine how avian community structure may change as the stands mature. In slash pine stands

Table 3. — Abundance of neotropical migratory birds in longleaf and slash pine forests[1].

Species	Stand Age[2] R	S	P	M	O
Longleaf Pine					
Common nighthawk	P[3]	P	U	U	U
Chuck-will's-widow			U	U	U
Eastern wood-pewee			U	C	C
Acadian flycatcher				P	P
Great-crested flycatcher		U	P		
Eastern kingbird				P	P
Purple martin	U				
Barn swallow	U				
Prairie warbler	C				
Summer tanager		U	U	C	C
Blue grosbeak	P	P			
Slash Pine					
Yellow-billed cuckoo			U	U	U
Ruby-throated hummingbird	C	C			
Eastern wood-pewee			C		
Acadian flycatcher			C		
Great-crested flycatcher			P	C	C
Eastern kingbird		P			
Bewick's wren			C		
Blue-gray gnatcatcher			P	P	
White-eyed vireo			C		
Yellow-throated vireo				P	
Yellow-throated warbler		C			
Prairie warbler	U	U	U		
Common yellowthroat		C	P	P	P
Yellow-breasted chat		C			
Summer tanager	C		C	C	C
Blue grosbeak	P	P			
Indigo bunting	C	C	P	U	U
Longleaf-Slash Pine					
Osprey				U	U
American swallow-tailed kite				U	U
Yellow-billed cuckoo	P				
Common nighthawk	P	U	U	U	U
Chuck-will's-widow			U	U	U
Ruby-throated hummingbird	U				
Eastern wood-pewee			U	C	C
Great crested flycatcher	P		U	P	P
Eastern kingbird	U	U	U	U	U
Purple martin	U				
Barn swallow	U				
White-eyed vireo				C	C
Yellow-throated warbler		U	U	U	U
Prairie warbler	U	U	U	U	U
Common yellowthroat	U	P	P	C	C
Yellow-breasted chat	U	U			
Summer tanager		U	U	P	P
Blue grosbeak	P	P			
Indigo bunting	C	C	P	U	U

[1] From Hamel et at. (1982), Johnson and Landers (1982), O'Meara et al. (1985), Repenning and Labisky (1985), Dickson (1991), and Hamel (in press),

[2] R = regeneration, S = sapling, P = poletimber, M = mature, O = old growth.

[3] A = abundant, C = common or regular, P = present, U = uncommon

in southeastern Georgia in relation to stand age and regeneration method, Johnson and Landers (1982) found that bird numbers tended to be lowest in the 1-year-old slash pine plantations, increased in the 2-6-year-old stands, and then declined again until approximately mid-rotation (16 years). Once stands passed mid-rotation ages (16-28 years), the initial stand treatments such as site preparation or whether naturally regenerated or planted, had no detectable effect on the avifauna. Five species of breeding NTMB were found in the fallow areas, with only the Blue-gray Gnatcatcher being abundant, and five species were regularly observed in the regenerating areas. Of the seven species found in the seedling/sapling stage, the Indigo Bunting, Common Yellowthroat, and Ruby-throated Hummingbird were either abundant or common. The Common Yellowthroat, Blue-gray Gnatcatcher, and Eastern Wood Pewee were the most commonly observed of the 10 NTMB in the pole stage.

Also, regenerating longleaf pine/slash pine stands in the grass forb stage are year round habitat for the Bachman's Sparrow, Northern Bobwhite , Mourning Dove and Eastern Bluebird; breeding habitat for the Common Nighthawk; and wintering habitat for Henslow's and Leconte's sparrows. The sapling stage is suitable habitat for the Common Nighthawk, Common Yellowthroat, Indigo Bunting, and a number of permanent resident species.

The effects of prescribed burning on a 20 year-old slash pine stand resulted in a drastic decline in ground cover and shrub foliage in Everglades National Park, Florida (Emlen 1970). However no significant difference was detected in NTMB or foraging guilds after the fire, possibly because of individual attachments to home range and familiar foraging sites.

Harris et al. (1974) compared site preparation techniques in three 9-year old slash pine stands with a naturally regenerated slash pine stand and with a mature longleaf pine stand that had been prescribed burned the previous year. The average number of birds observed per transect sampled was higher in areas that had undergone low intensity site preparation than in mature slash pine; however, the number of species observed per transect was significantly lower. There were nine times more birds in mature longleaf pine stands than in the low intensity site prepared slash pine stands and 60 times more than in the high intensity treated site prepared stands.

Repenning and Labisky (1985) compared the avian community in 3 naturally regenerated longleaf pine stands (>50 years) to slash pine plantations of 4 different ages (1-, 10-, 24-, and 40-year-old stands) (3 stands per age group). Density of breeding birds was highest in the longleaf pine stands (288 birds/km^2) and oldest slash pine stands (149 birds/km^2). Longleaf pine stands supported more breeding birds, a higher biomass, and greater species richness than any of the slash pine stands. Cavity and ground nesters increased in both density and number of species from the youngest to oldest stands and were highest in the longleaf pine forests. Of the 7 species of neotropical migrant breeding birds, 2 species were found in 1-year old stands (13 birds per km^2), 4 in 10-year old stands (19 birds per km^2), 2 in 24-year old stands (22 birds per km^2), 4 in 40-year old (33 birds per km^2), and 5 in mature longleaf pine forest (33 birds per km^2). Wintering birds were most numerous in the youngest slash pine stands, perhaps the result of the abundance of seed-producing grasses and forbs (Repenning and Labisky 1985). They concluded that conversion of mature longleaf stands to slash pine plantations did not accommodate the bird community associated with the mature habitat.

O'Meara et al. (1985) and Rowse and Marion (1980) examined the same 3 areas of flatwoods in Florida containing slash and scattered longleaf pine trees. The areas had been harvested 35 years prior, allowed to regenerate naturally, and fire had been excluded for 20 years. Pine stands in 2 of the areas were clearcut and were monitored before cutting and for 3 years afterwards. Unharvested slash pine 35-years-old, regenerating slash pine (recently clearcut), cypress and edge areas (< 10 m from the interface of 2 other habitats) were compared. The Great-creasted Flycatcher, White-eyed Vireo, and Common Yellowthroat were the NTMB in the 35-year old stands. For the 3 years subsequent to clearcutting, harvested habitats contained low spring and summer densities with only a few species adapted to early-successional vegetation. Three NTMB species (Common Nighhawk, Common Yellowthroat, and Blue Grosbeak) were present at densities less than $7/km^2$. Winter densities in clearcut habitat were higher resulting from the presence of wintering flocks of American Robins and Red-winged Blackbirds and mixed species flocks of sparrows. The findings of this study are similar to that of Repenning and Labisky (1985) in that an immediate result of clearcutting slash pine was a replacement of birds by species adapted to early successional stages, a lower density of breeding birds, reduced BSD, and a much larger wintering than breeding population.

The above studies evaluated the effects of even-aged management on the avifauna. However, little work has been done in relation to the response of birds to uneven-aged harvesting techniques. Single tree selection harvesting opens up the forest canopy, creating small gaps in the forest floor. In the group selection method, cuts are usually 0.2 to 0.8 ha in size and thus create numerous small gaps in the forest. In both cases, species that use edge habitats or small gaps will benefit. However, it is not clear if the habitat fragmentation created by this approach will be detrimental to birds requiring large tracts of undisturbed forest.

OAK-GUM-CYPRESS FORESTS

Oak-gum-cypress forests (also called bottomland hardwoods) occur on mesic to hydric sites along streams or rivers from Virginia to eastern Texas and up the Mississippi river to Indiana. Dominant vegetative communities of this complex are closely associated with sites which are determined mainly by soils, elevation, and hydroperiod. Oak-gum-cypress forest area has declined, especially in the Mississippi River Delta where land was converted to soybeans, cotton, and pasture. Recently there have been some efforts to restore bottomland forests that have been converted to agricultural uses and to protect what remains.

The avifauna of oak-gum-cypress forests is abundant and diverse. Habitat suitability for bird communities and species depends on stand structure and other factors.

Breeding Birds

There are a variety and abundance of breeding birds in the mature bottomland hardwood forests of the South. In a Louisiana floodplain forest about half of the number and species of breeding season birds were neotropical migrants and about half were permanent residents (Dickson 1978b). The proportion of neotropical migrant breeders was lower than in more northerly and seasonally harsher climates.

Oak-gum-cypress forests are special habitat for many species of birds (Dickson 1978a, 1988, Hamel et al. 1982). A survey of breeding bird censuses from seven mature stands (Dickson et al. 1980) showed that Yellow-billed Cuckoos, Acadian Flycatchers, and Red-eyed Vireos were consistently abundant in oak-gum-cypress habitat. Other species regularly inhabit these stands, and some have special affinities for this habitat (Table 4).

Table 4. — Neotropical migrant breeding bird species present in southeastern oak-gum-cypress forests (from Hamel et al. 1982 and other sources)

American anhinga	Blue-gray gnatcatcher
Green-backed heron	White-eyed vireo
Great blue heron	Yellow-throated vireo
Little blue heron	Red-eyed vireo
Cattle egret[1]	Black-and-white warbler
Great egret	Prothonotary warbler
Snowy egret	Swainson's warbler
Tricolored heron	Worm-eating warbler
Black-crowned night heron	Bachman's warbler
Yellow-crowned night heron	Northern parula
Wood stork	Black-throated green warbler
Glossy ibis	Yellow-throated warbler
White ibis	Prairie warbler[2]
Hooded merganser	Ovenbird
American swallow-tailed kite	Louisiana waterthrush
Mississippi kite	Kentucky warbler
Cooper's hawk	Common yellowthroat[2]
Bald eagle	Yellow-breasted chat[2]
Osprey	Hooded warbler
Purple gallinule	American redstart
Common moorhen	Eastern meadowlark[1]
Mourning dove[1]	Red-winged blackbird
Yellow-billed cuckoo	Brown-headed cowbird[1]
Chimney swift[1]	Orchard oriole
Ruby-throated hummingbird	Northern oriole
Belted kingfisher	Summer tanager
Great-crested flycatcher	Blue grosbeak[2]
Eastern phoebe[1]	Indigo bunting[2]
Acadian flycatcher	Painted bunting[2]
Eastern wood pewee	Rufous-sided towhee[2]
Barn swallow[1]	
Purple martin[1]Wood thrush	

[1] Associated with human altered non-forest habitat.

[2] Associated with early successional stands.

Many long-legged waders nest and forage in aquatic woodlands. Wood Storks, which are now endangered, nest in tall cypress and hardwoods and feed in associated aquatic systems.

Several migratory raptors inhabit bottomland hardwoods, such as the Mississippi and Swallow-tailed kites, Cooper's Hawks, Bald Eagles, and Ospreys. Also, Purple Gallinules and Common Moorhens are found in appropriate aquatic habitat.

Acadian Flycatchers are strongly associated with forested wetlands (Shugart and James 1973, Smith 1977), and Wood Thrushes are a common breeding bird in the mesic sites. White-eyed Vireos are common in this type in low, shrubby foliage and Red-eyed Vireos in canopy foliage. There are many warblers in this habitat, some with special affinities. Prothonotary, Swainson's, Northern Parula, Kentucky, and Hooded are strongly associated with this habitat. Prothonotary Warblers nest in cavities, often over water. Northern Parulas construct their nest with Spanish moss in moist woods. The Swainson's Warbler is primarily associated with understory thickets of southern river floodplains and the southern Appalachian Mountains (Meanly 1971). The habitat of the rare Bachman's Warbler is bottomlands and headwater swamps subject to disturbances (Hooper and Hamel 1977). Both Swainson's and Bachman's warblers are associated with cane thickets, which were once extensive in southern bottomland forests (Meanly 1971, Remsen 1986). Kentucky and Hooded warblers are usually found in the moist understory of bottomland hardwoods (Dickson and Noble 1978). Other warblers often found in mature stands include Black-and-white, Worm-eating, Yellow-throated, Ovenbird, American Redstart, and Louisiana Waterthrush (Hamel et al. 1982).

Bird communities are related to age and development of forest stands (Shugart and James 1973, Dickson and Segelquist 1979). Breeding birds discussed previously have been those associated with mature stands of mixed species, and these would also generally be present in middle-aged stands. Young stands would have mostly a different bird composition. In the earliest stages of hardwood stand development the Dickcissel and Red-winged Blackbird would be characteristic species (Weinell 1989). Neotropical migrant birds typifying the avian community in young brushy stands include the Yellow-breasted Chat, Indigo Bunting, Painted Bunting, Prairie Warbler, Common Yellowthroat, and White-eyed Vireo.

Winter Birds

Winter is an important period for many birds. Mature oak-gum-cypress forests provide critical habitat for wintering birds, and support very abundant wintering bird communities (1400 - 2000/ km^2, Dickson 1978b). Most of the species are permanent or winter residents, such as Common Grackle and White-throated Sparrow, that do not winter in the tropics. But these mature bottomland forests are regular habitat for several species that winter from southern forests into the tropics, including Yellow-bellied Sapsuckers, American Robins, Hermit Thrushes, Ruby-crowned Kinglets, and Orange-crowned Warblers.

Silviculture and Bird Communities

Although specific studies of bird community changes related to silvicultural practices in oak-gum-cypress forests are generally lacking, some information may be presented based on general habitat relationships of bird species and from study results of the other habitats in the South. Drastic habitat alteration in oak-gum-cypress forests will influence bird community composition. Conversion of mature bottomland forest stands to other land uses, of course, will drastically alter bird communities. Many bottomland stands and their associated bird communities have been lost to reservoirs. This conversion probably only benefits a few aquatic species such as cormorants and perhaps some cavity nesters in the short term if the trees are not cleared before inundation and water-killed snags are left. Conversion of bottomland forests to agricultural land also results in elimination of the forest associated avian community.

Tree harvesting and regeneration in bottomland forests is a habitat alteration that results in changes to the bird community. The replacement of mature stands of mixed hardwoods by hardwood plantations alters bird communities. These plantations and natural stands of pure black willow or cottonwood lack vegetative diversity and support fewer birds and a less diverse bird community than natural mixed stands (Wesley et al. 1976). But in areas where the majority of land is in mature mixed stands and the plantations represent a small land commitment, the overall beta (landscape) bird diversity of an area could be increased because of the birds associated with early successional stands that inhabit the plantations. In Mississippi, Red-winged Blackbirds, Common Yellowthroats, Yellow-breasted Chats, Northern and Orchard orioles, Rufous-sided Towhees, and Warbling Vireos were common in plantations, but not in natural stands (Wesley et al. 1976).

Clearcuts with natural regeneration generally would favor edge species such as Wood Pewees and early successional species such as Indigo Buntings, Prairie Warblers, White-Eyed Vireos, and Yellow-breasted Chats (Dickson and Segelquist 1979, McComb et al. 1989, Thompson et al. 1992).

Harvest regimes in which some trees are harvested and some left, such as improvement cuts or thinnings would have a less drastic effect on bird communities than clearcuts and would favor early successional and edge species. Partial cuts or small clearcuts usually result in higher bird diversity and most mature forest associated birds remain in forested stands where some mature trees or stands remain. Understory vegetation growth in the opened stands would favor understory associated species such as Kentucky and Hooded warblers (Dickson and Noble 1978, McComb et al. 1989, Thompson et al. 1992).

A few forest interior species associated with closed canopy forest would dwindle with tree harvest and stand opening. Studies have shown Ovenbird and Wood Thrush abundance were negatively correlated with stand harvest (Crawford et al. 1981, Webb et al. 1977).

Rotation age also would affect bird community composition in forest stands. Short rotations would favor early successional species, whereas long rotations should favor cavity using species such as the Great-crested Flycatcher and canopy associated species such as the Red-eyed Vireo, Yellow-throated Vireo, Northern Parula, and Summer Tanager (Dickson and Noble 1978).

MANAGEMENT RECOMMENDATIONS

NTMB communities are determined by local habitat factors as well as landscape composition. At a landscape level the single most important consideration is to maintain large areas in breeding and wintering forest habitats to provide for large NTMB populations and minimize numbers of cowbirds and predators associated with agricultural, suburban, and urban land uses. At the habitat level the most basic management step is to maintain native ecosystems. Management should promote rare ecosystems and habitats required by threatened or endangered species and regional species of high management concern. A high priority in southeastern forests is to protect existing old-growth stands and corridors, and to allow new old growth stands to develop. Restoration and maintenance of natural ecosystems that have been substantially reduced or altered, such as longleaf and oak-gum-cypress forests, should be accelerated. NTMB species exhibiting population declines and identified as species of high management concern breed in all stages of forest succession (Hunter In Press, Thompson et al. In Press), so a diversity of successional stages should be provided. Unless specific concerns dictate otherwise, both selection cutting and even-aged management should be used to create small openings for gap species, large openings for early successional forest migrants, and a balanced age-class distribution to maintain sufficient mature forest habitats. This range of opening sizes more closely imitates the range in size of natural openings or disturbances in forests (Hunter 1990) than the use of any one regeneration practice. Where late successional, area or edge-sensitive NTMBs are a concern (e.g. Red-eyed Vireo, Ovenbird, Pine Warbler, etc.) some blocks of unfragmented forest should be set aside from timber harvest, larger regeneration cuts on longer rotations used in even-aged systems, and single tree selection favored over group selection. Even-aged systems should be used to provide young forest habitats for early successional species (e.g. Prairie Warbler, Yellow-breasted Chat, Blue-winged Warbler, etc.) because openings created by selection cutting may be too small for many of these species. Other stand level practices that will maintain NTMB community viability include retaining live cavity trees and snags when stands are regenerated, and maintaining both coniferous and deciduous components of mixed stands. An extensive monitoring program should be implemented which tracks bird species abundance and viability over the long term.

Research of NTMB and their forest habitat should be expanded to develop more complete information for management of NTMB. The different forested ecosystems, their components and function, should be explored more fully. Species density may not always be a suitable measure of habitat quality (Van Horne 1983). A better understanding of species demographics, including productivity, cowbird parasitism, and nest predation is essential. Moreover, additional information relating avian communities to forest composition, distribution, fragmentation and various silviculture practices is needed to ensure the future of sensitive NTMB.

LITERATURE CITED

Baker, J. B., & W. E. Balmer. 1983. Loblolly pine. Pp. 149-152 in Silvicultural systems for the major forest types of the United States (R.M. Burns, tech. compl.). USDA For. Serv. Agric. Hdbk No. 445.

Blair, R. M. 1982. Growth and nonstructural carbohydrate content of southern browse species as influenced by light intensity. J. Range Manage. 35: 756-760.

Blair, R. M., & H. G. Enghardt. 1976. Deer forage and overstory dynamics in a loblolly pine plantation. J. Range Manage. 29: 104-108.

Childers, E. L., T. L. Sharik, & C. S. Adkisson. 1986. Effects of loblolly pine plantations on songbird dynamics in the Virginia Piedmont. J. Wildl. Manage. 50: 406-413.

Chritton, C. A. 1988. Effects of thinning a loblolly pine plantation on nongame bird populations in east Texas. M.S. Thesis. Stephen F. Austin State Univ., Nacogdoches, Texas.

Conner, R. N., & C. S. Adkisson. 1975. Effects of clearcutting on the diversity of breeding birds. J. For. 73: 781-785.

Conner, R. N., J. G. Dickson, B. A. Locke, and C. A. Segelquist. 1983. Vegetation characteristics important to common songbirds in east Texas. Wilson Bull. 95: 349-361.

Conner, R. N., J. W. Via, & I. D. Prather. 1979. Effects of pine-oak clearcutting on winter and breeding birds in southwestern Virginia. Wilson Bull. 91: 301-316.

Crawford, H. S., R. G. Hooper, & R. W. Titterington. 1981. Songbird population response to silvicultural practices in central Appalachian hardwoods. J. Wildl. Manage. 45: 680-692.

Dickson, J. G. 1978a. Forest bird communities of the bottomland hardwoods. Pp. 66-73 in Proceedings of the Workshop: Management of Southern Forests for Nongame Birds (R. M. DeGraff, tech. coord.). U.S. For. Ser. Gen. Tech. Rep. SE-14.

Dickson, J. G. 1978b. Seasonal bird populations in a south central Louisiana bottomland hardwood forest. J. Wildl. Manage. 42: 875-883.

Dickson, J. G. 1988. Bird communities in oak-gum-cypress forests. Pp. 51-62 in Bird Conservation 3. International Council for Bird Preservation (J. A. Jackson, Ed.). University of Wisconsin Press, Madison.

Dickson, J. G. 1991. Birds and mammals of pre-colonial southern old-growth forests. Natural Areas J. 11: 26-33.

Dickson, J. G., R. N. Conner, & J. H. Williamson. 1980. Relative abundance of breeding birds in forest stands in the southeast. South. J. Appl. For. 4:174-179.

Dickson, J. G., R. N. Conner, & J. H. Williamson. 1984. Bird community changes in a young pine plantation in east Texas. So. J. Appl. For. 8: 47-51.

Dickson, J. G., & R. E. Noble. 1978. Vertical distribution of birds in a Louisiana bottomland hardwood forest. Wilson Bull. 90: 19-30.

Dickson, J. G., and C. A. Segelquist. 1977. Winter bird populations in pine and pine-hardwood stands in east Texas. Proc. Annu. Conf. S.E. Assoc. Fish Wildl. Agencies. 31: 134-137.

Dickson, J. G., & C. A. Segelquist. 1979. Breeding bird populations in pine and pine-hardwood forests in Texas. J. Wildl. Manage. 43: 549-555.

Emlen, J. T. 1970. Habitat selection by birds following a forest fire. Ecology 51: 343-345.

Evans, K.E. and R.A. Kirkman. 1981. Guide to bird habitat of the Ozark Plateau U.S. For. Serv. Gen. Tech. Rep NC-68.

Eyre, F. H. (Ed.) 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC.

Garrison, G. A., A. J. Bjungstad, D. A. Duncan, M. E. Lewis, & D. R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. U.S. Dept. Agric., Agric. Handbook 475.

Gingrich, S. F. 1971. Management of young and intermediate stands of upland hardwoods. U.S.D.A. For. Serv. Res. Paper NE-195.

Hall, S. B. 1987. Habitat structure and bird species diversity in seedtree and clearcut regeneration areas in east Texas. M.S. Thesis. Stephen F. Austin State Univ., Nacogdoches, Texas.

Hamel, P. B., H. E. LeGrand, Jr., M. R. Lennartz, & S. A. Gauthreaux, Jr. 1982. Bird-habitat relationships on southeastern forest land. U.S. For. Serv. Gen. Tech. Rep. SE-22.

Harris, L. D., L. D. White, J. E. Johnston, & D. G. Milchunas. 1974. Impact of forest plantations on north Florida wildlife and habitat. Proc. Southeastern Assoc. Game Fish Comm. 28: 659-667.

Hooper, R. G., & P. B. Hamel. 1977. Nesting habitat of Bachman's Warbler- A review. Wilson Bull. 89: 373-37979.

Hunter, M. L., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, N.J.

