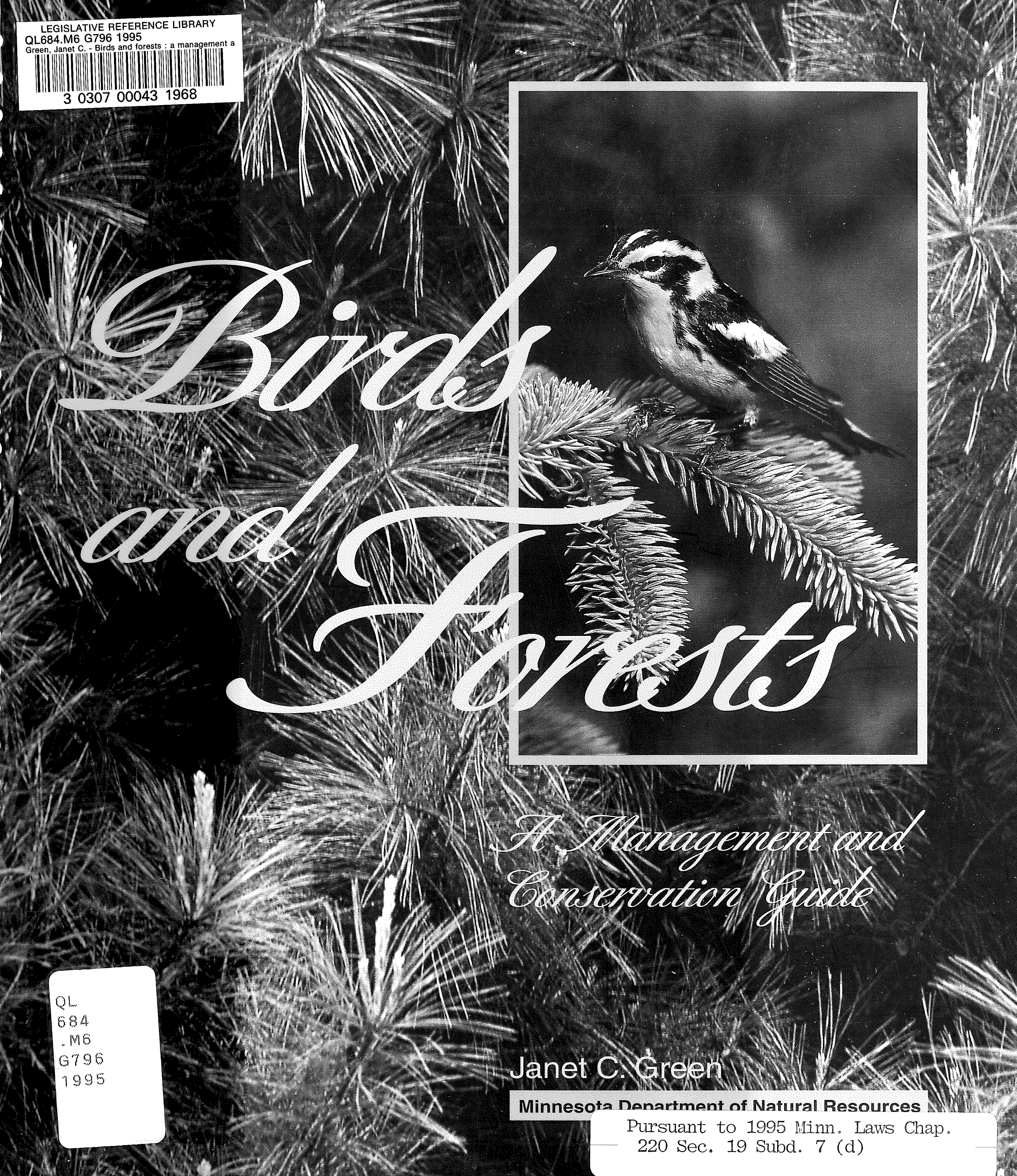

# Birds and Forests

## A Management and Conservation Guide

Janet C. Green

Minnesota Department of Natural Resources

# *Birds and Forests*

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Minnesota
DEPARTMENT OF NATURAL RESOURCES

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## Foreword

This book is about birds in Minnesota forests and how they respond to a changing landscape. For most people, birds are the most conspicuous part of the wildlife community. Their abundance and wide distribution in virtually all habitats coupled with songs and calls and colorful plumage make them obvious to the most unobservant citizens. Almost everyone has at least a passing interest in birds. They are excellent indicators of environmental health and are relatively easy to count and monitor compared to other vertebrates.

Forest managers are interested in birds because timber harvest and other silvicultural treatments can drastically affect habitat suitability over time and space. These changes can alter breeding success, species occurrences, and processes such as predation and parasitism. Understanding these relationships becomes a complex ecological problem because of the large number of species and their various habitat needs. Clear-cutting a stand of timber, for example, does not necessarily lead to a reduction in bird populations. In fact, just the opposite may occur depending on the site and the context of the surrounding landscape. What is assured, however, is a different mix of bird species after cutting, which will continue to change as the stand regenerates and matures.

Planners, biologists, foresters, and others charged with maintaining healthy forest ecosystems and at the same time providing forest products have a daunting task of integrating these often contradictory objectives into land management plans. The knowledge needed to document, evaluate, and mitigate the effects of forest management on birds is spread throughout countless books and periodicals, or may not be published at all.