Hunter, W. C. In Press. Species and habitats of special concern within the southeast region in Proceedings of a workshop on the status and management of neotropical migratory birds. Rocky Mountain Forest and Range Experiment Station General Technical Report.

Johnson, A. S., & J. L. Landers. 1982. Habitat relationships of summer resident birds in slash pine flatwoods. J. Wildl. Manage. 46: 416-428.

Johnston, D. W., & E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37: 50-62.

Lawson, E. R., & R. N. Kitchens. 1983. Shortleaf pine. Pp. 157-161 in Silvicultural systems for the major forest types of the United States (R.M. Burns, tech. compl.). USDA For. Serv. Agric. Hdbk No. 445.

McComb, W. C., P. L. Groetsch, G. E. Jacoby, & G.A. McPeek. 1989. Response of forest birds to an improvement cut in Kentucky. Proc. SE Assoc. Fish and Wildl. Agencies 43: 313-325.

Meanly, B. 1971. Natural history of the Swainson's Warbler. North Am. Fauna No. 69.

Meyers, J. M., & A. S. Johnson. 1978. Bird communities associated with succession and management of loblolly-shortleaf pine forests. Pp. 50-65 in Proceedings of the workshop Management of southern forests for nongame birds. USDA For. Serv. Gen Tech. Rept. SE-14.

Noble, R. E., & R. B. Hamilton. 1976. Bird populations in even-aged loblolly pine forests of southeastern Louisiana. Proc. Southeast. Assoc. Game Fish Comm. 29: 441-450.

O'Meara, T. E., L. A. Rowse, W. R. Marion, & L. D. Harris. 1985. Numerical responses of flatwoods avifauna to clearcutting. Florida Scientist 48: 208-219.

Pulliam, H. R. 1988. Sources, sinks, and population regulation. Amer. Nat. 132: 652-661.

Remsen, J. V., Jr. 1986. Was Bachman's Warbler a bamboo specialist? Auk 103: 216-219.

Repenning, R. W., & R. F. Labisky. 1985. Effects of even-age timber management on bird communities of the longleaf pine forest in northern Florida. J. Wildl. Manage. 49: 1088-1098.

Rowse, L. A., & W. R. Marion. 1980. Effects of silvicultural practices on birds in a north Florida flatwoods. Pp. 349-357 in First Biennial Southern Silvicultural Res. Conf.(J. P. Barnett, Ed.). USDA Forest Service Gen. Tech. Rep. SO-34.

Sander, I.L. & B. C. Fischer. 1989. Central Hardwood forest types. Pages 1.021-1.022 in Central Hardwood Notes (F. B. Clark and J. G. Hutchinson Eds.). North Central Forest Experiment Station, St. Paul, Minnesota.

Shugart, H. H., Jr., & D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90: 62-77.

Shugart, H. H., S. H. Anderson, & R. H. Strand. 1975. Dominant patterns in bird populations of the eastern deciduous forest biome. Pp. 90-95 in The management of forest and range habitats for nongame birds Symp. Proc. U.S. Dep. Agric. Gen. Tech. Rep. WO-1. U.S. Dep. Agric. For. Serv., Washington, DC.

Smith, K. G. 1977. Distribution of summer birds along a forest moisture gradient in an Ozark watershed. Ecology 58: 810-819.

Thompson, F. R., III, W. D. Dijak, T. G. Kulowiec, & D. A. Hamilton 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. J. Wildl. Manage. 56: 23-30.

Thompson, F. R., III, & E. K. Fritzell. 1990. Bird densities and diversity in clearcut and mature oak-hickory forest. U.S. For. Serv. Res. Pap. NC-293, St. Paul, Minnesota.

Thompson, F. R., III, W. D. Dijak, T. G. Kulowiec, & D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. J. Wildl. Manage. 56(1): 23-30.

Thompson, F. R., III., S. J. Lewis, J. Green, and D. Ewert. In Press. Status of neotropical migrant birds in the midwest identifying species of management concern in Proceedings of a workshop on the status and management of neotropical migratory birds. Rocky Mountain Forest and Range Experiment Station General Technical Report.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47: 893-901.

Webb, W. L., D. F. Behrend, & B. Saisorr. 1977. Effect of logging on songbird populations in a northern hardwood forest. Wild. Monographs. 55: 6-35.

Weinell, D. E. 1989. Initial effects of hardwood reforestation and plant succession upon avian richness at the Ouachita Wildlife Management Area, Louisiana. M.S. Thesis. Northeast Louisiana Univ., Monroe.

Wesley, D. E., C. J. Perkins, & A. D. Sullivan. 1976. Preliminary observations of cottonwood plantations as wildlife habitat. Pp. 460-476 in Proc. Symp. East. Cottonwood and Related Species. Greenville, Mississippi.

Yahner, R. H. 1986. Structure, seasonal dynamics and habitat relationships of avian communities in small even-aged forest stands. Wilson Bull. 98: 61-82.

Yahner, R. H., and D. P. Scott. 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Manage. 49: 508-513.

Ziehmer, R. L. 1992. Effects of uneven-aged timber management of forest bird communities. M.S. Thesis, Univ. of Missouri, Columbia.

Effects of Silvicultural Treatments on Forest Birds in the Rocky Mountains: Implications and Management Recommendations

Richard L. Hutto[1], Sallie J. Hejl[2],
Charles R. Preston[3], and Deborah M. Finch[4]

Abstract — The short-term effects of timber harvesting practices on landbird species vary widely among species. Thus, the maintenance of populations of all species will require a long-term management strategy that involves maintenance of a variety of habitats over a broad landscape.

INTRODUCTION

Despite widespread timber harvesting in the Rocky Mountains, and despite mandates (e.g., NFMA 1976) to maintain populations of all vertebrate species on Forest Service management areas, there are relatively few studies (18 by our count; Hejl et al., in press) on the effects of silvicultural practices on songbird populations. This situation can be expected to change, now that current silvicultural treatments are beginning to incorporate multiple objectives, including the objective to maintain populations of nongame species. In this paper, we review a synthesis (see Hejl et al., in press) of existing literature that deals with effects of timber harvesting practices on nongame landbirds in the Rocky Mountains, and we provide specific management guidelines that address the needs of nongame species, particularly neotropical migratory songbirds.

[1] *Division of Biological Sciences, University of Montana, Missoula, MT 59812.*

[2] *USDA Forest Service, Intermountain Research Station, P. O. Box 8089, Missoula, MT 89807.*

[3] *Department of Zoology, Denver Museum of Natural History, Denver, CO 80205.*

[4] *USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, 700 S. Knoles Drive, Flagstaff, AZ 86001.*

METHODS

Habitat and Silvicultural Categories

We perused a wide variety of federal publications, ornithological and ecological journals, and unpublished reports for studies dealing with effects of timber harvesting on either landbird or raptor communities within the Rocky Mountains. Census data from a given study site were classified into one of the following vegetative cover types: ponderosa pine, (2) mixed-conifer, (3) lodgepole pine, (4) spruce-fir, (5) Cascadian forest, or (6) aspen. Harvest method was also categorized as either a clearcut (where, at most, a handful of snags were left), or an incomplete cut (any cutting treatment besides clearcut). We do not know if "uncut" sites or "control" sites from most studies were truly never cut. We assumed that, if anything, they were lightly cut. We also do not know the ages of uncut stands, but most were probably mature forests.

Synthesis of Census Data

For each study, we scored each bird species as one that declined (-1), was unaffected (O), or increased (+l) in abundance as a result of timber harvesting activity. The overall effect on each species was then evaluated by calculating the average score over all studies. Thus, a mean of -1.0 would indicate that every study reported an increase in density in response to timber harvesting, and a mean of 1.0 would indicate that every study reported a decrease in density in response to timber harvesting.

Old-growth Associates

We summarized results of studies in the Rocky Mountains to find possible indications of old growth associates. Four studies compared uncut or lightly cut "old-growth" forests to immature or mature second-growth stands, and another two studies compared birds in uncut mature vs. old-growth forests.

Effects of Forest Fires

We reviewed the existing literature on the relationship between forest fires and landbirds in the northern Rockies, and also used census results from 38 sites in Montana that burned in the 1988 forest fires (Hutto, MS).

RESULTS

Differences Between Cut and Uncut Conifer Forests

Brown Creeper abundance differed consistently between harvested and unharvested treatments; creepers were always less abundant in clearcuts or partially logged forests than in uncut areas (Table 1). Twelve other species (e.g., Red-breasted Nuthatch, Ruby-crowned Kinglet, Golden-crowned Kinglet, and Mountain Chickadee) were also always less abundant in recent clearcuts than uncut forest, but were not always so in partially cut forests. Pygmy Nuthatch and Pine Grosbeak were always less abundant in partially logged areas but not so in clearcuts. In general, a large majority of species appear to be less abundant in treated as compared to unlogged areas (Table 1).

All permanent resident species were less abundant in recently clearcut forests than in uncut forests, but only about 60% of the migrants were less abundant. In addition, 94% of the residents were less abundant in partially logged forests, while about 40% of the migrants were less abundant.

Ten species were consistently more abundant in one of the three age categories of clearcuts or in partially cut forests--Mountain Bluebird and Townsend's Solitaire in early clearcuts; Mountain Bluebird, Warbling Vireo, MacGillivray's Warbler, Rufous Hummingbird, American Kestrel, and Broad-tailed Hummingbird in 10-20-year-old clearcuts; Cassin's Finch in older clearcuts and Calliope Hummingbird, House Wren, and Rock Wren in partial cuts. All species that were more abundant in logged areas are migrants.

Differences Between Cut and Uncut Aspen Forests

We found only two studies on effects of logging treatments on birds in aspen forests. These were conducted in different areas (Utah, Colorado), and involved treatments on vastly different scales. The combined results are equivocal, and underscore the need for more specific, practical information for managers.

Old-Growth and Second-Growth Associates

No species was consistently more abundant in old-growth or mature second-growth stands across four studies that compared such stands. In general, however, woodpeckers and nuthatches were more abundant in old-growth than in mature second-growth stands. In two of four studies, six species (Hairy Woodpecker, Western Wood-Pewee, Brown Creeper, Golden-crowned Kinglet, Swainson's Thrush, and Townsend's Warbler) were relatively more abundant in old-growth stands and four species (Dusky Flycatcher, Solitary Vireo, Chipping Sparrow, Brown-headed Cowbird) were relatively more abundant in mature, second growth stands. All but two of these species are migrants.

Raptors

Only three raptor species were sampled adequately enough to be listed in our assessment of bird presence in various logging treatments across forests in the Rocky Mountains (Table 1). Northern Goshawk appeared to be positively affected by young clearcuts, and negatively affected 10-20 years later. Red-tailed Hawks and American Kestrels were, on average, positively affected by clearcuts.

A review of the owl (vis-à-vis timber harvesting) literature suggests that at least three owl species may be associated with old-growth habitats in the Rocky Mountains--Flammulated Owl, Mexican Spotted Owl, and Boreal Owl.

Effects of Forest Fires

Fire is the single-most important factor influencing the development of landscape patterns in the northern Rockies (Habeck and Mutch 1973, Gruell 1983, Agee 1991). Moreover, landbird communities associated with standing dead "forests" that characterize early post-fire habitats are unique and distinctly different from clearcuts (Hutto, MS). The distinctness is largely due to the relative abundance of species that are nearly restricted in their habitat distribution within the Rocky Mountains to early post-fire conditions (e.g., Black-backed Woodpecker), and to species not restricted to, but relatively abundant in, early post-fire habitats (e.g., Olive-sided Flycatcher). These

Table 1. — Indices of the tendency for a bird species to be more or less abundant in clearcut or partially cut forest than in uncut forest. A given study was scored according to whether the species increased (+1), decreased (-1), or was unaffected by cutting (0). Values in table are averages of these scores over all studies in which the species was recorded. Species are listed in order from -1.00. Sample sizes in parentheses. This table was taken directly from Hejl et al., in press.

Species[a]	NTMB[b] status	Clearcuts 0-10 yrs	Clearcuts 10-20 yrs	Clearcuts 20-40 yrs	Partially Cut
Red-breasted Nuthatch	P	-1.00 (8)	-1.00 (4)	-1.00 (3)	-0.70 (10)
Brown Creeper	B	-1.00 (8)	-1.00 (5)	-1.00 (3)	-1.00 (12)
Golden-crowned Kinglet	P	-1.00 (8)	-	-	-0.60 (10)
Ruby-crowned Kinglet	B	-1.00 (8)	-1.00 (4)	-1.00 (3)	-0.40 (10)
Mountain Chickadee	P	-1.00 (7)	-1.00 (5)	0.00 (3)	-0.77 (13)
Winter Wren	P	-1.00 (6)	-	-	-0.20 (5)
Varied Thrush	P	-1.00 (6)	-	-	-0.75 (4)
Townsend's Warbler	A	-1.00 (6)	-	-	-0.40 (5)
Black-capped Chickadee	P	-1.00 (5)	-	-	-0.67 (3)
Swainson's Thrush	A	-1.00 (5)	-	-	-0.50 (6)
Three-toed Woodpecker	P	-1.00 (4)	-1.00 (3)	-	-0.50 (6)
Solitary Vireo	A	-1.00 (4)	0.00 (4)	-	0.33 (9)
Evening Grosbeak	P	-1.00 (3)	-	-	-
Hammond's Flycatcher	A	-	-1.00 (3)	-	-
White-breasted Nuthatch	P	-	-1.00 (3)	-	-0.14 (7)
Pygmy Nuthatch	P	-	-	-	-1.00 (5)
Cooper's Hawk	B	-	-	-	-0.67 (3)
Violet-green Swallow	A	-	-	-	-0.60 (5)
Gray Jay	P	-0.75 (8)	-1.00 (3)	0.00 (3)	-0.25 (4)
Warbling Vireo	A	-0.75 (4)	1.00 (3)	-	0.33 (9)
Western Tanager	A	-0.75 (4)	-1.00 (4)	-	0.09 (11)
Orange-crowned Warbler	A	-0.67 (3)	-	-	-0.50 (4)
Yellow-rumped Warbler	B	-0.67 (9)	-0.67 (6)	0.67 (3)	-0.46 (13)
Hairy Woodpecker	P	-0.62 (8)	-0.67 (6)	-0.33 (3)	-0.25 (12)
Common Nighthawk	A	-	-0.67 (3)	-	-0.50 (4)
Red Crossbill	P	-	-0.25 (4)	-	-0.33 (3)
Red-naped Sapsucker	B	-0.60 (5)	-0.25 (4)	0.67 (3)	0.17 (6)
Clark's Nutcracker	P	-0.60 (5)	-	-	0.33 (3)
Hermit Thrush	B	-0.60 (5)	-1.00 (3)	-	-0.80 (10)
Black-headed Grosbeak	A	-0.60 (5)	0.20 (5)		0.22 (9)
Steller's Jay	P	-0.50 (4)	0.00 (4)	-	-0.29 (7)
Common Raven	P	-0.43 (7)	-0.33 (3)	-	-0.17 (6)
Pine Siskin	B	-0.38 (8)	-0.17 (6)	0.00 (3)	-0.08 (12)
Northern Flicker	B	-0.37 (8)	0.33 (6)	0.33 (3)	-0.17 (12)
Pine Grosbeak	P	-0.33 (3)	-	-	-1.00 (3)
Cassin's Finch	B	-0.33 (3)	-0.50 (4)	1.00 (3)	0.60 (5)
Western Wood-Pewee	A	-0.20 (5)	-	-	-0.50 (4)
Fox Sparrow	B	-0.20 (5)	-	-	-
MacGillivray's Warbler	A	-0.17 (6)	1.00 (3)	-	0.17 (6)
American Robin	B	-0.10 (10)	0.33 (6)	0.33 (3)	0.15 (13)
Rufous Hummingbird	A	0.00 (5)	1.00 (3)	-	0.33 (3)
House Wren	A	0.00 (3)	-0.25 (4)	-	0.86 (7)
Wilson's Warbler	A	0.00 (5)	-	-	-
Williamson's Sapsucker	B	-	-	-	0.00 (5)
Cordilleran Flycatcher	A	-	-	-	0.00 (6)
Western Bluebird	B	-	-	-	0.20 (5)
Chipping Sparrow	A	0.13 (8)	0.50 (6)	-	0.60 (10)
Olive-sided Flycatcher	A	0.20 (10)	0.00 (3)	-	0.67 (9)
Red-tailed Hawk	B	0.33 (3)	0.33 (3)	-	0.33 (3)
Tree Swallow	B	0.33 (3)	-	-	-
White-crowned Sparrow	B	0.40 (5)	-	-	-
Dark-eyed Junco	B	0.60 (10)	0.67 (6)	0.67 (3)	0.38 (13)
Northern Goshawk	B	0.67 (3)	-0.75 (4)	-	-
Mourning Dove	B	0.67 (3)	0.33 (3)	-	0.67 (3)
Townsend's Solitaire	B	0.80 (5)	0.00 (5)	0.00 (3)	-0.25 (8)
Mountain Bluebird	B	1.00 (7)	0.80 (5)	-	0.67 (6)
Lincoln's Sparrow	A	-	0.67 (3)	-	-
American Kestrel	B	-	1.00 (3)	-	-
Broad-tailed Hummingbird	A	-	1.00 (3)	-	0.25 (4)
Calliope Hummingbird	A	-	-	-	1.00 (3)
Rock Wren	B	-	-	-	1.00 (3)

[a]Only those results from sample sizes greater than three are included in the table.
[b]Neotropical migrant (NTMB) status, as designated in the Partners in Flight Newsletter (1992, Vol. 2, No. 1, p. 30): A = long-distance migrant species, those that breed in North America and spend their nonbreeding period primarily south of the United States, B = short-distance migrant species, those that breed and winter extensively in North America, P = permanent resident species that primarily have overlapping breeding and nonbreeding areas.

associations deserve greater attention by land managers because frequent, low intensity understory fires do not satisfy the needs of fire-dependent bird species; such species rely on the presence of large, high-intensity crown fires that characterize the historical fire regime of many conifer forest types in the northern Rockies.

DISCUSSION

To a manager in need of information on timber harvesting effects on Rocky Mountain birds, it should be clear that too few studies have been conducted. We are unable to discuss effects of alternative silvicultural techniques except in very general (clearcuts vs. all other) terms. Moreover, there are no quantitative data on the range of habitats occupied by landbird species (which is necessary before we can evaluate the extent to which a negative effect on a species in one habitat type translates into a serious effect on the species as a whole), no data on cumulative landscape effects, few data from other than the breeding season, and no data on reproductive or survival success in relation to treatments.

Nevertheless, there is no question that clearcuts have negative effects on many forest-dependent species and positive effects on many species that frequent open forests or open habitats in general. This result alone raises two important management issues, which are discussed below. In turn, these issues lead us directly to a series of management recommendations. First, different species within various behavioral guilds respond differently to a given silvicultural treatment (for example, Hammond's Flycatcher is negatively affected by clearcutting, while Olive-sided Flycatcher is not, or the migratory Ruby-crowned Kinglet declines, while the migratory Mountain Bluebird does not). Thus, managing for "guilds" of species would be to the detriment of those species that respond atypically in comparison with the guild as a whole. In terms of managing for maintenance of bird populations, there is no substitute for understanding habitat needs of each species, and for monitoring populations of as many of them as possible. Thus, we still need a species-by-species management approach, but that can be accomplished largely through development of land-based management plans coupled with species-by-species monitoring efforts (see below).

Secondly, determining "effects of timber harvesting" is much more complicated than conducting studies such as those described in the papers we reviewed. This is because "effect" can be measured as either a short-term or a long-term consequence of harvesting activity. The literature deals exclusively with short-term consequences, but managers' legal mandates require a long-term, broad-scale perspective that allows only land use patterns that will not cause the widespread or complete disappearance of natural populations, patterns, and processes. Thus, a timber harvesting practice that might cause a relatively great amount of short-term change from pre-harvest conditions may actually be integral to a long-term strategy for maintaining populations of all wildlife species, especially in areas that experience frequent and widespread disturbance. Therefore, rather than simply asking what the short term effect of a given harvest method is, we should be asking, What is the best long-term strategy for achieving (mimicking) natural patterns and processes over the long term, and How should we manage for those species that fall through the cracks even after our strategy mimics nature as well as any can?

To illustrate, consider that conifer forests of the Northern Rocky Mountains are part of a fire-maintained system and that there is much less vegetation cover in early successional stages now than prior to fire control in some cover types. If, of all timber harvesting practices, clearcuts come closest to matching patterns produced by an intense fire regime, then perhaps clearcutting, which produces the greatest change from pre-harvest conditions in an immediate sense, is the best practice in a long-term sense. The point here is not to argue that clearcuts are similar to post-fire bird communities; they are not (Hutto, MS). The point is to emphasize that the least harmful timber harvesting practice may not be the one that appears over the short run to cause minimal change from pre-harvest conditions. Current thinking and future research efforts need to be directed along these lines if we are to make progress in managing land for the maintenance of migratory landbirds, resident landbirds, and all other plant and animal species (i.e., biological diversity).

MANAGEMENT RECOMMENDATIONS

Assuming that an important management goal is to maintain natural populations, patterns, and processes over broad landscapes, we recommend the following management guidelines:

1. Manage for Desired Landscape Patterns

Harvest-by-harvest decisions should not be made in the absence of a clear picture of trends and conditions over a broad landscape. Unfortunately, emerging landscape patterns are largely products of incremental habitat modification with little or no consideration of how each unit fits into the larger scene. Therefore, we recommend that managers develop a clear picture of the landscape (including the proportions and juxtaposition of cover types) that they are trying to create and maintain so that decisions on single harvests are made in the context of a desired landscape picture, and in light of the processes and patterns that would normally produce that landscape.

In general, we recommend managing timber harvesting activities to either (1) have negligible impact in the present, and not affect the probability that natural processes (e.g., fires, insect outbreaks) occur in the treatment area in the future, or (2) have moderate to extreme impact on the land and biological community, but in a manner that is close to what some natural process would have been expected to do in the same place at about the same time. The first option means cutting in a manner such that the same species and processes (e.g., fire) persist on the management unit. The second option means understanding that management activities should never be viewed as substitutes for natural processes because human activities differ in important ways from natural disturbance (e.g., clearcutting differs in important ways from fire-caused disturbance).

Some critics would claim that a changing world makes it difficult to know what the existing landscape patterns "ought to be", and that past environments may be inappropriate models for desired future conditions. We agree it is presumptuous to assume that we know what "ought to be", but we disagree that such an approach is unworkable. It is not that hard to identify largely "unnatural" distributions and proportions of land cover types that are a consequence of current management practices. Botanists have provided a good deal of information about what landscapes looked like before mechanized land-use became the norm, and it would be well worth putting that information to use. Managing at the landscape level will require improved inter-agency coordination, and knowledge of the conditions of private lands in the same region. In short, management decisions will have to be made in the context of broader bio-regional planning efforts.

This is quite different from traditional wildlife management schemes, where the goal is to maximize the production of a select few (mostly game) species. It is also a matter of changing management priorities, NOT a matter of finding money to pay more attention to nongame species.

2. Manage for the Maintenance of Natural Disturbance Regimes

Because the adaptive histories of most species in natural ecosystems are linked to natural periodic disturbance, it is highly unlikely that the maintenance of biodiversity will be possible without allowing natural disturbances to occur as they have historically. This means a huge public education effort (by a better-informed Smokey the Bear?) so that (1) fires, blowdowns, insect outbreaks, and the like are properly viewed as natural events, and (2) efforts to maintain these processes are understood and encouraged by both natural resource managers and the public. Only then will land managers have a reasonable chance of doing whatever else it takes to manage for natural processes.

3. Use Knowledge of the Local Ecology

Be cautious about extrapolating results from other areas. Everything from habitat use to food requirements changes markedly from one place to another. Rely heavily on information about the natural history and ecology of the local area for management decisions.

4. Move Toward Multi-Species Management

It is a predictable result that some species are benefitted and some hurt through any silvicultural method. The result is not trivial, however. Managers will have to deal increasingly with this fact as they generate information for the larger numbers of species that will be part of newer multi-species management schemes. Management for the maintenance of larger systems will, in fact, emphasize this apparent conflict. We say "apparent" conflict because managing for some species and against others is not a conflict when viewed from the perspective of a large landscape and a long time period. Pieces of the larger landscape should be managed to the detriment of some species and benefit of others, but there should always be enough variety in the constantly shifting mosaic of successional stages such that all native species are being managed for simultaneously over a broader landscape. Defining the pieces of the puzzle (cover types and other elements) necessary to maintain populations of all vertebrates requires knowledge of the habitat needs of a larger number of species than wildlife biologists have traditionally considered, especially nongame species.

5. Use Single-Species Management Only When Necessary

Manage for single species only when they become species of special concern, threatened, or endangered, and only for as long as it takes for the species to recover.

6. Monitor Both Landscape Patterns and Species Populations

Even though we recommend managing for landscape patterns, and monitoring how well the "target" landscape is being maintained, this does not remove the need for a multi-species monitoring program. One could be maintaining a "proper" landscape, but still witness population declines of bird species because of improper management elsewhere, or because of the decline of habitat elements that cannot be monitored at the landscape level. Thus, ecosystem management is not a move away from monitoring single species, it is a move away from managing the land for the benefit of relatively few species.

For landscape monitoring, we recommend using a GIS to monitor how successfully the landscape is matching the suspected "natural" pattern of cover types, including their sizes, proportions, and juxtapositions. For bird monitoring, we recommend using as many species as possible to monitor how successfully we are managing for the maintenance of all wildlife species. Landbirds are a powerful tool here because a large number of species can be monitored as easily as one. Moreover, the range of conditions that landbirds occupy is so varied that the monitoring of these species might be expected to provide a good indication of how well we are managing for the variety of species that are not monitored through other methods.

ACKNOWLEDGEMENTS

We thank Diane Evans, Mike Hillis, Peter Landres, L. Jack Lyon, and Peter Stangel for reviewing this manuscript; their comments helped immensely.

LITERATURE CITED

Agee, J. K. 1991. Fire history of Douglas-fir forests in the Pacific Northwest. Pp. 25-33 in L. F. Ruggiero, K. B. Aubry, A. B. Carey, and M. H. Huff, tech. coords. Wildlife and vegetation of unmanaged Douglas-fir forests. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-285, Portland, OR.

Gruell, G. E. 1988. Fire and vegetative trends in the Northern Rockies: interpretations from 1871-1982 photographs. USDA Forest Service Gen. Tech. Report INT-158.

Habeck, J. R., and R. W. Mutch. 1973. Fire dependent forests in the northern Rocky Mountains. Quaternary Research 3:408-424.

Hejl, S. J., R. L. Hutto, C. R. Preston, and D. M. Finch. 1993. The effects of silvicultural treatments on forest birds in the Rocky Mountains. In: Martin. T., and D. M. Finch (eds.), Population ecology and conservation of neotropical migratory birds. Oxford Univ. Press, New York, in press.

Hutto, R. L. MS. On the ecological uniqueness of post-fire bird communities in northern Rocky Mountain forests.

Protection of Neotropical Migrants as a Major Focus of Wildlife Management

Lawrence J. Niles[1]

Abstract — Due to their funding source, wildlife management programs devoted most resources to game species management, and ignored large scale biodiversity initiatives, such as the protection of neotropical migrant land birds. Neotropical migrants are, however, a major focus of the new field of conservation biology, whose proponents consider the field more inclusive than wildlife management, and consider wildlife management a subdiscipline on the scale of forestry or range management. However, the relationship between conservation biology and wildlife management is evolving toward a partnership. Preserving biodiversity requires protection and management of public land, infrastructure of trained professionals in existing agencies, and the support of the wildlife management agency constituency. I suggest the relationship could be improved by 1) conservation biologists giving greater consideration to the value of traditional wildlife management techniques such as hunting; 2) coordinating regulatory protection of neotropical migrants in existing agencies, primarily fish and wildlife agencies; 3) developing and incorporating management of neotropical migrants into existing land and population management actions; and 4) developing stable funding for nongame wildlife programs.

Over the last decade protection of neotropical land birds has become a major conservation issue (Robbins et al. 1989, Askins et al. 1990). Concern for this large group of birds has grown within many national conservation groups such as The Nature Conservancy, National Audubon, and agencies such as U.S. Forest Service and U.S. Fish and Wildlife Service (Salwasser 1987, Thomas and Salwasser 1989). Issues relevant to the protection of neotropical migrant birds, such as fragmentation, have been important in the formation of the new field of conservation biology (Soule and Kohm 1989). But the field of wildlife management and many agencies employing wildlife management biologists have been slow to recognize the importance of neotropical migrant bird management and develop programs to meet the needs of this group of birds.

The slow response of wildlife management agencies in this important area of nongame wildlife protection is part of a more general reluctance to tackle most issues related to the protection of biodiversity. It has had a significant effect on protection of nongame species in general and contributed in some degree to creation of an entirely new discipline of conservation biology and the growing network of state Nature Conservancy offices and Heritage Programs. What, then, is wildlife management? Is it just game management and endangered species protection, or does it embrace all wildlife?

Because it is relevant to a discussion of the role of wildlife management agencies in protection of neotropical migrants, I first develop a history of wildlife management with regard to conservation biology, highlighting their divergent backgrounds. I then offer a few reasons why separation is counterproductive and why it is crucial for wildlife management agencies to be involved in protection of neotropical migrants. I finish with a few recommendations for change.

Most state and federal wildlife agency people were trained in the science of wildlife management. For many the discipline began with publication of Aldo Leopold's Principles of Wildlife Management (Leopold 1937), and most wildlife managers recognize his working model for wildlife biologists that "to keep every cog and wheel is the first precaution of intelligent tinkering" (Leopold 1953).

With this code, a new generation of wildlife professionals set out to intelligently tinker. As a regional biologist with Georgia Fish and Game, I worked for one of these new

[1] *Endangered and Nongame Species Program, NJ Division of Fish Game and Wildlife, CN 400, Trenton, NJ 08625-0400.*

biologists, Frank Parrish, who got a Master's degree under the G.I. Bill, a benefit of his time in Korea. At the time he came to Georgia Fish and Game, he and other biologists in the division were the only professionals protecting wildlife including nongame species. But the funding that supported these biologists, such as the Pittman-Robertson Act of 1937, required them to concentrate on resources that benefited people who were paying, namely hunters. Wildlife management inevitably became game management.

This is not to say that state agency biologist worked solely on game species. In many states, funds from game resources were used to protect habitats that benefited all species. In some states, game funds were used to sustain new programs to protect endangered and threatened species as well as the vast list of other species known as nongame.

These nongame programs were an initial attempt by wildlife management agencies to address a broader array of wildlife issues. Nongame programs grew in the 1970's largely from state income tax check-off programs and other donated monies. But without stable funding, state programs were left to operate with budgets that were erratic and rarely grew, making long-term planning difficult. Most state programs focused on the immediate challenge; species at or near the brink of extinction. In a necessary triage scheme the rest, including most neotropical migrants, were dealt with indirectly or not at all.

But the growing list of rare species and communities during the last decade required a more comprehensive approach. Without strong support from within wildlife agencies, the effort to protect our nation's wildlife diversity came from an entirely new discipline. The Society for Conservation Biology was formally established in 1987, but publication of the journal Conservation Biology was the first formal declaration of this conservation movement (Ehrenfeld 1987, Aplet et al. 1992). These biologists applied theories of population and community ecology to preserve biodiversity and envisioned their role much differently than did game management biologists. The conservation biologist was not so much a farmer of wildlife trying to provide a harvestable resource, but doctor of a natural organism that required care to prevent ecological catastrophe (Noss 1989). These scientists were not simply re-applying the basic principles of wildlife management as set by a generation of game biologists. Conservation biology covered a number of topics that deal directly with problems of small and fragmented populations of animals and strategies needed to preserve them.

For example, a topic of serious discussion centered on the character of a nature reserve. This so-called SLOSS controversy (Single Large Or Several Small), was an attempt to apply the theory of island biogeography to reserve design (Noss 1989). Although this discussion centered largely on tests of the theory's predictions, it implied that biodiversity must not only be protected from habitat destruction but from all uses including hunting (Grumbine 1990).

Exclusion of wildlife management or at least game management from the mainstream of conservation biology is apparent in much early literature. For example, in the opening editorial of the first issue of Conservation Biology, conservation biology is described as a new discipline that relies on a variety of academic disciplines such as ecology, ethology, paleontology, climatology and oceanography, among others (Ehrenfeld 1987). The author also lists a group of "real world" resources such as federal and fundraisers. But nowhere does he acknowledge the academic discipline of wildlife management or state agencies that practice that discipline.

Literature about conservation biology creates the impression that conservation biology is the central discipline with wildlife management as a peripheral discipline along with forestry and range management (Soule 1985). Moreover, it implicitly denies any value to hunting, which threatens the core philosophy of many wildlife professionals and their livelihood. The impact of these impressions on many wildlife management professionals, whether justified or not, cannot be underestimated.

In a remarkably short time a transition has occurred that suggests the two disciplines may concentrate on common goals rather than on different ideological positions. One reason for this discussion is that we cannot protect biodiversity by relying on reserves managed exclusively protecting biodiversity (Waller 1988, Thomas and Salwasser 1989, Trauger and Hall 1992). Reserves account for a relatively small area of the continent, about five to ten percent, a proportion that is not likely to grow significantly (Salwasser 1987). Most public land, about 50% of the continental area, is managed for multiple use by professionals trained in wildlife management (Salwasser 1987).

A second reason for an improved discussion between wildlife management professionals and conservation biologists is that there are relatively few conservation biologists and their number is insufficient to effect changes necessary to protect biodiversity. Several authors argue the existing network of wildlife management professionals must be included in a long term strategy to protect biodiversity (Salwasser 1987, Thomas and Salwasser 1989, Aplet et al. 1992).

In the last year the ideological gap between the two disciplines has diminished. Aplet et al. (1992) argue in Conservation Biology that conservation biology is really a part of the discipline of wildlife management as it was originally envisioned by Leopold, Errington, and others. They argue that wildlife management is not game management but a larger discipline that aims, among other things, to protect our nation's biodiversity. As evidence of the growing union, The Wildlife Society is now developing a position on biodiversity and this year held a joint meeting with the Society for Conservation Biology.

The present conference on neotropical migrants promises an even better mix of wildlife management professionals and those who consider themselves conservation biologists. If the current trend persists it is likely that protection of biodiversity will become a major goal of wildlife management agencies and the science of conservation biology will become an equal and viable part of wildlife management.

Understanding the complimentary roles of conservation biology and start to defining the role of wildlife management in the protection of neotropical migrants. After all, the hundreds of species of neotropical migrants are a major part of the nation's vertebrate fauna that is currently in need of attention. Wildlife management agencies' strong support is needed for several reasons:

1) Neotropical migrants include a large group of species with diverse habitat needs spanning nearly all successional stages of most plant community types. Recent work on breeding neotropical migrant land birds highlights the role of habitat change in population regulation. For example, Litwin and Smith (1992) found that changes in species composition of passerine neotropical migrants were best explained by successional changes in the forest. Bollinger and Gavin (1992) pointed to intensive agriculture as the main factor in decline of the Bobolink (*Dolichonyx oryzivorus*) in the east. Management of forest succession and agricultural fields are important aspects of wildlife management.
2) Maintaining viable populations of many different neotropical migrants species will require some protection on most public lands, many under direct or indirect control of wildlife management organizations. A protection strategy that depends on newly acquired reserves dedicated to neotropical migrants will probably not cover a sufficient area to make much of a difference. An alternate protection strategy of drastically restricting resource use on currently owned public land will meet obstinate resistance from restricted user groups that will turn public opinion against the need for protection. A successful long-term strategy for protection must engage wildlife agencies currently managing public land in a partnership that will serve the long-term needs of neotropical migrants while still supporting resource use.
3) Neotropical migrants protection will not only require skills of conservation biologists and other concerned professionals, but also a great number of field professionals and technicians already in place and devoted to protection of wildlife resources. These professionals could provide the basis for a major action protecting neotropical migrants for several reasons.
   a. Although few wildlife management professionals are trained in protection of neotropical migrant birds specifically, most are trained and experienced in issues surrounding their protection, such as predation, habitat destruction, and habitat degradation.
   b. Many wildlife professionals have experience manipulating populations of many species such as deer, fox, and raccoon that have a great impact on many neotropical migrant breeding.
   c. Given the appropriate background data, many wildlife professionals can provide a good interface between neotropical migrants' protection needs and resource managers such as foresters.
4) Lastly, neotropical migrants constitute an enormously popular group of species for birders, as well as for an even larger group of outdoor users including hunters and fishermen. The 1985 National Survey of Fishing, Hunting and Wildlife-Associated Recreation (USDI 1989) shows there were nearly 61 million birders in the U.S. (Wiedner and Kerlinger 1990). But Kellert (1985) found only 3% of this number are committed to birding. The rest include birding as one of many outdoor activities and probably includes many of the estimated 16.7 million hunters and 46.6 million fishermen who consider presence of birds an essential part of the outdoor experience. Although these hunters and fishermen don't consider themselves birders, they value their knowledge of birds. This potentially large group is the constituency of wildlife agencies and could provide another strong and vocal force for protection of neotropical migrants.

Drawing the wildlife management profession into a program for the protection of neotropical migrants should be a high priority. It is important to wildlife management professionals because it helps reinstate a broader perspective to the discipline. It is important to neotropical migrants because of substantial resources wildlife professionals bring to the job.

The purpose of the papers in this section is to give some specific examples of the role of wildlife management in the protection of neotropical migrants. I offer a few general directions:

1) We should recognize hunting as a viable method of managing deer, waterfowl and other wildlife species. Professionally done, hunting not only provides a resource, it controls species that may have a serious impact on habitats of neotropical migrant birds. Just as importantly, it paves the way for a cooperative relationship with wildlife management agencies essential to long-term protection of neotropical migrants.
2) Wildlife management agencies must become involved in protection of neotropical migrants. Several possible methods are:
   a. In some states, wildlife agencies could incorporate neotropical migrants into state regulatory review programs.
   b. Agency administrators could allow regional game biologists to spend some portion of their time on neotropical migrant protection plans.
   c. State agencies should establish state-level working groups to provide a method of coordinating actions at the state level with regional and national protection, and to provide non-governmental groups access to the regulatory

and management authority that most wildlife agencies command within state governments. This includes regulatory protection of important habitats, habitat management procedures on state lands, and establishing a research agenda amongst several agencies within the state or among states.

3) We must concentrate on integrating protective measures for neotropical migrants into existing schemes for utilizing forest and game resources and protection of endangered and nongame species populations. Papers in this section and in Land Management are a good start in that direction. We need win/win programs that provide for needs of neotropical migrants while requiring minimal change in resources provided to existing users. If serious change is necessary it must be done with willing cooperation of user groups. We must further empower state agency endangered and nongame programs. Their experience with the wide variety of rare species makes them an able resource for conducting most monitoring and management programs for neotropical migrants.
4) Last, we must develop a stable funding source for agency work on these species. Lack of stable funding is a major cause of poor agency involvement in this area. It is a major impediment to long term protection plans within states. Current funding through the federal government or programs such as Partners in Flight is inadequate. It does not provide enough funds for agencies to increase staff, so existing staff must squeeze neotropical migrants into an already heavy burden. Moreover, relying on funds generated by other programs such as Pittman-Robertson, Endangered Species Section Six, or state tax check-offs is ludicrous in light of massive public support for protection of neotropical migrants.

I believe the plight of neotropical migrants and concurrent growing public awareness is analogous to the threat to waterfowl in the beginning of this century that led to the Pittman-Robertson Act. I strongly recommend that the International Association of Fish and Wildlife Agencies' "Diversity Initiative" (Duda 1991) should form the basis for a new state-federal partnership aimed at protecting neotropical migrants.

ACKNOWLEDGEMENTS

I thank K. Clark of the ENSP for her patience and assistance in the preparation of this manuscript. J. Burger from Rutgers University and D. Dobkin of the High Desert Museum provided constructive criticism that helped shape this manuscript. Several biologists with the Division of Fish, Game and Wildlife offered constructive comments, including L. Herrighty, T. Petrongolo and F. Snyder. I am also grateful to S. Paul who reviewed the final draft.

LITERATURE CITED

Aplet, G.H., R.D. Laven, and P.L. Fiedler. 1992. The relevance of conservation biology to natural resource management. Conservation Biology 6:298-300.

Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7:1-57.

Bollinger, E.K. and T.A. Gavin. 1992. Ecology and conservation of E. Bobolink population. In Ecology and Conservation of Neotropical Migrant Landbirds. J. M. Hagan III and David W. Johnston, Eds. Smithsonian Inst. Press., Washington, DC.

Duda, M.D. 1991. A bridge to the future: the wildlife diversity initiative. Western Association of Fish and Wildlife Agencies. 33 pp.

Ehrenfeld, D. 1987. Editorial. Conservation Biology 1:6-7.

Grumbine, R.E. 1990. Viable populations, reserve size, and federal lands management: a critique. Conservation Biology 4:127-134.

Kellert, S.R. 1985. Bird-watching in American society. Leisure Science 7:343-360.

Leopold, A. 1937. Principles of Wildlife Management. Charles Scribner Sons, New York.

Leopold, A. 1953. The Round River. Oxford University Press, New York.

Litwin, T.S., and C.R. Smith. 1992. Factors influencing decline of migrants in forest fragments. In Ecology and Conservation of Neotropical migrant landbirds. J.M. Hagan III and David W. Johnston, Eds. Smithsonian Inst. Press., Washington, DC.

Noss, R.F. 1989. Who will speak for biodiversity? Conservation Biology 3:202-203.

Robbins, C.S., J.R. Sauer, R.S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proc. Nat. Academy of Science, 86:7658-7662.

Salwasser, H. 1987. Editorial. Conservation Biology 1:275-277.

Soule, M.E. 1985. What is conservation biology? A new synthetic discipline addresses the dynamics and problems of perturbed species, communities, and ecosystems. BioScience 35:727-734.

Soule, M. E., and K. A. Kohm (Eds.). 1989. Research Priorities for Conservation Biology. Island Press, Washington, DC.

Thomas, J.W. and H. Salwasser. 1989. Bringing conservation biology into a position of influence in natural resource management. Conservation Biology 3:123-127.

Trauger, L., and R. Hall. 1992. The challenge of biological diversity: professional responsibilities, capabilities, and realities. Internat. Assoc. Fish and Wildlife Agencies.

U.S. Department of the Interior. 1989. The 1985 National Survey of Fishing, Hunting and Wildlife-associated Recreation. U.S. fish and Wildlife Service, Washington, DC.

Waller, D.M. 1988. Sharing responsibility for conserving diversity: the complementary roles of conservation biologists and public land agencies. Conservation Biology 2:398-401.

Wiedner, D., and P. Kerlinger. 1990. Economics of birding: A national survey of active birders. Inter. Council for Bird Preservation 44:209-213.

Antelope, Sage Grouse, and Neotropical Migrants

Reg. Rothwell[1]

The momentum this Partners in Flight initiative has developed is very impressive. I'm encouraged because, although it will have its costs, I see it as a potential aid to existing wildlife management efforts. Here, I will discuss some types of information that are routinely used by wildlife and habitat managers for other species. If this same information is made available for the species that are the subject of the Partners in Flight program, it can be readily plugged in to existing systems.

Wyoming is experiencing some of the same confusion, concern, and mixed emotions that are probably being experienced elsewhere regarding biological diversity and neotropical migrants. The concerns over migratory nongame birds are not limited to the general public and federal agencies. Among other things state wildlife managers wonder how we can spread already small budgets even thinner; and they are worried that emphasis on these species may impact, conflict with, or compromise traditional management of the "bread and butter" species - game birds and big game. In a frontier state like Wyoming where we do not have a large population and our funding options are limited, these are big concerns. Granted, even in Wyoming, where we have a surprisingly active nongame pro-gram, there is much additional work necessary. But, the decline in neotropical migrants is becoming an important issue to the general public and at an international level, focusing attention on the biological diversity issue. In addition, many federal agencies have made a commitment to address neotropical mi-grants and biological diversity in documents such as this BLM publication entitled "Fish and Wildlife 2000". As managers we should be, and many of us are, managing more on an ecosystem basis with emphasis on those species that are economically important, are on the Threatened or Endangered Species lists, are approaching candidacy, or get a lot of public attention.

I question whether this new initiative will involve a lot of profound changes in our management direction. Rather, I see the strong interest in these species as being more impetus to manage habitats correctly and in a more holistic manner. These neotropical migrants require habitat conditions similar to those necessary within seasonal ranges of big game and game birds. They were all here and thriving under natural conditions before we began our environmental pillaging (albeit, perhaps in different relative abundances). And, they all are suffering from the very same habitat impacts. For example, am I referring to big game, game birds, or songbirds when I say the major influences on summer breeding habitat in rangelands include extensive shrub eradication, agricultural land conversion, rural and urban development, and overgrazing?

Many people think mainly of bird species that use forested habitats when they think of neotropical migratory birds. But, many of these species are in-habitants of grasslands and rangelands on their summer ranges in North America. Shrublands, particularly sagebrush habitat, are extremely important, particularly in the West. Johnson et al. (1980) found that the number of bird species and their population densities in sagebrush and other shrublands are intermediate to numbers and densities in all other habitats in North America. Smith, Nydegger and Yensen (1984) found that the big sagebrush-winterfat mosaic had the highest bird densities of all habitats on the BLM Snake River Birds of Prey Area in southwestern Idaho. And, Medin's (1990) research in Nevada's Snake Range showed that sage-brush communities are some of the most valuable nongame bird breeding habitat in the Great Basin.

To illustrate the compatibility of game and nongame management, let me give ranges of some habitat characteristics of several rangeland species (Table 1). Similar comparisons can be made for grasslands, deciduous forests and conifer habitats. I want to first point out that in the limited time I had to do literature searching for this presentation, I had difficulty finding habitat characterizations for nongame birds. That's one reason the number of species I used is so limited.

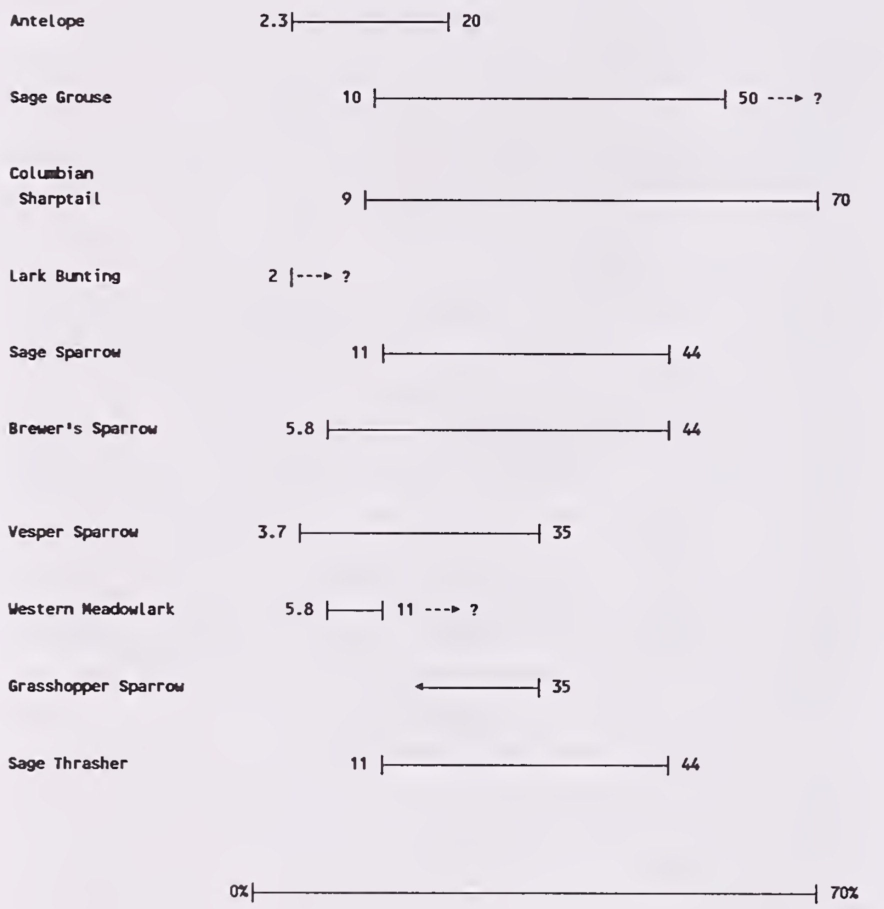
- ***Total vegetation cover***: The literature shows that, of the rangeland species, the lark bunting has a high percent cover requirement; sage grouse and mountain plover tolerate little vegetation cover (Table 1). Pronghorn are associated with all these species in Wyoming. I suspect there's a lot of overlap between species within extremes demonstrated by these. But, the information is not compiled anywhere I looked, and I question whether it's available for many species.

[1] Staff Biologist, Wyoming Game and Fish Department, Cheyenne, WY

Table 1. — Habitat Characteristics, Movements, and Areas Occupied by Shrubland Wildlife Species Documented in the Literature.

	Veg. Cover (%)	Shrub Cover (%)	Shrub Density (#/ha)	Shrub Height (cm)	Home Range/ Territory/ Movement	Comments
PRONGHORN						
Yoakum 1978	50	2.5 - 5				
Autrieth 1978	50	2.5 - 10		< 76		
Kinschy et al. 1978		5 - 20				
Plummer et al. 1968			1,000			
Sundstrom et al. 1973	40-60	7-15		≥ 46		
Mitchell & Smoliak 1971		2.3-3.2				
Kitchen 1974					440-1200 ha	Nursery & bachelor herds
Kitchen & O'Gara 1982					18-160 km	Seasonal movements
Bayless 1969					165-2300 ha	Winter home ranges
Yoakum 1972	50					
Cole 1956				$\bar{x}$ = 27.9		
Wentland 1968					1149-2256 ha	Summer home ranges
SAGE GROUSE						
Hayden-Wing et al. 1985	22-48			$\bar{x}$ = 33		At nest sites
Wallestad & Schadweiler 1974		> 20				Winter
Klebenow 1969		18- >30				Nesting & broods in mid-summer
Wallestad 1971		10-20				Varies in this range from June-Sept
Martin 1970		$\bar{x}$ = 24				Summer
Wallestad & Schladweiler 1974		20-50		18-64	up to 1.8 km	Breeding season males
Wallestad & Schladweiler 1974		> 15				Winter & nesting habitat
Eng & Schladweiler 1972		> 20			1058-3140 ha. 1.6-2.5 km	Winter
Wallestad & Pyrah 1974		$\bar{x}$ = 27		$\bar{x}$ = 40	2.5-2.8 km	Nest site
Martin 1976		$\bar{x}$ = 14				Brood rearing
Wallestad & Schladweiler 1974		$\bar{x}$ = 32				Breeding season
Postovit 1981		10-23				
Colenso et al. 1980		25		35-65($\bar{x}$=27)		Nest sites.
Postovit 1981		25				Recommended for nesting
Tessmann 1991		> 15	20,000- 50,000			
Patterson 1952/Klebenow 1969		20-40				Nest sites
Johnsgard 1973					up to 5-11.7km	Females from lek to nestsite
COLUMBIAN SHARP-TAILED GROUSE						
Hart et al. 1950					< 100-400 m	Summer
Marks & Marks 1987					1.87 km	Spring - fall
Marks & Marks 1987		9				Brood rearing & summer
Giesen 1987				< 100	.75-2.52 ha (x=1 .03)km^2	Nesting
Bredehoft 1981			10,778 11,000			Lek sites
Dix 1961		70				Brood rearing & summer
Giesen 1987			4,200-24,000			Brood rearing & summer
McArdle 1977		20-40				Brood rearing & summer
McArdle 1977		> 40				Winter
NONGAME BIRDS						
Lark Bunting/Finch et al. 1987	90	2			0.7-0.75 ha	HEP model
Lark Bunting/Woolfolk 1945						100% nest assoc. w/sagebrush in mountains
Sage Sparrow, Sage Thrasher Brewer's Sparrow/Rich 1980		11-44*		67-84	1 nest/1.25 ha*	*over entire study area
Brewer's Sparrow/Best 1972					1 breeding pair/ 0.9-1.6 ha	
Brewer's Sparrow/Schroeder & Sturgis 1975					1 breeding pair/ 1.0-1.2 ha	
Vesper Sparrow/Arnold & Higgins 1986		35.0^a 3.7^b			$3.5/km^{2a}$ $0/km^{2b}$	[a] shrubby habitat [b] shrubless habitat
Western Meadowlark/Arnold & Higgins 1986					$17.8/km^{2a}$ $57.6/km^{2b}$ $23.3/km^{2a}$ $27.1/km^{2b}$	
Brewer's Sparrow/Castrale 1982		11.8	7,396	44	7.0-7.5/ha	17 yr old plowed
Vesper Sparrow					4.5-5.0/ha	
Western Meadowlark					2.0-3.5/ha	
Brewer's Sparrow		5.8	5,117	41.4	6.0-7.0/ha	4 year old chained
Vesper Sparrow						
Western Meadowlark					2.5-3.5/ha	
Brewer's Sparrow		0.0	229	0.0	1.0-3.5/ha	4 year old burned
Vesper Sparrow					4.0-5.5/ha	
Western Meadowlark					3.0/ha	
Brewer's Sparrow/Short 1983		> 30		27-63	0.15 ha	HEP model
Grasshopper Sparrow/Arnold & Higgins 1986		≤ 35			0.49-1.34 ha	Relative cover; est. absolute=17.5%

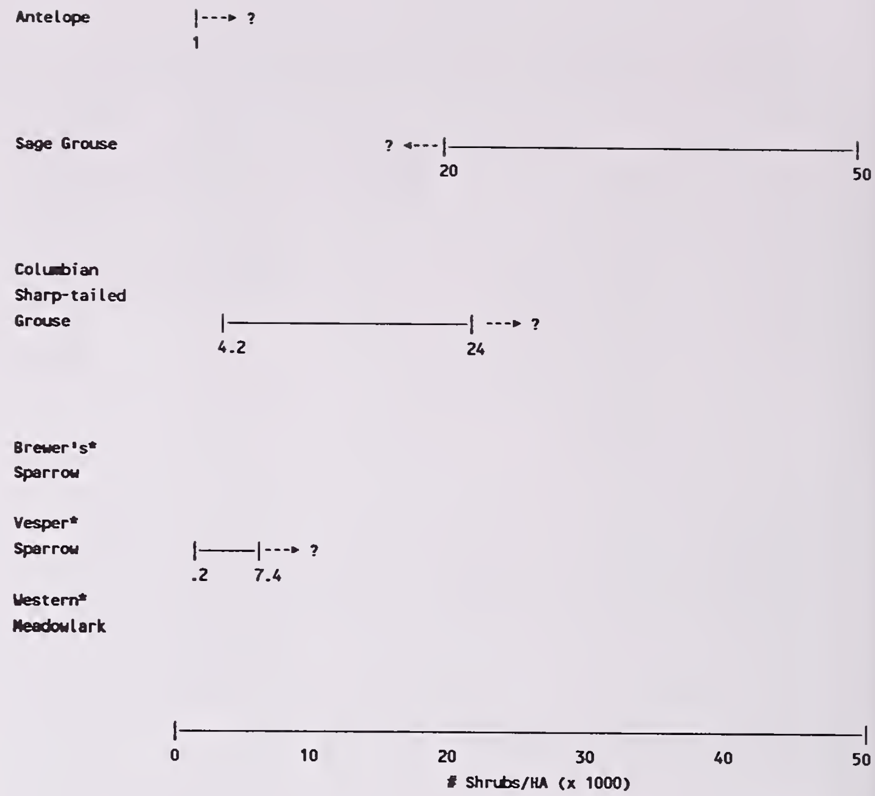
- ***Shrub cover*** is the most well-documented habitat for the species we're dealing with here. However, it is also deficient when it comes to nongame birds. It can be seen that ranges of shrub cover for nongame birds fall within those of game species. (Table 1 and Figure 1). I should note here that I had to juke with the following data to get it in common units of measurement. Also, for shrub cover, it wasn't always clear whether it was relative or absolute, so I adjusted those where it appeared necessary. The symbol ?<- is my speculation that this range of a particular habitat characteristic extends some distance in that direction.



NOTE: The symbol ---► indicates the range of this value probably extends some distance in the direction specified.

Figure 1. — Ranges in Percent Shrub Cover for Shrubland Wildlife Cited.

- ***Shrub density data*** are also limited, but, again, there is a wide range given for game species and, where I could find it for nongame, it falls in the low end of that range (Table 1 and Figure 2). I'm sure more data would show a wider range for antelope, the lark bunting and grasshopper sparrow using densities at the low end of the spread, and other shrub using nongame birds occupying higher density habitats.

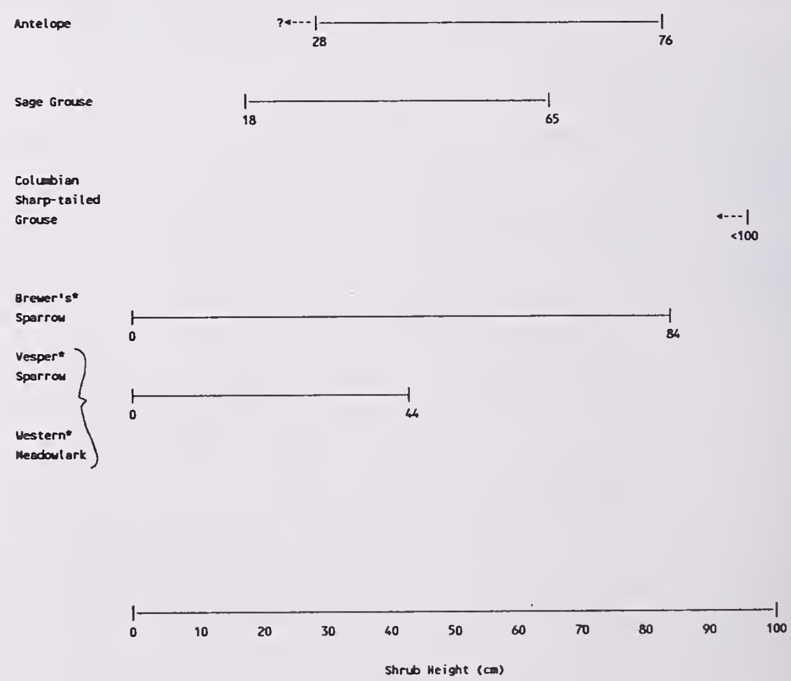


* From one study on response to shrub treatments.

NOTE: The symbol ---► indicates the range of this value probably extends some distance in the direction specified.

Figure 2. — Ranges in Shrub Density (# Shrubs/Ha) Documented for Various Shrubland Wildlife Cited in Table 1.

- ***Shrub heights***: Where data are available, show similar overlap, with shrub using nongame birds falling in the mid to high end. (Table 1 and Figure 3).



* From one study on response to shrub treatments.

Figure 3. — Ranges of Shrub Heights for Shrubland Wildlife Species Cited in Table 1.

- ***Home Range/Territory/Movements:*** Even though some of these nongame species may be at the low end of the shrub cover range of the species we've traditionally emphasized in our management, consider the difference in home range/territory/movements (Tables 1, 2 and 3). Game species seasonal ranges are relatively huge area in comparison to the breeding territories or summer ranges of individual nongame birds. And, movements to seasonal ranges may, for species like antelope, involve travelling from 10-20 km to well over 100 km in areas such as Wyoming's Sublette Antelope Herd Unit.

Table 2. — Summary of Home Range, Territory and/or Movements of Various Rangeland Game Species Cited in Table 1.

SPECIES	HOME RANGE	NOTES
Antelope	440-1200 ha	Nursery and bachelor herds
	165-2300 ha	Winter home ranges
	18- 160 km	Seasonal movements
Sage Grouse	1058-3140 ha	
	up to 1.8 km	Breeding season males
	1.6 - 2.5 km	Winter
	2.5 - 2.8 km	Movements to nest sites
	up to 5 - 11.7 km	Movements to nest sites
Columbian Sharp-tailed Grouse	<100-400 m	Summer
	0.75 - 2.52 ha	
	1.87 km	Spring/fall
	$\bar{x}$ = 103 ha	Nesting females

NOTE: $\bar{x}$ is the mean.

Table 3. — Summary of Home Range, Territory and/or Movements of Various Rangeland Nongame Species Cited in Table 1.

SPECIES	HOME RANGE	COMMENTS
Lark Bunting	0.7 - 0.75 ha	
Sage Sparrow, Sage Thrasher, Brewer's Sparrow	1 nest/1.25 ha	
Brewer's Sparrow	1 pr/0.9 - 1.6 ha	Breeding pairs
	1 pr/1.0 - 1.2 ha	Breeding pairs
	7.0 - 7.5/ha; 6.0 - 7.0/ha; 1.0 - 3.5/ha	Various shrub treatment sites
	0.15/ha	
Vesper Sparrow	0.035/ha - 0.23/ha	Shrubby habitat
	0/ha - 0.57/ha	Shrubless habitat
	4.5 - 5.0/ha; 4.0 - 5.5/ha	Various shrub treatment sites
Western Meadowlark	2.0 - 3.5/ha; 2.5 - 3.5/ha; 3.0/ha; 0.23 - 0.27/ha	Various shrub treatment sites
Grasshopper Sparrow	.49 - 1.34 ha	

Research has established that game species we've been looking at need different habitat characteristics at different times of the year. On young rearing and winter ranges, shrub densities (and heights) may be generally greater than they need to be on other seasonal ranges. But, even these ranges are mosaics of shrubby and shrubless areas. The findings of Roth (1976) and Rotenberry and Wiens (1980) which show that songbird species diversity and richness increase with horizontal habitat diversity, are compatible with high habitat heterogeneity or patchiness that is important to wider ranging species. Patchiness within seasonal ranges of these game species provides places for the songbirds which may only need breeding territories 60 or so meters across. Accommodating a relatively diverse summer bird community bird can be accomplished at the same time the wider ranging species are addressed. You just can't expect to have the country blanketed with sage thrasher or sage sparrow habitat or, conversely, grasshopper sparrow habitat. Rangeland was never monotypic.

The fact that these nongame birds we're so concerned about require habitat qualities similar to those of species who've gotten most of the attention to this point is further justification for proper land management. Land management plans identify species for which management will be directed to assure maintenance of various habitat types. These "indicator" species include a mix of those that are economically important, those that are threatened or endangered (where applicable), and those that are specifically dependent on certain habitats. For example, the elk is a common choice for the land use plans for western national forests because it is economically important, a charismatic species, and its seasonal habitat needs cover a wide range of vegetation communities. The goshawk and pine marten are also often included because they are sensitive to and indicators of quality of forested habitats.

The same can and should be done in rangelands. As an example, pronghorn and sage grouse, although strongly dependent on shrubs, require a wide variety of seasonal habitats, and gross management can be directed at their needs. On a finer scale, species such as the Brewer's sparrow or sage thrasher could be used to direct management for shrubby habitats while species like the grasshopper sparrow, vesper sparrow or lark bunting could be used to direct management for the grassy areas or grassland types. Similarly, mule deer and sharp- tailed grouse can be the focus for macro habitat management in mountain foothills while the towhees and species that require more open habitats can help guide micro management. This principle can be applied to different ecosystems throughout the country.

Protection or enhancement of habitat for nongame species, in conjunction with that of big game or game birds, should not be considered only in land management plans. State managers deal on a daily basis with shrub eradication, land conversions, grazing management plans, mineral extraction, and other disturbances. They also are involved with habitat improvement projects on public and private lands. This occurs during various agencies' project planning and through our environmental commenting process.

The key is collecting the right information and getting it to the wildlife and land managers. And, this is one area where the Partners in Flight and state and federal nongame programs can help. In Wyoming, where field biologists are dealing with 7-8 big and trophy game species, an equal number of resident game birds, a variety of migratory game birds, and a host of other responsibilities, including almost nonstop involvement in environmental protection, state wildlife biologists are wondering how they can wedge another focus in, or find the time to determine what these species need. To put this further in perspective, I might also add that attendance at this workshop is more than double the size of our entire Department (330 positions) and Wyoming ranks 9th among the states in size. The kind of information I just discussed is needed to convince the managers that your needs and their needs are compatible, and it provides them with stronger arguments in their efforts to promote proper habitat management.

If managers are aware of who's in trouble and have this information avail-able, they'll use it. Prescriptions and guidelines for management of elk, sage grouse, turkey, deer, moose, and so on are readily available. And, they are generally accepted by wildlife and land managers. Those people are building on and refining these criteria as more information becomes available. Comparable information for nongame birds or related groups of these species, particularly those we need to be concerned about, is needed. With this in-formation, we can mobilize the most important and effective ground level constituencies of this effort.

LITERATURE CITED

Arnold, T. and K. Higgins. 1986. Effects of shrub coverages on birds of North Dakota mixed-grass prairies. Can. Field-Natur. 100:10-14.

Authrieth, R. 1978. Guidelines for the management of pronghorn antelope. Proc. Bienn. Pronghorn Antelope Workshop 8:472-526.

Bayless, S. 1969. Winter food habits, range use and home range of antelope in Montana. J. Wildl. Manage. 33:538-551

Best, L. 1972. First year effects of sagebrush control on two sparrows. J. Wildl. Manage. 36:534-544.

Bredehoft, R. 1981. Baggs sharp-tail study. Job Completion Rept. Wyo. Game & Fish Dept., Cheyenne.

Castrale, J. 1982. Effects of two sagebrush control methods on nongame birds. J. Wildl. Manage. 46:945-952.

Cole, G. 1956. The pronghorn antelope - it's range use and food habits in central Montana with special reference to wheat. Mont. State Col. Exper. Sta. Bull. 516.

Colenso, B., M. Boyce, and J. Tate, Jr. 1980. Developing criteria for reclamation of sage grouse habitat on a surface coal mine in northeastern Wyoming. pp 27-31 in Symposium on surface mine hydrology, sedimentation and reclamation. Lexington, KY.

Dix, R. 1961. An application of the point-centered quarter method in phytosociological sampling. Ecology 37:776-778.

Eng, R. and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in Central Montana. J. Wildl. Manage. 36:141-146.

Finch, D., S. Anderson, and W. Hubert. 1987. Habitat suitability models: lark bunting. USFWS, Nat. Ecol. Cent. Biological Rept. 82(10.137). Washington.

Giesen, K. 1987. Population characteristics and habitat use by Columbian sharp-tailed grouse in northwest Colorado. Final Rept., Colo. Div. Wildl. Fed. Aid Proj. W-152-R, Denver.

Hart, C., O. Lee, and J. Low. 1950. The sharp-tailed grouse in Utah. Utah Dept. Fish & Game, Salt Lake City.

Hayden-Wing, L., L.D. Constan, J. Hull, M. Jackson, and T. Segerstrom. 1985. Movement patterns and habitat affinities of a sage grouse population in northeastern Wyoming. pp. 207-226 in Issues and technology in the management of impacted western wildlife. Thorne Ecological Institute, Boulder, CO.

Johnsgard, P. 1973. Grouse and quails of North America. Univ. of Neb. Press, Lincoln.

Johnson, R., L. Haigh, M. Riffey, and J. Simpson. 1980. Brushland/steppe bird populations. pp 98-112 in R. DeGraff (ed.). Management of western forests and grasslands for nongame birds. USFS Intermtn. For. & Range Exper. Sta. Gen. Tech. Rept. INT-86.

Kinschey, R., C. Sundstrom and J. Yoakum. 1978. Range/wildlife interrelationships--pronghorn antelope. Proc. Bienn. Pronghorn Antelope Workshop 9:216-219.

Kitchen, D. 1974. Social behavior and ecology of the pronghorn antelope. Wildl. Monogr. 38.

_________. and B. O'Gara. 1982. Pronghorn pp. 960-971 in J. Chapman and G. Feldhammer (eds). Wild mammals of North America. The Johns Hopkins Univ. Press.

Klebenow, D. 1969. Sage grouse nesting and brood rearing habitat in Idaho. J. Wildl. Manage. 33:649-662.

Marks, J. and V. Marks. 1987. Habitat selection by Columbian sharp-tailed grouse in west-central Idaho. U.S. Bur. Land Manage., Boise District, Idaho.

Martin, N. 1970. Sagebrush control related to habitat and sage grouse occurrence. J. Wildl. Manage. 34:313-320.

_______. 1976. Life history and habitat requirements of sage grouse in relation to sagebrush treatment. Proc. West. Assoc. State Game and Fish Comm. 56:289-294.

McArdle, B. 1977. The effect of sagebrush reduction practices on sharp-tailed grouse in southeastern Idaho. M.S. Thesis. Utah State Univ., Logan.

Medin, D. 1990. Birds of an upper sagebrush-grass zone habitat in east-central Nevada. USFS Intermtn. For. & Range Exper. Sta. Gen. Tech. Rept. INT 433.

Mitchell, G. and S. Smoliak. 1971. Pronghorn antelope range characteristics and food habits in Alberta. J. Wildl. Manage. 35:238-250.

Patterson, R. 1952. The sage grouse in Wyoming. Sage Books, Denver, CO.

Plummer, A., D. Christiansen and S. Monsen. 1968. Restoring big game range in Utah. Utah. Div. Fish and Game, SLC. Publ. No. 68-3.

Postovit, B. 1981. Suggestions for sage grouse habitat reclamation on surface mines in northeast Wyoming. M.S. Thesis, Univ. of Wyo., Laramie.

Rich, T. 1980. Nest placement in sage thrashers, sage sparrows, and Brewer's sparrows. Wilson Bull. 92:362-368.

Roth, R. 1976. Spatial heterogeneity and bird species diversity. Ecology 57:773-782.

Rotenberry, J. and J. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228-1250.

Schroeder, M. and D. Sturgis. 1975. The effect on the Brewer's sparrow of spraying big sagebrush. J. Range Manage. 28:294-297.

Short, H. 1983. Wildlife guilds in Arizona desert habitats. U.S. Bur. Land Manage. Tech. Note 362.

Smith, G., N. Nydegger and D. Yensen. 1984. Passerine bird densities in shrubsteppe vegetation. J. Field Ornithology 55(2):261-264.

Sundstrom, C., W. Hepworth and K. Diem. 1973. Abundance, distribution and food habits of the pronghorn. Wyo. Game & Fish Dept. Bull. No. 12.

Tessmann, S. 1991. Shrub cover recommendations for wildlife on reclaimed mine lands. Wyo. Game & Fish Dept. Unpubl. Rept.

Wallestad, R. 1971. Summer movements and habitat use by sage grouse broods in central Montana. J. Wildl. Manage. 35:129-136.

_________. and D. Pyrah. 1974. Movement and nesting of sage grouse hens in central Montana. J. Wildl. Manage. 38:630-633.

_________. and P. Schladweiler. 1974. Breeding season movements and habitat selection of male sage grouse. J. Wildl. Manage. 38:634-637.

_________. 1975. Sage grouse nesting and brood rearing habitat in Idaho. J. Wildl. Manage. 33:649-662.

Wentland, H. 1968. Summer range habits of the pronghorn antelope in central Montana with special reference to proposed sagebrush control study plots. Proc. Bienn. Antelope States Workshop. 3:99-103.

Woolfolk, H. 1945. Some observations of lark buntings and their nests in eastern Montana. Condor 42(2):128.

Yoakum, J. 1972. Antelope-vegetative relationships. Proc. Antelope States Workshop. 5:171-177.

_________. 1978. Managing rangelands for the American pronghorn antelope. Proc. Bienn. Pronghorn Antelope Workshop. 8:321-326.

Integrating Management of Forest Interior Migratory Birds With Game in the Northeast

Glenn D. Therres[1]

Abstract — State wildlife agencies in the northeastern United States, and throughout the country, are funded primarily through hunting license revenues. As such, most efforts by state agencies are game oriented. To more effectively influence Neotropical migratory bird management within state wildlife agencies, integration of habitat management with that for game species is strongly recommended. In recent years there has been growing concern for Neotropical migratory birds that are forest interior breeders. Forest interior breeding birds are those species that need relatively large contiguous tracts of forest to support viable breeding populations. They are generally adversely effected by edge conditions. Habitat management for forest game species, particularity wild turkey, ruffed grouse, and American woodcock, is practiced by many northeastern state wildlife agencies. This paper discusses habitat management practices for turkey, grouse, and woodcock and its implications for forest interior breeding birds. Recommendations are given for integrating Neotropical migratory bird needs with management of these game species. Regional planning to accommodate both game and forest interior birds is recommended. Research on direct effects of game management on these Neotropical migrants is warranted.

There has been a prevailing dogma throughout the traditional wildlife profession that good game habitat management is good for nongame as well. Though this may be true for certain nongame species, it is not appropriate as a general rule. Temple (1986) noted out this philosophy is demonstrably naive and incorrect. In his land ethic essay, Leopold (1949) noted we are getting closer to having a land ethic when we admit that songbirds should continue as a matter of biotic right, regardless of presence or absence of economic advantages to us. He stressed the importance of managing the total wildlife community. Game and nongame managers should strive for this approach.

Community or ecosystem management, in lieu of featured species management, is increasing in application and should continue. However, featured species management, particularly of game species, is still widely practiced throughout the country. This approach, in some form or another, is the norm for most state wildlife agencies.

Though state wildlife agencies are usually legally responsible for all wildlife species, their funding base is primarily through hunting revenues. As a result, many habitat management practices employed by state wildlife agencies are game oriented. Appropriateness of this orientation can be argued a number of ways, but the reality is game management is a very high priority by state agencies and accounts for a significant amount of their efforts. In the northeastern U.S., which is the focus of this paper, the percentage of state wildlife agencies' budgets dedicated to nongame management ranges from 1 to 10%. This probably is representative of all state wildlife agencies nationwide.

To more effectively manage nongame species, such as Neotropical migratory birds, it is essential for state agencies to integrate this management with game management. I suggest

[1] *Maryland Department of Natural Resources, P.O. Box 68, Wye Mills, MD 21679.*

ways of integrating management of forest interior breeding Neotropical migratory birds with game species in the Northeast as an example of this strategy.

Little research on direct effects of various game habitat management techniques on Neotropical migratory birds are available to aid in developing an integrated approach. In the Northeast, studies on effects of ruffed grouse (*Bonasa umbellus*) habitat management on songbirds (Euler and Thompson 1978; Yahner 1984, 1986, 1991; Yahner and Scott 1988; Yahner and Voytko 1989; Yahner et al. 1989) are the only published papers available reporting direct effects of forest game management. More research in this area is needed.

Though effects of game habitat management on songbirds has not been well documented, impacts of these practices relative to the overall problems facing Neotropical migrant populations is small. Game management is not the major environmental factor effecting these birds, but modifications to game habitat practices that can benefit Neotropical migratory birds will help the cause.

In this paper I discuss general requirements for forest interior breeding Neotropical migrants, predominately used habitat management practices for select forest game in the Northeast, and provide recommendations for integrating habitat management for both groups. Most of my recommendations are based on biological interpretation of the literature and not the result of direct research on this topic. This paper is intended to alert land managers to conflicts and possible resolutions of integrating forest interior breeding bird and game habitat management using the best information available today.

FOREST INTERIOR BREEDING BIRDS

In the Northeast, there is growing concern for Neotropical migratory birds that are forest breeders. Population declines of forest breeding Neotropical migrants have been well documented (e.g. Hall 1984, Johnston and Winings 1987, Holmes and Sherry 1988, Leck et al. 1988, Sauer and Droege 1992), with an accelerated decline noted in recent years (Robbins et al. 1989b).

Many of these species require large (>150 ha) contiguous tracts of forest for breeding. They are generally characterized as being (1) area sensitive, (2) ground nesters or nesting near the ground, (3) open cup nesters, and (4) single brooded with small clutch sizes (Robbins 1979, Whitcomb et al. 1981). Bushman and Therres (1988) summarized these species habitat requirements as needing large contiguous forest with a closed or partially opened canopy, moderate to dense understory, relatively mature trees, and a low level of disturbance during the breeding season. Of course, each species has its own unique habitat needs so the above generalizations must be viewed with this in mind. For example, some species nest in the canopy and not on the ground. Table 1 lists Neotropical migratory birds considered forest interior breeders in the Northeast. Though these species are considered forest interior specialists, they will breed in less than optimum conditions and will be found in other than forest interior. The important factor to keep in mind is that these species are area sensitive and that their population viability depends on large forested ecosystems.

Table 1. — Species of Neotropical migratory birds considered forest interior breeders in the northeastern United States. (Sources: DeGraaf and Rudis 1986, Brittingham 1989, Robbins et al. 1989a).

Species	Scientific Name
Whip-poor-will[1]	*Caprimulgus vociferus*
Yellow-bellied flycatcher[2]	*Empidonax flaviventris*
Acadian flycatcher	*Empidonax virescens*
Blue-gray gnatcatcher	*Polioptila caerulca*
Veery	*Catharus fuscescens*
Swainson's thrush[1]	*Catharus ustulatus*
Wood thrush[1]	*Hylocichla mustelina*
Yellow-throated vireo	*Vireo flavifrons*
Red-eyed vireo	*Vireo olivaceus*
Northern parula	*Parula americana*
Black-throated blue warbler	*Dendroica caerulescens*
Black-throated green warbler	*Dendroica virens*
Blackburnian warbler	*Dendroica fusca*
Yellow-throated warbler	*Dendroica dominica*
Cerulean warbler[1,3]	*Dendroica cerulea*
Black-and-white warbler[1]	*Mniotilta varia*
American redstart	*Setophaga ruticilla*
Prothonotary warbler	*Protonotaria citrea*
Worm-eating warbler	*Helmitheros vermivorus*
Swainson's warbler	*Limnothlypis swainsonii*
Ovenbird	*Seiurus aurocapillus*
Northern waterthrush	*Seiurus noveboracensis*
Louisiana waterthrush[2]	*Seiurus motacilla*
Kentucky warbler	*Oporomis formosus*
Hooded warbler	*Wilsonia citrina*
Canada warbler[2]	*Wilsonia canadensis*
Scarlet tanager	*Piranga olivacea*

[1] *Significant negative BBS trend for 1966-1991.*
[2] *Significant negative BBS trend for 1982-1991.*
[3] *Listed as migratory nongame bird of management concem by USFWS.*

The two major habitat management considerations that influence forest interior breeding birds are amount of contiguous forest habitat and amount and juxtaposition of edge.

Robbins et al. (1989a) demonstrated that forest area influences breeding abundance of forest interior species. They found the highest probability of breeding by most forest interior species in forests > 3,000 ha in size. Estimated minimum areas needed to support breeding populations ranged from 1 ha for wood thrush to 1,000 ha for black-throated blue warbler, with half the species needing 150 ha or more. There were few forest interior species for which forests < 10 ha appeared to provide adequate habitat for breeding. In small forested tracts nest success may be significantly reduced by nest predation (Wilcove 1985). The issue of forest area is complicated by forest vegetation characteristics and the distance between forest stands (Lynch and Whigham 1984, Blake and Karr 1987).

Forest interior breeding birds generally avoid edge conditions (Kroodsma 1984). Chasko and Gates (1982) found the mean nesting distance from transmission corridor edges in western Maryland of 11 forest interior species was 40.7 m, with species differences ranging from 21 m for scarlet tanager to 65 m for worm-eating warbler. Numerous studies (e.g. Wilcove 1985, Andren and Angelstam 1988, Yahner and Scott 1988) have demonstrated higher predation rates of nests along forest edges. Martin (1992) reported predation as the primary cause of nest mortality of Neotropical migrants and suggested against managing for habitat features that decrease reproductive output, such as edge creation. Brood parasitism by brown-headed cowbirds (*Molothrus ater*) is also much higher along edges as compared to forest interior (Brittingham and Temple 1983). This combination of higher predation and parasitism rates can result in reduced reproductive success and possibly lower populations. For a more comprehensive discussion of edge effects refer to Reese and Ratti (1988) and Yahner (1988).

The issue of edge effect is the major conflict between forest interior bird and game species management. In reference to Neotropical migrants, Temple (1986:19) stated "intentional ecosystem modifications undertaken by game managers, with the specific goal of creating additional ecological edges in an area, are likely to have a negative impact on a segment of the local wildlife community that is already suffering population decline." Herein lies the need for integration.

FOREST GAME MANAGEMENT

In the Northeast, the primary forest game species are wild turkey (*Meleagris gallopavo*), ruffed grouse, American woodcock (*Scolopax minor*), squirrels, white-tailed deer (*Odocoileus virginianus*), and black bear (*Ursus americanus*). Standard forest silvicultural practices, such as even-aged management, are generally used to manage forests for these game species. Most states in the Northeast implement limited habitat management practices for squirrels, deer, and bears, but many do specifically manage habitat for turkey, grouse, and to a lesser degree woodcock.

Following is a brief description of habitat management techniques used for each of these gamebirds by state agencies in the Northeast. Impacts of these practices on Neotropical migrants are discussed, and suggestions for integrating management are presented.

Ruffed Grouse

Grouse habitat management is focused on successional forest conditions. Aspens are the forest type most often managed for grouse, though oak-hickory forests are also manipulated. Standard recommendations are to manage by creating small (2.5-4 ha) even-aged blocks of varying age classes. Usually ¼ of each management unit (i.e combination of four blocks of varying age classes) is clearcut, followed by rotating the clearcut of each ¼ block over a 40-year rotation for aspens or 80 years for oak-hickories. This management technique follows that detailed by Gullion (1972), who described a patchwork or checkerboard system of these management units. This patchwork system applied over a large area creates a tremendous amount of edge.

In Pennsylvania, this intensive grouse management strategy was employed on a 583 ha area beginning in 1976-1977. Breeding bird surveys conducted 4 years after the initial ¼ blocks were clearcut found only 1 of 7 forest interior species at a lower abundance on the managed tract than on a forested control area immediately adjacent to the site (G. Therres, unpub. data). Yahner (1984) reported 2 of 5 forest interior species at lower densities on the same managed tract the year following clearcutting of the second ¼ block. This technique resulted in increased populations of 4 Neotropical migrants which breed in early successional habitats. Brown-headed cowbird populations were similar between managed and control sites. In a similar study in Minnesota, Fouchi and Gullion (1984) found breeding densities for 6 of 9 forest interior birds greater in the unmanaged forest than on the grouse management area. This grouse area had been under management for over a decade longer then the Pennsylvania site.

Studies with artificial nests on the Pennsylvania grouse management area found greater predation rates in areas with 50% clearcuts compared to an unmanaged control (Yahner and Scott 1988), greater predation in forested ¼ blocks as compared to clearcuts (Yahner and Wright 1985), and that predation may have a greater effect on birds nesting above rather than on the ground (Yahner et al. 1989). Corvids were the major nest predators.

Grouse management techniques used on a smaller scale include planting small patches (< 0.5 ha) of evergreens for winter cover, planting fruit producing shrubs, daylighting roads, seeding logging roads and landings with grasses and legumes, and controlled burning. These practices increase edge and may negatively impact forest interior birds.

Habitat Management Recommendations

Following are management recommendations for integrating ruffed grouse and forest interior breeding bird habitat management:

1. Timber harvesting should be designed to minimize edge creation. A square or circular design provides the least amount of edge.
2. Avoid creating grouse management units in forest interior.
3. Locate habitat management practices in existing successional forest types or near existing permanent edges.
4. Limit grouse management units to 20 ha and avoid large patchwork management systems.

5. Avoid daylighting roads. If necessary, daylight only one side < 25 m.
6. Seed logging roads and landings with shade tolerant grasses and legumes suitable for grouse, so that a closed forest canopy can be allowed to develop or be maintained for forest interior birds.

Wild Turkey

Turkey habitat management primarily encourages forests of mast producing trees, particularly oaks and hickories. An optimum balance of age and size classes would include 40% sawtimber, 30% pole stands, 20% saplings, and 10% recently regenerated stands (Dellinger 1973). Distribution and juxtaposition of these age and size classes will effect forest interior breeding birds in varying ways. Thompson et al. (1992) studied several forest tracts, approximately 200 ha each, with similar age and size class distributions for optimum turkey habitat and found 2 forest interior species with lower breeding densities, 3 with greater densities, and 3 with no differences between these areas and areas of 100% pole-sawtimber. In a 15,700-ha forest ecosystem in western Maryland, considered prime turkey habitat, 16 forest interior breeding birds were documented (J.E. Gates, unpub. data). Of the top ten species by breeding density, eight were forest interior species. Brown-headed cowbird was also one of the top ten. The age and size class distribution in this system was 67% sawtimber, 26% pole stands, and < 10% seedling/saplings.

In the Northeast, small (0.2-2 ha) permanent openings dispersed throughout the forest at 0.4-0.8 km intervals are often recommended to provide turkey brood foraging habitat. Long, narrow openings are often recommended. Robbins et al. (1989a) defined contiguous forest as forested tracts separated by < 100 m of non-forested habitat. Using this as a guide to define the maximum size of an opening and still maintaining contiguous forest, openings should not exceed 2.5 ha. However, since Chasko and Gates (1982) found avoidance of edges by forest interior birds of transmission corridors 50 m wide, a more conservative opening is recommended. Research is needed to determine the maximum forest opening dimensions compatible with forest interior breeding bird needs.

Other habitat management techniques used to enhance forest for brood rearing include daylighting roads and seeding logging roads and landings with grasses and legumes. These techniques increase edge.

Habitat Management Recommendations

Following are management recommendations for integrating turkey and forest interior breeding bird habitat management:

1. Timber harvesting should be designed to minimize edge creation. A square or circular design provides the least amount of edge.
2. Utilize selective harvest techniques when feasible.
3. Avoid creating permanent openings in forest interior. Locate openings near existing permanent edge.
4. Minimize size and number of permanent openings. Restrict size to < 1 ha with a maximum width < 50 m. Shape should be circular or square.
5. Avoid daylighting roads. If necessary, daylight only one side < 25 m.
6. Seed logging roads and landings with shade tolerant grasses and legumes suitable for turkey use, so that a closed forest canopy can be allowed to develop or be maintained for forest interior birds.
7. Manage transmission corridors as brood habitat for turkeys in lieu of creating permanent openings.

American Woodcock

Woodcock management is usually conducted in bottomlands or lowlands adjacent to streams, near bogs and swamps, and in early successional forests. Alder stands, young aspen forests, and moist shrub thickets are particularly desired habitats. Habitat management techniques include maintaining alder stands, maintaining young (30-yr old) aspen stands by clearcutting, and enhancing or creating shrub thickets, especially hawthorn thickets. Release cuttings through removal of overstory trees > 15 cm d.b.h. is also recommended to rejuvenate remnant stands of shrubs (Liscinsky 1972). Sepik et al. (1981) provided a number of management plans utilizing small patch and strip clearcuts to maintain young second growth conditions. These cuts are usually < 1 ha in size.

As with turkeys, small permanent openings are often recommended for use as woodcock singing grounds. Sepik and Dwyer (1982) suggested numerous clearings are necessary to realize the full courting-male potential of an area since not all openings will be utilized due to unknown selection preferences. These areas should be at least 0.1 ha in size and maintained in grasses, weeds, or other short vegetation (Liscinsky 1972). Gutzwiller and Wakeley (1982) concluded that opening size does not appear to be important in determining the quality of singing sites, so smaller openings would have less impact on forest interior birds with no impact on woodcock.

While sharing common concerns with grouse and turkey management, woodcock habitat management adds the concern that it is often associated with riparian forests. These forests usually support higher densities of forest interior breeders. Several forest interior species are directly dependent on streams and bottomland forests for breeding (DeGraaf and Rudis 1986). Conversely, several Neotropical migrants depend on forested wetlands, bogs, alder swamps, and early successional habitats needed by woodcock.

Habitat Management Recommendations

Following are management recommendations for integrating woodcock and forest interior breeding bird habitat management:

1. Concentrate woodcock habitat management near edges of alder swamps, bogs, and shrub dominated wetlands.
2. Avoid intensive woodcock management in forested wetlands or in mature riparian or bottomland forests. Management in these areas should be located adjacent to permanent edges.
3. Maintain early successional habitat only in areas of existing successional forests or along permanent edges.
4. Avoid creating woodcock singing grounds in forest interior.
5. Limit size of permanent openings to < 0.5 ha with a maximum width < 50 m.
6. Manage transmission corridors in appropriate conditions suitable for singing woodcock and roosting cover in lieu of creating permanent openings.

FINAL CONSIDERATIONS

Management of forest interior breeding birds and forest game does not have to be mutually exclusive. Since forest interior birds and forest game share a common need, for forests, objectives for managing both are achievable. Managing exclusively for one group over the other is irresponsible and unnecessary. Applying the integration recommendations provided can feature both groups and is more conducive to the total wildlife community. However, it must be recognized that maximum production for game or forest interior species cannot be achieved in this process. A true conflict arises when habitat management for non-forested game species is applied in forested habitats.

Integration is effective when applied as a regional management strategy (Brittingham 1989). With this strategy all land uses, on both public and private lands, should be taken into consideration. Through this approach core forest interior areas can be managed primarily for forest interior birds and peripheral areas managed primarily for forest game. Robbins (1979) and Harris (1984) present various strategies that could be used to accomplish this regional approach.

Habitat management decisions of a local scale should take into consideration present habitat conditions and the wildlife community it supports. Priorities should be given to those communities or species that are rare, threatened, endangered, or in serious decline. In the Northeast, turkey populations have significantly increased while ruffed grouse and woodcock populations have declined according to BBS trends for 1982-1991. Table 1 lists forest interior species with declining populations regionally. These trends may differ by state.

Research specifically designed to determine effects of game habitat management practices on forest interior birds is needed. Determining size and frequency of permanent openings compatible with forest interior birds is one such need.

Finally, it is imperative that game and nongame biologists and managers communicate and work cooperatively in integrating management of forest interior breeding Neotropical migratory birds and game species. Without this cooperation state wildlife agencies and other land management agencies will be ineffective at managing our wildlife communities.

ACKNOWLEDGMENTS

Thanks are extended to those wildlife biologists from the northeastern states' wildlife agencies who provided information useful in preparing this paper. D.W. Brauning, E.J. Golden, S.A. Smith, and T.P. Mathews reviewed the manuscript and provided helpful comments.

LITERATURE CITED

Andren, H., and P. Angelstam. 1988. Elevated predation rates as an edge effect in habitat islands: experimental evidence. Ecology 69:544-547.

Blake, J.G., and J.R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68:1724-1734.

Brittingham, M.C. 1989. Effects of timber management practices on forest interior birds. Pages 163-170 *in* Timber management and its effects on wildlife (J.C. Finley and M.C. Brittingham, Eds.). Pennsylvania State Univ., University Park.

Brittingham, M.C., and S.A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31-35.

Bushman, E.S., and G.D. Therres. 1988. Habitat management guidelines for forest interior breeding birds of coastal Maryland. Maryland Dep. Nat. Resour. Wildl. Tech. Publ. 88-1.

Chasko, G.C., and J.E. Gates. 1982. Avian habitat suitability along a transmission-line corridor in an oak-hickory forest region. Wildl. Monogr. 82.

Degraaf, R.M., and D.D. Rudis. 1986. New England wildlife: habitat, natural history, and distribution. U.S. For. Serv. Gen. Tech. Rep. NE-108.

Dellinger, G.P. 1973. Habitat management for turkeys in the oak-hickory forests of Missouri. Pages 235-244 *in* Wild turkey management: current problems and programs (G.C. Sanderson and H.C. Schultz, Eds.). Univ. Missouri Press, Columbia.

Euler, D.L., and D.Q. Thompson. 1978. Ruffed grouse and songbird foraging response on small spring burns. New York Fish & Game J. 25:156-164.

Fouchi, C.M., and G.W. Gullion. 1984. Nongame bird response to aspen regeneration. Pages 218-229 *in* Proceedings of the workshop on management of nongame species and ecological communities. Univ. Kentucky, Lexington.

Gullion, G.W. 1972. Improving your forested lands for ruffed grouse. Ruffed Grouse Soc., Coraopolis, Pennsylvania.

Gutzwiller, K.J., and J.S. Wakeley. 1982. Differential use of woodcock singing grounds in relation to habitat characteristics. Pages 51-54 *in* Woodcock ecology and management (T.J. Dwyer and G.L. Storm, Eds.). U.S. Fish & Wildl. Serv., Wildl. Res. Rep. 14.

Hall, G.A. 1984. Population decline of neotropical migrants in an Appalachian forest. Am. Birds 38:14-18.

Harris, L.D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. Univ. Chicago Press, Chicago, Illinois.

Holmes, R.T., and T.W. Sherry. 1988. Assessing population trends of New Hampshire forest birds: local vs. regional patterns. Auk 105:756-768.

Johnston, D.W., and D.I. Winings. 1987. Natural history of Plummers Island, Maryland. XXVII. the decline of forest breeding birds of Plummers Island, Maryland, and vicinity. Proc. Biol. Soc. Washington 100:762-768.

Kroodsma, R.L. 1984. Effect of edge on breeding forest bird species. Wilson Bull. 96:426-436.

Leck, C.F., B.G. Murray, JR., and J. Swinebroad. 1988. Long-term changes in the breeding bird populations of a New Jersey forest. Biol. Conserv. 46:145-157.

Leopold, A. 1949. A Sand County almanac. Oxford Univ. Press, New York.

Liscinsky, S.A. 1972. The Pennsylvania woodcock management study. Pennsylvania Game Comm. Res. Bull. 171.

Lynch, J.F., and D.L. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, U.S.A. Biol. Conserv. 28:287-324.

Martin, T.E. 1992. Breeding productivity considerations: what are the appropriate habitat features for management. Pages 455-473 *in* Ecology and conservation of Neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Smithsonian Institution Press, Washington, D.C.

Reese, K.P., and J.T. Ratti. 1988. Edge effect: a concept under scrutiny. Trans. North Am. Wildl. & Nat. Resour. Conf. 53:127-136.

Robbins, C.S. 1979. Effect of forest fragmentation on bird populations. Pages 198-212 *in* Management of north central and northeastern forests for nongame birds (R.M. DeGraaf and K.E. Evans, Tech. Coord.). U.S. For. Serv. Gen. Tech. Rep. NC-51.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. 1989a. Habitat area requirements of breeding birds of the middle Atlantic states. Wildl. Monogr. 103.

Robbins, C.S., J.R. Sauer, R.S. Greenburg, and S. Droege. 1989b. Population declines in North American birds that migrate to the neotropics. Proc. Natl. Acad. Sci. USA 86:7658-7662.

Sauer, J.R., and S. Droege. 1992. Geographic patterns in population trends of Neotropical migrants in North America. Pages 26-42 *in* Ecology and conservation of Neotropical migrant landbirds (J.M. Hagan, III and D.W. Johnston, Eds.). Smithsonian Institution Press, Washington, D.C.

Sepik, G.F., and T.J. Dwyer. 1982. Woodcock response to habitat management in Maine. Pages 106-113 *in* Woodcock ecology and management (T.J. Dwyer and G.L. Storm, Eds.). U.S. Fish & Wildl. Serv., Wildl. Res. Rep. 14.

Sepik, G.F., R.B. Owen, JR., and M.W. Coulter. 1981. A landowner's guide to woodcock management in the Northeast. Univ. Maine Agric. Exp. Sta. Misc. Rep. 253.

Temple, S.A. 1986. Ecological principles of wildlife management. Pages 11-21 *in* Management of nongame wildlife in the Midwest: a developing art. North Central Chap. Wildl. Soc.

Thompson, F.R., III, W.D. Dijak, T.G. Kulowiec, and D.A. Hamilton. 1992. Breeding bird populations in Missouri-Ozark forests with and without clearcutting. J. Wildl. Manage. 56:23-30.

Whitcomb, R.F., C.S. Robbins, J.F. Lynch, M.K. Klimkiewicz, B.L. Whitcomb, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pages 125-206 *in* Forest island dynamics in man-dominated landscapes (R.L. Burgess and D.M. Sharpe, Eds.). Springer-Verlag, New York.

Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1214.

Yahner, R.H. 1984. Effects of habitat patchiness created by a ruffed grouse management plan on breeding bird communities. Am. Midl. Nat. 111:409-413.

Yahner, R.H. 1986. Structure, seasonal dynamics, and habitat relationships of avian communities in small even-aged forest stands. Wilson Bull. 98:61-82.

Yahner, R.H. 1988. Changes in wildlife communities near edges. Conserv. Biol. 2:333-339.

Yahner, R.H. 1991. Avian nesting ecology in small even-aged aspen stands. J. Wildl. Manage. 55:155-159.

Yahner, R.H., T.E. Morrell, and J.S Rachael. 1989. Effects of edge contrast on depredation of artificial avian nests. J. Wildl. Manage. 53:1135-1138.

Yahner, R.H., and D.P. Scott. 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Manage. 52:158-161.

Yahner, R.H., and R.A. Voytko. 1989. Effects of nest-site selection on depredation of artificial nests. J. Wildl. Manage. 53:21-25.

Yahner, R.H., and A.L. Wright. 1985. Depredation on artificial ground nests: effects of edge and plot age. J. Wildl. Manage. 49:508-513.

Wapiti and Warblers: Integrating Game and Nongame Management in Idaho

C. R. Groves[1] [2] and J. W. Unsworth[3]

Abstract — The primary concern of wildlife managers in the USDA Forest Service (USFS) and Idaho Department of Fish and Game (IDFG) is maintaining elk herds and quality elk hunting. As a result, nongame species like neotropical migratory landbirds do not receive much management attention. Cause for concern over this neglect are twofold: 1) forest fragmentation may be having detrimental effects on neotropical migrants in Idaho and 2) an emphasis on elk habitat management may not be in the best interests of achieving the broader goal of maintaining biological diversity on National Forest lands. We discuss biological, policy, economic, and political implications for neotropical migrants on USFS lands managed primarily for elk. Our analysis proceeds from a review of forest plans, a review of IDFG comments on these plans, interviews with USFS and IDFG biologists, and a synthesis of literature on the ecology of elk and neotropical migrants. Elk are inappropriately used as an ecological management indicator species because they are habitat generalists. The use of MIS and models to manage habitat for elk (habitat effectiveness models) are reviewed and critiqued. The extent to which forest fragmentation, to which elk appear well-adapted, may be negatively impacting neotropical migrants is discussed. A landscape-level approach for managing habitats for neotropical migrants is broadly outlined. We give recommendations for improving management of elk and neotropical migrants, and for improving individual and collective abilities of USFS and IDFG wildlife personnel for management of all wildlife species on USFS lands in Idaho.

INTRODUCTION

There is considerable evidence that many species of neotropical migratory landbirds are declining (Terborgh 1989, Robbins et al., these proceedings). Most evidence comes from monitoring and research efforts in deciduous forests of the eastern United States. Forest fragmentation is cited as one primary reason for declines (Faaborg et al., these proceedings). In the western U.S., where many habitats are naturally fragmented, only a few studies have examined effects of forest fragmentation on avian communities (Freemark et al., Hejl et al. 1993, these proceedings), and long-term monitoring data on bird populations are limited.

In most western states, fish and game agencies are primarily interested in welfare of game species. For example, the greatest concern of state wildlife managers in Idaho is maintenance of the state's elk (*Cervus elaphus*) herds and quality elk hunting. Idaho has the second largest elk population in the U.S., and Idaho hunters harvest more elk than any state except Colorado (1990 Western States Elk Workshop, unpublished data). Income to IDFG derived from elk hunting is substantial. National Forest lands provide the majority of habitat for elk. In fact, 90% of all elk in the U.S. spend some part of the year on public land (Thomas 1991). Elk populations, elk habitat effectiveness models and guidelines (Lyon 1983), and elk vulnerability (Christensen et al. 1991) during the hunting season are foremost among joint concerns of USFS and IDFG personnel.

[1] *Nongame and Endangered Wildlife Program, Idaho Department of Fish and Game, Box 25, Boise ID 83707. Current address: The Nature Conservancy, 2060 Roadway Suite 230, Boulder CO 80302.*

[2] *The opinions expressed in this paper are those of the authors and do not necessarily reflect those of the Idaho Department of Fish and Game or The Nature Conservancy.*

[3] *Idaho Department of Fish and Game, 3101 S. Powerline Rd., Nampa ID 83686.*

Because IDFG and USFS emphasize elk management, many other species, including neotropical migrants, have not received management attention they warrant. Ongoing timber harvest and resulting habitat fragmentation could have detrimental effects on forest breeding birds, including neotropical migrants. Furthermore, implications for other species of managing habitat based upon guidelines from elk habitat effectiveness models is largely unknown, but it is possible that managing habitat primarily for elk is not beneficial to other wildlife species such as forest-dwelling neotropical migrants. This is particularly important because USFS manages most habitat where neotropical and resident forest birds occur. In addition, there is increasing evidence that tree cover is not critical to elk survival (Peek et al. 1982) and that hunter access and intensity, not cover or forage areas, are most important in controlling managed elk herds (Unsworth et al. 1993). This suggests that emphasis placed on elk habitat management may not be in the best of interests of maintaining overall biological diversity as mandated by the National Forest Management Act (NFMA).

The purpose of this paper is to examine implications for forest-dwelling neotropical migrant birds of managing wildlife habitat on National Forest lands in Idaho primarily for elk. The complexity of this situation will be analyzed primarily from a biological management perspective, and secondarily from policy (differing agency mandates), economic (funding for game/nongame), and political (distribution of power) standpoints (Dery 1984). We focus on: 1) interactions between wildlife biologists in USFS and IDFG, 2) the use of management indicator species (MIS) and elk habitat effectiveness models in USFS, and 3) the potential biological effects of forest fragmentation and elk habitat management on neotropical migrants. Finally, we make recommendations on how both IDFG and USFS can individually and collectively improve management of both game and nongame species in Idaho.

BACKGROUND

Biological Diversity

Approximately 506 species of terrestrial vertebrates inhabit Idaho (Groves and Melquist 1991). These include 15 amphibian, 23 reptile, 360 bird, and 108 mammalian species. Of the 360 species of birds, 241 are thought to breed in the state, and about half of these (119 species) are classified as neotropical migrants (Saab and Groves 1992). As such, neotropical migrants constitute about 31% of the state's terrestrial vertebrate biological diversity (Fig. 1), exclusive of non-breeding birds.

Game species account for 73 of 506 terrestrial vertebrate species (14%), whereas nongame species make up about 86% (433/506). Of nongame species, neotropical migratory landbirds account for about 27% (119/433). Migratory landbirds have been further classified into two categories: obligate migrants (78

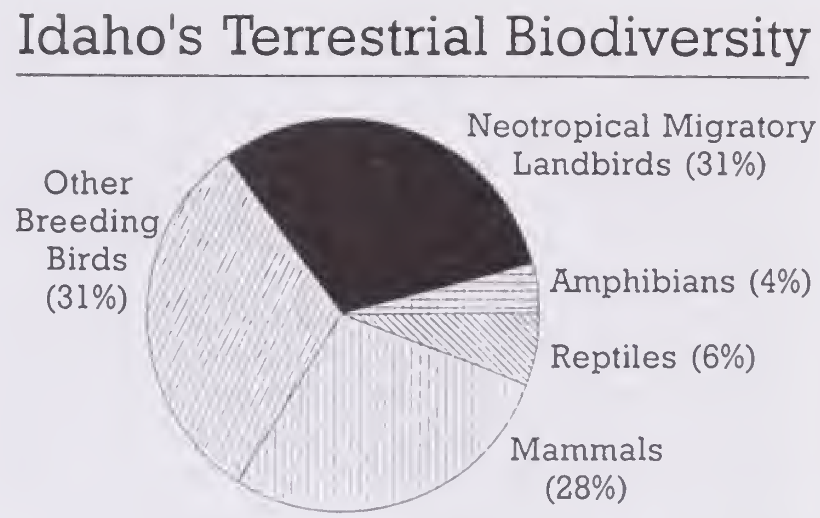


Figure 1. — Percentages of vertebrate classes accounting for the terrestrial biological diversity of Idaho. The total of 506 terrestrial vertebrates includes breeding and non-breeding birds, and introduced species.

species), those species in which nearly all individuals migrate to the tropics, and facultative migrants (41 species), species in which only some individuals migrate long distances (Saab and Groves 1992).

Landscape Setting

Idaho encompasses nearly 22 million ha, extending about 925 km from its northern to southern border (Tisdale 1986). Seventy-five percent of the state is mountainous with the level terrain being concentrated on the Snake River Plain in the south. Approximately 42% of the state is forested, primarily in central and northern portions; 26% is shrub steppe, mostly in the southern third; 23% is in agriculture, urban or exotic annual grasslands; and the remainder is a small percentage of wetland and alpine cover types (Caicco et al., in review). Idaho contains the largest amount of designated wilderness area in the contiguous 48 states. These 1.5 million ha of national forest wilderness are concentrated in five areas in central and west-central Idaho and consist primarily of montane forest, subalpine forest, and unvegetated terrain types.

About two-thirds of Idaho is under federal ownership with the USFS managing 9.3 million ha (38%), the Bureau of Land Management managing 4.9 million ha (23%), and other federal agencies managing about 0.6 million ha (Sharp and Sanders 1978). In addition, the state owns about 0.8 million ha. There are 10 national forests in Idaho, three in the Northern Region of USFS or those lands north of the Salmon River, and seven in the Intermountain Region south of the Salmon River.

Funding and Staff for Game and Nongame Management

In FY-92, IDFG's total budget was $38.5 million (IDFG, unpublished data). This budget is funded by revenue from the sale of hunting/fishing licenses and tags, and Federal Aid funds such as Pittman-Robertson and Dingell-Johnson. Twenty-two million dollars of this budget was funded by license revenues. Just over $5 million of license revenue was from sale of non-resident and resident elk tags and hunting licenses. Revenue from elk hunting represents the single largest portion of income to IDFG, constituting nearly one-fourth of the license budget and 13% of the entire IDFG budget.

Funding for the Nongame Program in FY-92 was about $600,000 or 1.5% of IDFG's total budget. This funding accounted for about 9% of the wildlife budget within IDFG. Funding for the Nongame Program has come from voluntary state income tax return contributions, which have declined from a high of $90,000 in 1982 at the program's inception to $55,000-$65,000/yr the last three years (Fig. 2). Additional funding for nongame comes from Federal Aid, Section 6 of the Endangered Species Act, contracts with other federal natural resource agencies, other direct donations, and sale of goods.

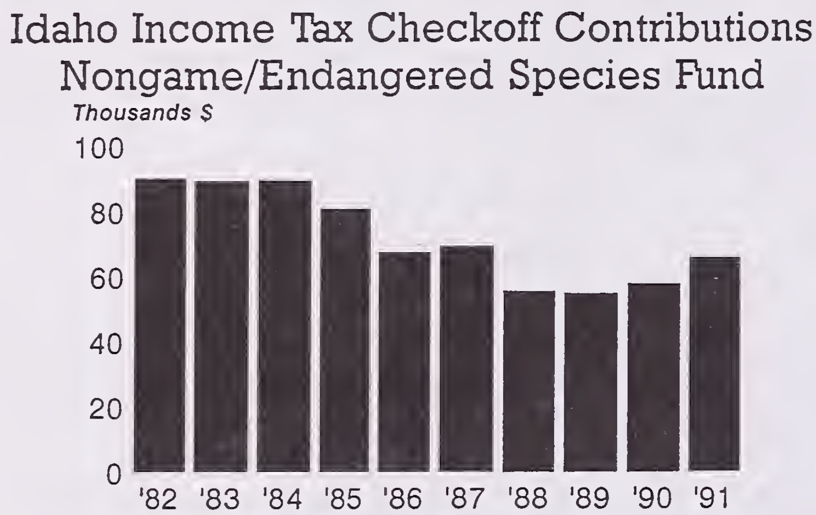


Figure 2. — Summary of voluntary contributions on the state income tax return for the Idaho Department of Fish and Game's Nongame and Endangered Wildlife Program, 1982-1991.

The Nongame Program, which includes the state's natural heritage program, employees two full-time nongame biologists and a plant ecologist. Although there are no regional nongame biologists, there are four wildlife research biologists who work on specific threatened, endangered, and sensitive species projects. In contrast, each of seven regional offices employees a minimum of two full-time wildlife biologists who concern themselves primarily with populations of game species. In addition, there is a whole cadre of wildlife habitat biologists whose primary concern is the management of game species on IDFG-owned lands, and a staff-person in each region who deals solely with wildlife (game) depredations. In total, over 60 permanent wildlife staff in IDFG have major responsibilities for management of game species' populations and habitat, compared to three permanent staff in the Nongame Program.

Management of Neotropical Migrants in Idaho

As detailed in the first "Partners in Flight" newsletter, IDFG's involvement with neotropical migrants has focused on several efforts. In 1992 IDFG, in collaboration with USFS Intermountain Research Station, published a 16-page color leaflet that provides technical information on descriptions, habitats, population trends, ecology, and conservation of neotropical migrants in Idaho (Saab and Groves 1992). IDFG also coordinated the U. S. Fish and Wildlife Service's (USFWS) breeding bird survey routes (BBS) in Idaho from 1985-1990 (Groves and Melquist 1991). During this period, the number of survey routes increased from about 15 to 50, and consistency in observers and annual surveys of routes improved substantially. IDFG published a new latilong booklet on the distribution and population status of all Idaho birds (Stephens and Sturts 1991), and finally, IDFG has been a participant in the USFWS gap analysis project in Idaho (Scott et al. 1993). One facet of this project is examining distributional patterns of neotropical migrants in relation to vegetation types and protected areas.

Elk Management

As previously indicated, revenue from elk hunting accounts for the largest portion of IDFG's annual budget. Using 1992 data on elk hunter-days and 1982 data on expenditures of elk hunters (Sorg and Nelson 1986), we conservatively estimated the annual net economic value of elk hunting to Idaho at $25 million in 1992. Because of the economic importance of elk hunting, every national forest in Idaho classifies elk as a management indicator species (MIS) (see discussion below). Elk are the only MIS consistently listed on every national forest in Idaho. Furthermore, they are the only MIS for which habitat models and guidelines have been extensively developed and implemented on Idaho national forests.

Nine of 10 Idaho national forests use elk habitat guidelines (e.g., Boss et al. 1983, Leege 1984) in forest plans and at the project level (e.g., environmental assessment of timber sale) that are based upon habitat effectiveness models (Lyon et al. 1985). These models (Fig. 3) predict the percentage of available habitat

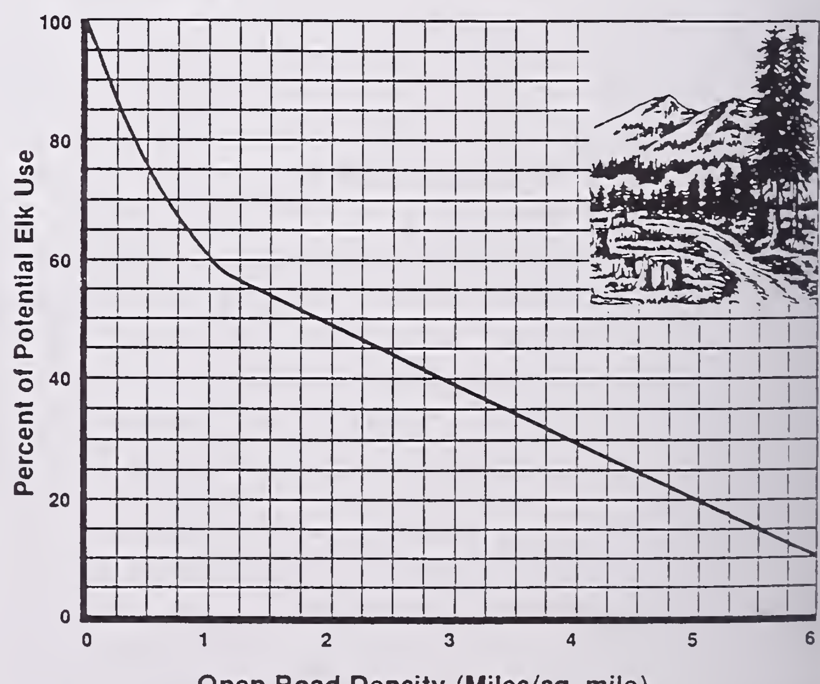


Figure 3. — The relationship between open road density and potential elk use of habitat (Lyon 1983).

usable by elk outside the hunting season (Lyon and Christensen 1992). Habitat effectiveness is most often based on road-density models; that is, with increasing road density there is a corresponding decrease in elk habitat effectiveness. Calculations of habitat effectiveness also often incorporate a 60:40 forage/cover component (Leege 1984). More recently, elk managers and researchers in both IDFG and USFS have emphasized elk vulnerability (Christensen et al. 1991). In contrast to habitat effectiveness, which deals with summer range habitat and behavioral responses of elk to habitat disturbance, elk vulnerability is a functional concept dealing with susceptibility of elk to being killed during the hunting season (Lyon and Christensen 1992).

METHODS

To examine roles of IDFG and USFS in wildlife management on national forest lands, three tasks were undertaken. First, we reviewed wildlife portions of all Idaho national forest plans and IDFG's comments on these plans (1985-1986) to determine the extent of their focus on elk, neotropical migrants, and other wildlife. Then, eight national forest biologists and six IDFG regional wildlife managers were interviewed via telephone to obtain information on: 1) positive and negative aspects of interactions between the two agencies, 2) adequacy of elk habitat effectiveness models and use of MIS, and 3) how wildlife management on USFS lands could be improved through individual and collective efforts of the two agencies (Table 1). Literature on ecology of elk and neotropical migratory landbirds was also reviewed to determine potential effects of forest fragmentation and elk habitat management on neotropical migrants.

Table 1. — Questions asked of U.S. Forest Service and Idaho Department of Fish and Game biologists concerning wildlife management on national forest lands in Idaho.

1. How are management indicator species (MIS) used on your forest (USFS biologists only)?
2. What wildlife species are usually involved in interactions between USFS and IDFG? What wildlife issues are usually involved in this interaction?
3. How strong of an influence does the IDFG have on your forest's wildlife program (USFS only)?
4. What do you view as the positive and negative aspects of the interaction between the IDFG and USFS?
5. How could the interaction between the two agencies on wildlife issues be improved?
6. Are the elk habitat effectiveness models useful? What changes would you suggest to improve elk management on national forest lands?
7. Have elk habitat management guidelines been skirted or manipulated by USFS personnel?
8. Do you focus most of your attention on game or nongame species (USFS only). How could management of these two groups be better integrated?
9. Is the IDFG focus in wildlife management on national forest lands too narrow (IDFG only)? If so, should it be broadened and what are the mechanisms for broadening it?
10. What tools do you need (excluding staff and $) to improve your wildlife management program?

RESULTS

Elk Management and Neotropical Migrants

Literature on elk and discussions with IDFG and USFS biologists all point out that elk can and do adapt to a wide variety of habitats. The notion that elk need trees for thermal cover and that forage/cover ratios of 60:40 are optimal for elk (Thomas 1979) may be useful in some parts of their range (e.g., Blue Mountains of Oregon), but clearly does not have wide-ranging applicability. In southern Idaho, elk herds flourish with good production year-round in sagebrush habitats (IDFG, unpublished data). Similarly, there are other herds living in areas with no tree cover in southern Washington, Jackson Hole, WY, and Wind Cave National Park, SD (Peek et al. 1982). Recent findings in northern Idaho that elk populations there are controlled by hunter access and behavior, not habitat factors, corroborates this point (Unsworth et al. 1993).

It is also clear that there have been considerable misunderstandings and miscommunication between the two agencies on elk management. What it amounts to is that maintaining elk herds and elk hunting are two different issues. Whereas IDFG's intent is to promote elk hunter opportunities, that is not always how the USFS perceives their goal. As Jack Ward Thomas (1991) noted, "...merely producing elk is not enough. The hunting experience and effect of hunting on elk welfare are also important and must be addressed simultaneously with the production of elk." Although the argument can be made that one charge of USFS is to provide recreational opportunity, including elk hunting, it is an unresolved matter as to whether USFS can meet elk harvest goals in the face of other mandates (e.g., timber harvest, maintenance of biodiversity).

Because of the emphasis placed on elk management, a perception still exists on some forests and ranger districts that managing for elk habitat will sufficiently meet the needs of other wildlife species. The following quote from an Idaho forest plan demonstrates this point: "Since elk use all forest cover types and successional stages, managing for elk is, in essence, managing for all species that occupy some part of elk habitat." Though dubious biologically, this thinking is too often espoused by USFS line officers (according to our interviewees) who feel that if they meet elk habitat or population goals, there is little else to be concerned about with regard to wildlife. Certainly the recent debates over spotted owls/old growth forests (Thomas et al. 1990) and even more recent concern for the Northern Goshawk (*Accipiter gentilis*) in relation to timber management (Reynolds et al. 1992) should put such thoughts to rest.

Forest fragmentation is a major concern for many of Idaho's neotropical migrants. Over 40% of Idaho's neotropical migrants nest in coniferous forest habitat (Fig. 4) and about 60% of these are canopy-nesters (Saab and Groves 1992). What effects forest fragmentation, either natural or human-caused, is having on these species is largely unknown. Some forest birds may be "edge-sensitive," meaning they prefer to nest in the forest interior away from edges, whereas other species may be "area-sensitive," that is, they may be eliminated or have lower density populations on forest fragments below a minimum size threshold. Increased forest edge from clearcuts and fragmentation can result in increased nest predation (Wilcove 1985) and parasitism by Brown-headed Cowbirds (*Molothrus ater*) (Rothstein et al. 1984).

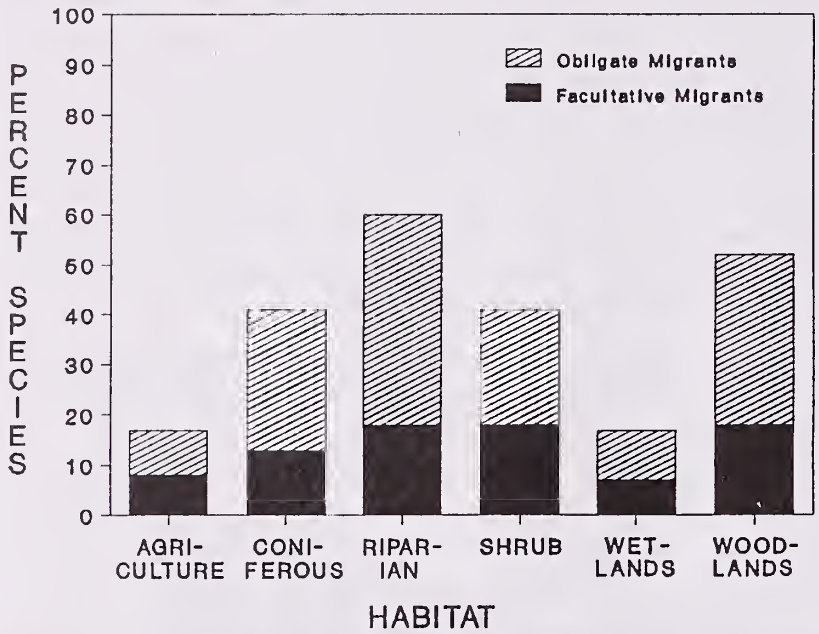


Figure 4. — General habitat associations of Idaho's neotropical migrants (Saab and Groves 1992). Most species use more than one type of habitat.

Although only a few western studies address the effects of forest fragmentation (*see* Faaborg et al. 1993; Freemark et al. 1993 for review) on avian communities, there is clearly cause for concern. Aney (1984), in a short-term study, examined bird distributions in old-growth forests of western Montana and noted the number of bird species increased with stand size. Hejl (1992) examined habitat associations of birds at stand and landscape levels in old-growth and second-growth Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) forests of western Montana and adjacent Idaho. She found several species of birds more abundant in old-growth than mature second-growth forests. Brown-headed Cowbirds were notably more abundant in second-growth stands surrounded by a greater amount of agricultural lands and grasslands. Keller and Anderson (1992) compared avian populations in uncut and fragmented stands of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) in southeastern Wyoming. They found two species, Brown Creeper (*Certhia americana*) and Hermit Thrush (*Catharus guttatus*), negatively affected by fragmentation whereas Pine Siskins (*Carduelis pinus*) were positively affected.

One link between elk and neotropical migrant habitat is riparian areas. Marcum (1975, 1976) found elk using areas within 320 m of water disproportionately greater than other summer range areas. Skovlin (1984) also reported a heavy preference for summer range within 0.8 km of water. Whether elk are attracted to riparian areas for lush forage or water or both is unclear (Ohmart and Anderson 1986). Riparian areas are the most important habitat in arid portions of the West for neotropical migrants (Knopf et al. 1988, Terborgh 1989). In Idaho, 60% of the migrant landbirds are associated with riparian habitats in the breeding season (Saab and Groves 1992). Thus, conservation of riparian habitats is wise stewardship for elk, neotropical migrants, and other wildlife species.

Review of Forest Plans and IDFG Comments on Forest Plans

Of nine forest plans reviewed, six plans clearly featured elk management as the highest wildlife management priority, whereas no single species stood out in the other plans. Several mentioned specific elk population or habitat effectiveness goals that the plan was striving to achieve, and several forests had developed standards and guidelines within their forest plans for elk. Elk was notably the only management indicator species for which a specific habitat model had been developed.

IDFG's comments on forest plans relative to wildlife management emphasized concernsabout elk. On each plan, IDFG was consistently most concerned about the impacts of increased roading on elk security areas and inconsistencies in elk population goals between IDFG and USFS. Although selected endangered and sensitive species were occasionally mentioned, the word *nongame* was mentioned only once in nine sets of forest plan comments.

Management Indicator Species

NFMA regulations indicate that each national forest is to specify MIS for planning and state reasons for selections (Code of Federal Regulations 1985). Species may be selected because they are: 1) a threatened, endangered, or sensitive species (TES), 2) commonly hunted, fished, or trapped, or 3) ecological indicators of the condition of populations of other species or habitats. Because neither the Northern or Intermountain Region of the USFS had implemented Sensitive Species programs (Groves and Melquist 1991) prior to the writing of forest plans, none of these plans listed any Sensitive species as MIS. The number of MIS averaged 7.4 species (n=10) and ranged from 4-15 species (excluding the federally listed threatened and endangered species). Two or three of the MIS on each forest were consistently big game species, including elk as a MIS on every forest. The Pileated Woodpecker (*Dryocopus pileatus*) and the Northern Goshawk were also selected by several forests as old-growth indicators. Several neotropical migrants including Red-naped Sapsucker (*Sphyrapicus nuchalis*), Williamson's Sapsucker (*S. thyroideus*), Brown Creeper, Ruby-crowned Kinglet (*Regulus calendula*), Mountain Bluebird (*Sialia currucoides*), Yellow Warbler (*Dendroica petechia*), Vesper Sparrow (*Pooecetes gramineus*), and Brewer's Sparrow (*Spizella breweri*) were also selected, but there was little consistency in their selection from one forest to another.

Elk were selected as MIS because of their socioeconomic value as a game species. Classification as MIS has undoubtedly been helpful in promoting the growth and maintenance of elk herds on national forest lands. The problem with elk classification as MIS is they are often treated as an ecological indicator species. Because they are habitat generalists, they are a poor choice for an ecological MIS, and their use as such may be indirectly detrimental to other wildlife such as neotropical migrants with more specialized habitat needs. Thus, selecting MIS for reasons other than ecological indicators can lead to management conflicts. More than one USFS and IDFG biologist indicated elk were of little to no value as an ecological MIS, and elk habitat effectiveness models should be eliminated or modified. Several biologists in both agencies indicated a new model was needed that incorporated features of habitat effectiveness and vulnerability or which focused primarily on elk mortality and vulnerability.

Interviews with USFS and IDFG Biologists

Several consistent answers emerged from USFS biologist interviews. All but one biologist indicated they used MIS in the forest plan and to evaluate impacts of proposed projects such as timber sales. Similarly, all but one forest biologist indicated elk was the MIS receiving the most attention and that IDFG had a strong influence on the USFS emphasis on elk management. Nearly all USFS biologists felt that IDFG influence on elk management was positive in that it helped them achieve wildlife habitat goals internally within the USFS. However, all expressed concerns that IDFG over emphasized elk management at the expense of other species. Most USFS biologists also expressed frustration concerning the IDFG's lack of expertise at a regional level in areas other than big game management. At least two forest biologists had been openly criticized for spending too much money on TES species and not enough on elk. On the flip side, two USFS biologists positively noted that IDFG had begun to address issues other than big game. Most forest biologists felt they had balanced wildlife management programs, but that nongame, particularly TES species, were increasingly important.

Despite limitations, most forest biologists felt that elk habitat effectiveness models were useful in habitat conservation and noted few attempts to skirt or manipulate the model guidelines. As to improving relationships between agencies, the most consistent USFS answers were that IDFG needs to: 1) broaden its horizons beyond big game, 2) communicate better so that employees of both agencies better understand their respective agencies' mandates and limitations, and 3) be more involved from the beginning and throughout the planning/evaluation process on USFS projects such as timber sales. Finally, nearly all USFS biologists commented that their greatest need was information on habitat relationships of TES species and a larger-scale approach (i.e., landscape-level analysis) that would use geographical information system (GIS) analysis.

IDFG biologists concurred that game species' issues, particularly surrounding elk, dominated their interactions with the USFS. All agreed that IDFG's focus was narrow, but necessarily so due to pressures of meeting needs of IDFG's primary constituent - the hunter, and limited funding/personnel to focus on nongame species. Nearly all IDFG biologists expressed a strong desire and need to have regional expertise on nongame matters. Several IDFG biologists expressed frustration at getting the USFS biologists to do what they felt was the right thing for the biological resource (usually a game species) as opposed to other resource values such as grazing or timber harvest. Most placed blame for any negative interactions on the differences in mandates between the agencies.

Contrary to USFS biologists' responses, IDFG biologists noted considerable problems with elk habitat effectiveness models. Among problems identified were misapplication of the model outside of summer range, lack of model standardization among forests, and manipulation of models to bias outputs towards timber harvest. One biologist observed that USFS often used the guidelines as a reason for harvesting timber under the auspices of improving habitat for elk. As for how the two agencies could work together better, IDFG responses varied from "they'll improve when the last tree on the forest is cut" to the need for increased interaction through frequent informal meetings.

SYNTHESIS AND RECOMMENDATIONS

Elk and Neotropical Migratory Landbirds

Although Unsworth et al. (1993) indicate that habitat factors are of little importance in control of elk herds in northern Idaho, their mortality model was developed in an area of relatively high tree cover. Cover may play a more important role in areas where it is relatively more limited. In addition, the value of cover to elk may diminish at high hunter densities but be more important to elk survival at lower hunter numbers (A. Christensen, *pers. comm.*) An obvious corollary is that habitat effectiveness models and guidelines may be most useful in areas with limited cover and fewer hunters. These models and guidelines have resulted in protection of some forest cover that might have otherwise been lost to timber harvest. Nevertheless, it seems safe to assume that elk have tolerated habitat fragmentation well and focusing our primary attention on managing forested habitats for an adaptive species such as elk makes little sense. How ironic that this fragmentation was often intended (ostensibly) to encourage higher levels of elk use of the managed forest (Thomas 1991).

How then are forested habitats to be managed for the diverse needs of neotropical migrants and other species? Managing landscape patterns and processes so they resemble presettlement times and re-establishing natural disturbance regimes is one alternative (Noss 1985, Hejl 1992, Huto et al., this proceedings). This approach necessitates investigating what presettlement vegetation in an area would look like and determining factors responsible for shaping the vegetation patterns. For example, in the northern Rocky Mountains, several factors (e.g., elevation, aspect, fire, avalanches, disease, insects, vulcanism) play a role in determining landscape patterns (Hejl 1992). Some USFS land managers recently re-focused efforts towards landscape-level management (e.g., Losensky 1991), and recent emphasis of ecosystem management (Kessler et al. 1992) in USFS will undoubtedly result in more landscape-level planning.

A similar and complementary approach, espoused by Jerry Franklin and colleagues in the Pacific Northwest (Swanson and Franklin 1992), uses knowledge of natural ecosystems to develop sustainable ecosystem management. Such a strategy might include modifying stand management practices to retain some live trees and greater amounts of woody debris instead of practices resulting in clearcut plantations. At the landscape level, timber harvest might shift from a pattern of dispersed to aggregated cuts to provide more forest interior habitat.

Management Indicator Species

Interviews with USFS biologists indicated several MIS were consistently used in evaluating individual projects such as timber sales on most forests, yet most MIS lack standards and guidelines developed for elk. Consequently, evaluating project impacts is more difficult. Several USFS biologists commented on lack of habitat-specific information for many MIS, particularly sensitive species. Only one biologist noted difficulties with the validity of MIS as a concept for evaluating environmental impacts.

A recent GAO report (1991) on USFS indicator species generally mirrors our interview results. GAO concluded there were several practical drawbacks to MIS including lack of understanding of the relationship between indicator species and habitat characteristics they are supposed to predict, detected changes in MIS levels due to habitat changes beyond management control, selection of MIS for other than reasons of ecological representativeness, and the large number of skilled staff required to implement the MIS approach. In addition, costs of monitoring populations of MIS to detect changes in habitat condition can be prohibitive. Despite acknowledgment by USFS staff of these problems, USFS headquarters officials believed the MIS concept to be basically sound and that many of the problems can be resolved.

This conclusion is inconsistent with findings of Landres et al. (1988) who thoroughly critiqued use of vertebrates as indicator species. They noted numerous, significant problems in MIS use including failure of assumptions behind their use on both a conceptual and empirical basis. They found selection criteria confounding, lack of guidelines for choosing the number of indicator species, statistical problems associated with sampling populations of many MIS, and inappropriate use of the same MIS from one geographic area to another. They specifically pointed out that game species like elk are "especially problematic as ecological indicators because their population density and distribution are affected by hunters and direct control actions to meet socioeconomic and political objectives." Landres et al. (1988) concluded that MIS use was inappropriate in most cases, and regulations and mandates requiring their use were biologically problematic and financially infeasible. Noss (1990) agreed, noting that MIS may mislead biologists into thinking that all is well in an area simply because an indicator species is thriving. As mentioned previously, this thinking is a problem with regard to elk management on some Idaho national forests.

Despite admonishments to abandon the concept, Landres et al. (1988) outlined a series of recommendations to improve MIS usefulness. Although there are some obviously compelling reasons to focus attention on MIS classified as TES, the critique of Landres et al. (1988) is persuasive that alternative approaches to environmental assessment are desperately needed. The landscape approaches mentioned above (Noss 1985, Swanson and Franklin 1992) will likely offer viable alternatives. Utilizing tools such as GIS and gap analysis (Scott et al. 1993) to identify protected and unprotected vegetation communities and species-rich areas should be a component of these landscape-level approaches. In Idaho, distributions of neotropical migrants and their habitats have been mapped under the auspices of the state's gap analysis project. Such information should be taken advantage of in determining "hot spots" of species richness, trends in habitats of declining species, and ecosystems and populations at risk.

Need for Nongame Expertise

> "All wildlife, including all wild animals, birds, and fish, within the state of Idaho, is hereby declared to be the property of the state of Idaho. It shall be preserved, protected, perpetuated, and managed." -- *Idaho Code* 36-103

Like most state fish and game agencies, IDFG has focused most attention on a handful of game species which generate the bulk of the agencies' income through hunting license and tag revenues. Idaho law to the contrary, the vast majority of the state's wildlife species (i.e., nongame species) are arguably not being preserved, perpetuated or protected, and they certainly are not being managed. As mentioned previously, only a small portion of IDFG's budget is for nongame management. USFS and IDFG biologists repeatedly emphasized need for IDFG to provide nongame technical information to national forests for planning and project purposes. State departments of fish and game have a unique and influential role in wildlife management on national forest lands which is recognized by federal law and has recently been clarified (Overbay 1992). This unique role affords IDFG a sizeable opportunity to influence all wildlife management on national forest land. If and when this opportunity is afforded, proponents of nongame will be indebted to sportsmen whose support of hunting and fishing has provided them a powerful, bureaucratic infrastructure from which to operate.

Idaho's Nongame Program ranks in the bottom 20% in funding and staff among state nongame programs nationally (Vickerman 1987). Like many agencies in the West, IDFG has been slow to respond to changing public attitudes concerning increased interest in nongame and watchable wildlife (Arrandale 1990). In fact, a recent IDFG policy plan for 1990-2005 pays scant attention to the nongame resource (IDFG 1991). This slow response is simply a reflection of the fact most state wildlife managers draw their pay from revenue derived from the sale of hunting, fishing, and trapping licenses. Thus, many state fish and game agencies, Idaho included, arguably manage sportsmen as much as they manage wildlife. Yet, there is light at the end of this tunnel. In 1991, IDFG hired environmental coordinators to focus on projects that could impact fish and wildlife populations and habitats. In 1992, the Idaho state legislature passed a bill that provides new funding to nongame through a wildlife license plate. Such funding will hopefully provide IDFG with regional nongame expertise desperately needed to effectively manage all wildlife species.

National forests are increasingly embroiled in conflicts with threatened, endangered, and sensitive species as well as other species such as neotropical migrants. If IDFG is to continue to be a major player in wildlife habitat management on public lands, it is imperative they obtain additional staff expertise in this area. But to deal with increasingly complex wildlife issues such as amphibian population declines, habitat fragmentation, and maintenance of viable populations, both USFS and IDFG biologists will need to call upon not only traditional wildlife management skills but new techniques and ideas. Some new tools emerging from the multi-disciplinary field of conservation biology include conservation genetics, population viability analysis, and landscape/ecosystem level analyses of biological diversity (Edwards 1989, Teer 1989).

Complexity of the Problem

Like many groups of species, neotropical migratory birds have received little attention on Idaho national forests from either USFS or IDFG. This neglect coupled with heavy emphasis on elk management is a technical, biological problem for which preliminary but scant data suggest there is cause for concern. However, the larger problem and its solution are far more complicated than its biological side would suggest. As we see it, there are several pieces to this puzzle. There is an economic aspect of the problem in that current wildlife management is largely driven by funding derived from big game hunting which, in turn, does not meet the needs of statewide conservation for all wildlife species. The two agencies involved, the USFS and the IDFG, have differing mandates which cause them to manage differently, and occasionally brings them into conflict. This aspect is essentially a policy problem. Finally, there is a political side of this problem whereby power and authority to make decisions is fragmented, in this case, between two organizations. The desired goal of the conservation of all wildlife species is thereby more difficult to achieve. By coming to a consensus on the definition of this multi-faceted problem, a solution is much more likely. Our recommendations follow below.

Recommendations

1. USFS should de-emphasize MIS as it is deficient on theoretical, empirical, and cost-effective grounds. This requires a policy and regulatory change within the NFMA. At best, MIS should be confined to ecological indicators. Even if MIS use continues, elk should not be classified as a MIS; they are a poor choice due to adaptations to a wide variety of habitats.
2. Elk management should emphasize development of vulnerability and mortality models as opposed to habitat effectiveness models and guidelines. These models should be developed over a wide array of habitats and different hunter densities to be most effective.
3. To manage forest-dwelling neotropical migrants, conservation of riparian habitats and a landscape approach to analyzing and conserving forested habitats should be emphasized. Research and monitoring efforts focused on effects of forest fragmentation in the West should be expanded. Extensive wilderness areas in Idaho should be taken advantage of for control areas in research and monitoring programs. A landscape approach emphasizing maintenance of natural patterns and process through such actions as aggregated tree harvest units, snag and woody debris retention, and prescribed fire should be strongly considered. Tools such as GIS and gap analysis will be invaluable in landscape-level approaches. Attention should also be given to silvicultural techniques at the stand-level of management. Thompson et al. (1993) provide a management framework from the landscape to stand levels.
4. IDFG should expand its nongame expertise to have a greater impact on wildlife management on USFS and other lands. Innovative funding approaches to support nongame management efforts are critical. Increased cost-sharing programs with federal and private partners (e.g., timber industry), legislative efforts tied to natural areas, watchable wildlife or outdoor recreation initiatives, and grants from private foundations and corporations for specific nongame projects are but a few examples of possibilities.

5. IDFG should try to break down barriers and distinctions between "game" and "nongame" biologists, a segregation which is a distraction in focusing on a goal of the conservation of biological diversity. Both IDFG and USFS staff need to move beyond traditional wildlife management and utilize new tools of conservation biology.
6. IDFG and USFS personnel should improve communication through more frequent and informal meetings at the regional and forest-level. Interagency task forces which search for a consensus in problem definition and problem solution should be used in tackling complex problems as the decline of neotropical migratory landbirds. Both agencies need to make efforts to better understand the mandates and limitations of each other's organization.

ACKNOWLEDGMENTS

Many of the ideas for this paper originated in conversations with fellow IDFG biologists and colleagues on National Forests in Idaho. Many thanks are due to IDFG staff Lonn Kuck, Jim Hayden, Jay Crenshaw, Chuck Harris, Craig Kvale, Carl Anderson, Ted Chu, Lou Nelson, Carl Nellis, and Wayne Melquist. USFS personnel whose thoughts helped develop our thinking in this paper include Paul Harrington, Dan Davis, Steve Blair, Floyd Gordon, John Erickson, Howard Hudak, Dave Reeder, and Dick Wenger. Reviews by Sallie Hejl, Peter Landres, Alan Christensen, Vicki Saab, and Tim Clark considerably improved earlier drafts of this paper.

LITERATURE CITED

Aney, W. C. 1984. The effects of patch size on bird communities of remnant old-growth pine stands in western Montana. M.S. thesis, Univ. Montana, Missoula. 98 pp.

Arrandale, T. 1990. The game is changing in the wild West. High Country News 22:21.

Boss, A., M. Dunbar, J. Gacey, P. Hanna, and M. Rath. 1983. Elk-timber relationships of west-central Idaho. USDA Forest Service, Boise National Forest, Boise.

Caicco, S., B. J. M. Scott, B. Butterfield, and B. Csuti. In review. A gap analysis of the protection status of actual vegetation of the state of Idaho using geographic information system technology.

Code of Federal Regulations. 1985. 36 CFR Chapter II 219.19:64

Christensen, A. G., L. J. Lyon, and T. N. Lonner (compilers). 1991. Proceedings of elk vulnerability - a symposium. Montana State Univ., Bozeman. 330 pp.

Dery, D. 1984. Problem definition in policy analysis. Univ. Kansas Press, Lawrence. 145 pp.

Edwards, T. C. 1989. The Wildlife Society and the Society for Conservation Biology: strange but unwilling bedfellows. Wild. Soc. Bull. 17:340-343.

General Accounting Office. 1991. Wildlife management: problems being experienced with current monitoring approach. Report to the Secretary of Agriculture, RCED-91-123.

Groves, C. R. and W. E. Melquist. 1991. Nongame and endangered species wildlife management plan 1991-1995. Idaho Dept. Fish and Game, Boise. 163 pp.

Hejl, S. J. 1992. The importance of landscape patterns to bird diversity: a perspective from the Northern Rocky Mountains. Northwest Environmental Journal 8:119-137.

Idaho Department of Fish and Game. 1991. A vision for the future:policy plan 1990-2005. Idaho Department of Fish and Game, Boise. 33 pp.

Keller, M. E. and S. H. Anderson. 1992. Avian use of habitat configurations created by forest cutting in southeastern Wyoming. Condor 94:55-65.

Kessler, W. H., H. Salwasser, C. W. Cartwright, and J. A. Caplan. 1992. New perspectives for sustainable natural resources management. Ecol. Applications 2:221-225.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, and R. C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100:272-284.

Landres, P. B., J. Verner, and J. W. Thomas. 1988. Ecological uses of vertebrate indicator species: a critique. Cons. Biol. 2:316-328.

Leege, T. 1984. Guidelines for evaluating and managing elk summer habitat. Wildlife Bulletin No. 11, Idaho Department of Fish and Game, Boise. 38 pp.

Losensky, B. J. 1991. Biodiversity analysis for Buck-Little Boulder Project Area. Unpublished report on file at: USDA Forest Service, Bitterroot National Forest, Sula Ranger District, Sula MT. 4 pp.

Lyon, L. J. 1983. Road density models describing habitat effectiveness for elk. J. Forestry 81:592-594.

Lyon, L. J. and A. G. Christensen. 1992. A partial glossary of elk management terms. USDA Forest Service General Technical Report INT-288, Intermountain Research Station, Ogden.

Lyon, L. J., T. N. Lonner, J. P. Weigand, C. L. Marcum, W. D. Edge, J. D. Jones, D. W. McCleerey, and L. L. Hicks. 1985. Coordinating elk and timber management. Final report of the Montana cooperative elk-logging study for 1970-1985. Mont. Dept. Fish, Wildl., and Parks, Bozeman. 53 pp.

Marcum, C. L. 1975. Summer-fall habitat selection and use by a western Montana elk herd. Ph.D. thesis, Univ. Montana, Missoula. 188 pp.

Marcum, C. L. 1976. Habitat selection and use during summer and fall months by a western Montana elk herd. Pages 91-96 *in* Proc. Elk-logging-roads Symposium, Univ. Idaho, Moscow.

Noss, R. F. 1985. On characterizing presettlement vegetation: how and why. Natural Areas Journal 5:5-19.

Noss, R. F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Cons. Biol. 4:355-364.

Ohmart, R. D. and B. W. Anderson. 1986. Riparian habitat. Pp. 169-199 *in* A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart (editors), Inventory and Monitoring of Wildlife Habitat. U. S. Govt. Printing Office, Washington D. C.

Overbay, J. C. 1992. Letter of July 20, 1992, from USDA Forest Service to Max Peterson, International Association of Fish and Wildlife Agencies.

Peek, J. M., M. D. Scott, L. J. Nelson, and D. J. Pierce. 1982. Role of cover in habitat management for big game in northwestern United States. Trans. 47th N. A. Wildl. Nat. Res Con. 46:363-373.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. Gen. Tech. Rep. RM-217. Ft. Collins, CO:U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 90 p.

Rothstein, S. I., J. Verner, and E. Stevens. 1984. Radio-tracking confirms a unique diurnal pattern of spatial occurrence in the parasitic Brown-headed Cowbird. Ecology 65:77-88.

Saab, V. and C. Groves. 1992. Idaho's migratory landbirds: description, habitats, and conservation. Nongame Wildlife Leaflet No. 10, Idaho Wildlife 12:11-26.

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'erchia, T. C. Edwards, J. Ulliman, and R. G. Wright. 1993. Gap analysis:a geographic approach to protection of biological diversity. Wildl. Monog. No. 123:1-41.

Sharp, L. A. and K. D. Sanders. 1978. Rangeland resources of Idaho. Idaho Rangeland Committee Misc. Publ. No. 6, Univ. Idaho, Moscow. 74 pp.

Skovlin, J. M. 1984. Impacts of grazing on wetlands and riparian habitat: a review of our knowledge. Pp. 1001-1104 *in* Committee on Developing Strategies for Rangeland Management. National Resource Council, NationalAcademyofSciences,WestviewPress,BoulderCO.

Sorg, C. F. and L. J. Nelson. 1986. The net economic value of elk hunting in Idaho. USDA Forest Service Resource Bulletin RM-12, Rocky Mountain Forest and Range Experiment Station, Fort Collins.

Stephens, D. A. and S. H. Sturts. 1991. Idaho bird distribution: mapping by latilong. Special Publication No. 11, Idaho Museum of Natural History, Pocatello. 76 pp.

Swanson, F. J. and J. F. Franklin. 1992. New forestry principles from ecosystem analysis of Pacific Northwest forests. Ecol. Applications 2:262-274.

Teer, J. G. 1989. Conservation biology - a book review. Wildl. Soc. Bull. 17:337-339.

Terborgh, J. 1989. Where have all the birds gone? Princeton Univ. Press, NJ. 207 pp.

Thomas, J. W. (editor). 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. Agricultural Handbook No. 533, USDA Forest Service. 512 pp.

Thomas, J. W. 1991. Elk vulnerability - a conference perspective. Pp. 318-319 *in* A. G. Christensen et al. (compilers), Proceedings of elk vulnerability - a symposium. Montana State Univ., Bozeman.

Thomas, J. W., E. D. Forsman, J. B. Lint, E. C. Meslow, B. R. Noon, and J. Verner. 1990. A conservation strategy for the Northern Spotted Owl: report of the Interagency Scientific Committee to address the conservation of the Northern Spotted Owl. U. S. Govt. Printing Office, Washington, D.C.

Tisdale, E. W. 1986. Native vegetation of Idaho. Rangelands 8:202-207.

Unsworth, J. W., L. Kuck, M. D. Scott, and E. O. Garton. 1993. Elk mortality in the Clearwater drainage of north-central Idaho. J. Wildl. Manage. 57:in press.

Vickerman, S. 1987. Comparison of state nongame programs. Audubon Activist (p.16) March 1987.

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1214.

Integration of Neotropical Migrant Bird Conservation into Other Resource Management Activities in the Midwest[1]

Information Needs for Forest Songbirds: The Minnesota Approach

Lee A. Pfannmuller[2]

In the Upper Great Lakes region, integration of wildlife management concerns and forest management practices has focused principally on game species, a select number of rare species, and a few other special interest species (e.g., cavity nesters). Although they comprise from 60-70% of the forest vertebrates, forest birds have received little management attention. If efforts to integrate the diverse needs of forest birds with other forest management practices are to succeed, traditional, single-species approach to forest wildlife management will need to be reexamined. Effective conservation of the region's diverse forest bird resource will depend instead, upon a landscape approach to forest management.

In 1992, a unique landscape project focusing on forest bird conservation began in Minnesota. The project is part of a new integrated resource management initiative launched by the Department of Natural Resources that is dedicated to integrating resource management activities across disciplinary boundaries and land ownership boundaries. Supported by a broad coalition of public and private partners, Minnesota's Forest Bird Diversity Project is designed to maintain the forest's rich diversity of birds while accommodating sustained resource utilization. Nationwide concern about the plight of forest birds, coupled with a significant increase in timber harvest levels in the State's northern region, prompted the project's initiation. It officially began January 1, 1992, with an appropriation of $300,000 from the State Environmental Trust Fund contingent on raising an additional $200,000 by January 1992. The match was successfully secured, providing full support for the project through June 1993. Preliminary approval to extend the project an additional two years beyond this date, with another $500,000 appropriation, was obtained this past July.

There are three major components to the project. The first component is directed at collecting data on Minnesota's forest birds. At its core is the design and implementation of a monitoring program that will extensively augment Breeding Bird Survey routes in Minnesota's northern forest region and provide more detailed information about the regional distribution and abundance of forest birds. Sampling is done at nearly 1,200 off-road point counts located in three large study regions: the Superior National Forest, the Chippewa National Forest, and the St. Croix River Valley. Each point is sampled for 10 minutes, once during the breeding season. The project's second component utilizes Geographic Information System (GIS) techniques to correlate bird population data with regional forest cover and land use information and to develop predictive models that assess the impact of future forest change. Recent satellite imagery will provide the forest cover information. Finally, as the project's third component, the knowledge gathered in the field and through modelling exercises will be applied to development of educational and management tools that integrate diverse habitat needs of forest birds.

A project of this scope is predicated on successful partnerships and, indeed, they have been key throughout the design and implementation stages of Minnesota's initiative. The Forest Bird Diversity Project is directed by an interagency steering committee and is supported by a broad coalition of nearly 35 Federal and State resource agencies, academic institutions, private foundations, conservation organizations, and private individuals.

---

[1] *Four case studies were presented to demonstrate how neotropical migrant bird conservation is being integrated into other resource management activities in the Midwest.*

[2] *Minnesota Department of Natural Resources, Box 25, DNR Building, 500 Lafayette Road, St. Paul, Minnesota 55155.*

Integrated Resource Management for Grassland Birds In Wisconsin

Gerald Bartelt[3]

The Wisconsin Department of Natural Resources (WDNR) will spend $12,000,000 over 10 years (1990-2000) restoring wildlife habitat in a 217,000-ha (838 square-mile) intensively farmed area in south-central Wisconsin to reverse the decline of grassland bird species, some of which are neotropical migrants. The management effort will focus on restoring 4,450 ha of wetlands and establishing 15,620 ha of grass cover on private lands. A Geographic Information System (GIS) database is being developed to assist wildlife managers in effectively siting habitat prescriptions and integrating efforts of local, State, and Federal conservation programs. Habitat guidelines for 14 species of grassland birds are being translated into computer models. The models will be used with the GIS data layers to identify where integrated management efforts will be most efficient. GIS data layers of land cover from Landsat Thematic Mapper satellite data and wetland inventories of WDNR and U. S. Soil Conservation Service will be used in wildlife modelling. A soils data layer will help locate hydric soils for wetland restoration and xeric soils for dry prairie management. Land ownership data from tax listing departments in four counties will aid in identifying which landowners to contact for participation in conservation programs. Data on land management and Federal easements (i.e., Conservation Reserve Program) provided by the U. S. Agricultural Stabilization and Conservation Service will assist in integrating grassland restoration efforts. The WDNR Natural Heritage Inventory, an extensive database on the locations of rare plants and animals, will be used to advance management for rare plants and animals. Historic land cover for the area from the 1830's (presettlement vegetation) and the 1930's (still abundant grassland birds) will be compared to the desired land cover in the 1990's. Use of a GIS will allow the most efficient placement of grassland habitat within this area and will integrate the WDNR program with other local, State, and Federal conservation programs.

An integrated approach is being used by the WDNR, Wisconsin Department of Agriculture, University of Wisconsin, and private agriculturists to identify ways of adapting current or future agricultural practices to benefit grassland birds. An interagency group has been formed with expertise in agronomy, agricultural economics, sustainable agriculture, nonpoint pollution, wildlife management and research, private lands management, and farm management. The approach taken is to identify habitat requirements for each grassland bird species. A complementary database of habitat characteristics is being compiled for conventional and alternative agricultural practices. The two databases will then be integrated to identify potentially good habitats for each bird species and to point out limitations of cropping systems. From these results, modifications of existing cropping systems and development of new systems will be suggested. Modifications to existing cropping systems or development of new cropping systems will be tested for their agronomic, economic, and wildlife habitat effectiveness. Results will be communicated to the public through farm field days, extension publications, and WDNR Private Lands program. Research on the benefits of short-term rotational grazing to grassland bird productivity will begin in Spring, 1993.

Integration of Neotropical Migrant Birds Into Natural Resource Planning and Research in Missouri

Brad Jacobs[4]

Missouri is a diverse State located between the tallgrass prairie and the eastern deciduous forest. Its varied landscape includes extensive forest and spring-fed rivers in the Ozarks, native prairie grasslands, wetlands, baldcypress swamps, and extensive cropland and pastures. The Missouri Department of Conservation, charged with conserving the forest, fish, and wildlife of the State, is developing a long-term, ecologically-based, regional planning process. An ecological classification system will provide a common language for agencies to communicate effectively. Based on the potential natural vegetation of Missouri, inventory efforts will focus restoration of natural ecosystems on the most suitable areas. The planning process will equally rely on a State recreation plan as well as provide for sustainable-use commodity production.

[3] Wisconsin Department of Natural Resources, 1350 Femrite Drive, Monona, Wisconsin 53716.

[4] Missouri Dept. of Conservation, P.O. Box 180, Jefferson City, Missouri 65102.

The Missouri Ozark Forest Ecosystem Project (MOFEP), a cooperative ecosystem research effort, studies the pre- and post-treatment conditions related to even- and uneven-age forest management. MOFEP and other large-scale projects will help formulate management guidelines for the future.

A Statewide communication network coordinates and facilitates cooperative biodiversity efforts in Missouri. Initially, a task force published an excellent book, "The Biodiversity of Missouri", to guide future discussions. A State biodiversity Coordinating Committee, made up of representatives of many agencies, will act as a forum for joint and parallel planning efforts. Within the Department of Conservation, a task force has been set up to act as a contact point as well as to monitor the biodiversity management programs within the Department.

The Missouri Working Group on Neotropical Migrant Birds, associated with the Midwest Working Group on Neotropical Migrant Birds, is composed of two members each from the Department of Conservation, University of Missouri, U. S. Forest Service, and U. S. Fish and Wildlife Service. This working group will propose projects for neotropical migrants as well as serve as a resource to the Biodiversity Coordinating Committee.

Landscape Scale and Pattern - Implications for Management of Neotropical Migrant Birds and Forest Openings in the Hoosier National Forest, Indiana

Monica J. Schwalbach[5]

Questions of ecological representativeness, abundance, quantity, and quality are addressed in different ways at landscape, community, and population levels. Each level is tied together functionally; ecological processes are influenced by interactions within and between levels. In this presentation, I illustrate how knowledge of landscape patterns at several scales can help guide management decisions for community and species conservation on the ground.

Large areas of continuous forest are lacking in Indiana. Hoosier National Forest (NF) occurs in a portion of the State that has the largest remaining patches of forest in closest proximity. Still, from a landscape perspective, much of Hoosier NF is comprised of numerous small patches of forest rather than big blocks. The exception to this general pattern is the Pleasant Run Unit, where a relatively large, continuous forest area exists. This is of particular significance regionally as such large forest patches, and species associated with them, are extremely limited.

Comparisons of habitat and community structure across the landscape can provide meaningful insights for management. For example, the Pleasant Run Unit has larger patches of continuous forest than other units. Pleasant Run also has more interior forest (defined here as forest areas 300 m or more from a forest/non-forest edge). Forest birds appear to respond to these large-scale differences in habitat geometry. Some species, like Red-eyed Vireos, are much more abundant in the Pleasant Run Unit than other areas of Hoosier NF.

Opportunity Area 4 (OA 4) occurs as a transition zone between a largely forested area to the north, and more open, agricultural lands to the south. Approximately 74% of the area is forested, 12% is shrubby or herbaceous open land, and 12% is cropland. One third of the forested area is considered to be interior forest. This interior forest contributes to the large, continuous patch of forest in Pleasant Run.

OA 4 occurs in an area of Hoosier NF that allows maximum flexibility in vegetative management. It also allows for development and maintenance of forest openings and early successional habitat. Considering the landscape context of OA 4 and management concerns for several conservative and rare forest bird species, we delineated a Continuous Forest Emphasis Area and an Openings Emphasis Area in the OA. Forest management in the Continuous Forest Emphasis Area will enhance the character of the large patch of continuous forest in the Pleasant Run Unit; openings management will be restricted. In the Openings Emphasis Area, management will focus on development of mosaics of openland habitat. Considerations of pattern and scale at landscape, community, and population levels will be integrated into openings management.

[5] *Wayne-Hoosier National Forest, 811 Constitution Avenue, Bedford, Indiana 47421.*

Summary of Southeastern Group Breakout Sessions

Bob Ford[1] and Charles P. Nicholson[2]

The breakout sessions held by the southeastern representatives at the *Partners In Flight* meeting in Colorado were extremely well attended. Most states were represented, as well as several federal agencies (including USFS, USFWS, TVA, EPA), and non-government organizations. Two sessions were held, one to discuss a strategy of management by physiographic province, the other to discuss integrated management approaches.

The first session was held to discuss the species prioritization scheme for physiographic provinces in the southeast and to transfer to a strategy for formulation of habitat management opportunities (as developed by Hunter and Pashley in the southeast and published in these proceedings). There was general agreement that the strategy was fundamentally good and workable for public land managers. Topics of discussion included 1) need for specific stand management options for groups of species, 2) better integration of migratory bird recommendations into existing management guidelines for game species, and 3) permanent funding source to pay for active management and monitoring programs.

Physiographic province coordinators within the Southeastern Management Working Group were identified and introduced to the group. The agenda and topics for the southeastern meeting in Memphis, Tennessee this November were discussed.

As a further topic of concern, Breeding Bird Survey results need to be used carefully for guiding management by resource professionals, but not to exaggerate population declines to imply a "crisis" situation. It was generally agreed that use of "statistically significant" is not always appropriate, but use of the terms "definite declines" (significant) and "possible declines" (non-significant) would be generally understood by both professionals and lay people.

The second session was held to discuss potential management options for conservation of neotropical migrants and impacts of various silvicultural practices on these species. The group generally agreed that, for some areas where commercial timber production on a rigid rotation is a top priority, the best management may be relatively large clear cuts as opposed to a group selection approach with many small patch cuts. This may be recommended considering that the same amount of timber is to be harvested regardless of forestry practices used, that migrants requiring early successional habitats may be area sensitive as are forest interior species, and that the longevity of interior forest roads will be shorter using clear cuts when compared with group selection, where such roads will be more numerous and permanent. However, there was a general consensus that specific recommendations will vary between physiographic provinces and among forest types depending on local land management objectives.

[1] *Tennessee Conservation League, 300 Orlando Ave., Nashville, Tennessee 37209.*

[2] *Tennessee Valley Authority, 17 Ridgeway Road, Norris, Tennessee 37828.*

Integrated Wildlife Management: Western Working Group

Moderated by Beaumont C. McClure[1]

This session, attended by 90-100 people, focused on current wildlife management practices in the West, how they conflict with neotropical migratory bird conservation, and possible solutions for resolving these conflicts.

About 20 minutes were devoted to "brainstorming", where the audience identified 17 reasons why conflicts were occurring. They then voted on their two top priorities; the following four conflicts, listed in order of concern, received the most votes.

- **Lack of commitment by agencies to incorporate neotropical migratory birds in current wildlife management practices.** Game species receive most attention even though neotropical migratory birds may be better indicators of whether ecosystem goals are being met. Several people pointed out that this concern is a generalization, and that even though this is a problem, there are specific instances where neotropical migratory birds are being given due consideration.

- **Lack of time and money to do the work that needs to be done.** There is a great interest and enthusiasm in neotropical migratory bird conservation, but actions are limited by lack of time and money.

- **Continuing emphasis on single-species management**, and a failure by agencies to recognize the need to manage functions and processes of entire ecosystems.

- **Lack of data on neotropical migratory birds and their habitats in the West.** Managers must continue to make resource management decisions on a daily basis, and the severe lack of data in the West means these decisions do not have the benefit of information that would indicate population trends, habitat needs, or other relevant facts.

[1]*Deputy State Director, Division of Lands and Renewable Resources, Arizona State Office, Bureau of Land Management,*

The audience then identified three possible solutions for resolving these four highest concerns. **First**, top concerns should be provided as feedback to signatory agencies and organizations in Partners in Flight. **Second**, more public support for Partners in Flight needs to be recruited. The informed public would then be expected to help generate funding source momentum and increased consideration for the program. **Third**, all Partners in Flight need to sell the benefits of neotropical migratory birds to management so priorities will change toward ecosystem management.

All concerns identified at the brainstorming session are listed below, along with a tally of votes.

43	Lack of agency commitment.
28	Species management instead of ecosystem management.
37	Time and funding limits.
25	Lack of data.
8	Political and economic conflicts.
3	Need to include industry and private groups at earliest stages of process/plan.
1	Public misperception that all wildlife are being managed.
	Lack of understanding of structure and function of NTMB communities.
	Failure to understand human demographics and impacts of NTMB needs.
	Need better tools to synthesize data for management.
	Lack of consistency among agencies.
	Failure of agencies to recognize relationships and information beyond their own boundaries when they are planning.
	Lack of training.
	Failure to determine whether a conflict exists between wildlife programs and NTMBs.
	Lack of implementation on the ground.
	Failure to have adequate data before planning.

*U.S. Government Printing Office: 1993 — 776-896/85048

NATIONAL AGRICULTURAL LIBRARY
1022343753

USDA policy prohibits discrimination because of race, color, national origin, sex, age, religion, or handicapping condition. Any person who believes he or she has been discriminated against in any USDA-related activity should immediately contact the Secretary of Agriculture, Washington, DC 20250.

NATIONAL AGRICULTURAL LIBRARY
1022343753