This book brings it all together. Jan Green provides us with information and data to better understand the relationship between forest birds and forest management. She has combined a vast amount of scientific information with her personal knowledge of birds and forest management policy into a guide that is practical, credible, and, most importantly, understandable.

I can think of no one more qualified for such an undertaking than Jan Green. A renowned ornithologist with a lifetime of devoted study of bird life, she has been in the forefront of environmental and conservation issues in Minnesota. As an active participant and advisor, she has been effective in influencing and developing forest management policy in a balanced and straightforward manner. This book is a reflection of her thoughtful manner and inquiring mind and is worthy of a prominent place on your bookshelf.

John E. Mathisen
Wildlife Biologist
Chippewa National Forest
U.S. Forest Service (Retired)

## Preface and Acknowledgments

Birds and forests have long been a strong presence in my life. Forests came first, going back to when I played in the woods as a child in rural Maine; now I work in a house surrounded by a boreal hardwood-conifer forest in northern Minnesota. Birds came later, in early adulthood, but they soon provided the lens through which I approached the natural world both aesthetically and intellectually. As I fashioned an eclectic career from bird-watching to ornithology to environmental activism to environmental regulation to natural resource policy, birds and forests were always present to study and enjoy and to use in contemplating ecological ideas.

The opportunity to put what I had learned about birds and forests in an instructive package began when I became involved in the research and policy responses to concerns about increased timber harvesting in Minnesota. As worldwide demand for paper and other forest resources accelerated in the 1980s, Minnesota's forest products industry expanded its capacity. The annual statewide harvest is projected to double from the late 1970s (2.3 to 2.4 million cords) to the late 1990s (4.5 to 4.7 million cords). The implications of this increase for sustaining the ecological and economic attributes of the state's forests prompted the Environmental Quality Board to commission a large, multiresource study called the Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota (GEIS). I served on an advisory committee for that study from its inception in December 1989 to its completion in April 1994. That work was followed by my membership on a GEIS Implementation Strategy Roundtable whose charge was to recommend institutional structures that could accomplish the mitigation measures and policies the environmental study proposed.

Through the countless meetings of those two committees, I learned much about forestry—its programs, its practices, its policies, and its politics. In these discussions it was also apparent to me that information about wildlife, habitat, forest composition, and ecological processes was fragmented, often anecdotal, and definitely not integrated. Confusion about the diversity of forest birds and their ecological function was obvious to me. For example, the phrase "wildlife habitat" is often used as if it were just one component of the forest rather than a myriad of different environmental and ecological conditions, each one fitting a particular species. In contrast, the phrase "tree habitat" is never used because it is well understood that site conditions vary for different species. While the GEIS was under way, scientific investigations of forest-wildlife problems multiplied and I worked at keeping up with the pertinent literature in ornithology, wildlife management, landscape ecology, and conservation biology.

My forays into the literature were helped by a research project that also began in response to the expansion of the forest products industry. In 1992, with money from state, federal, and private sources, the Minnesota Department of Natural Resources and the Natural Resources Research Institute at the University of Minnesota, Duluth, began a long-term, cooperative research project called Minnesota's Forest Bird Diversity Initiative. I was involved in helping to provide political support from environmental organizations for the legislative funding and was on the steering committee that designed the study. Cooperative research plots have been established on lands managed by government (federal, state, and county), industry, and environmental learning centers.

This long-term research project has three major goals:

- The establishment of an extensive, long-term monitoring program designed to investigate the response of forest birds to regional land-use patterns,
- The utilization of a geographic information system (GIS) to spatially and temporally relate distribution and abundance of forest birds to forest landscape patterns, and
- The development of educational and management tools to promote the conservation of forest birds.

Long-term research means 10 to 15 years in this project; therefore, definitive answers to the questions of appropriate temporal and spatial patterns for the conservation of forest birds are not yet in hand. Meanwhile, exploration of these questions has heightened the understanding of several concepts and management practices as they relate to the diversity of birds dependent on forests and trees. Rather than waiting for management prescriptions to emerge from the research, the Forest Bird Diversity Initiative is committed to information transfer as a continuing educational process. I undertook the task of putting together what I had learned about birds and forests as part of that educational effort.

This guide brings together what is now known about forest birds in Minnesota, concepts that affect their populations, and some ideas for planning and practices to further their conservation. Birds here provide a lens, both for conservationists and managers, to view ideas about ecosystem function and biodiversity. In addition, birds serve as an excellent indicator of forest health. In Minnesota we are also given the opportunity, because of our extensive northern forests, to create management solutions that perpetuate our native bird populations and simultaneously provide forest products. The loss and fragmentation of forests elsewhere and the decline of many songbirds makes this a critical responsibility.

Many people helped in the production of this book. Crucial assistance was provided by my team of editors: Mary Keirstead, copy editor; Carol Pearson, managing editor; and Lee Pfannmuller, supervisor. They were a pleasure to work with, and they added immeasurably to the final product. I am very grateful for their efforts. Carol Pearson, besides managing all the production details, also organized the bibliography, secured the photographs, created the glossary and the index, put the appendixes into final form, and provided oversight in the drafting of the illustrations and maps; her tireless help was absolutely essential to the completion of this book. Mary Keirstead's fine editorial insights into language and organization made the text clearer to read and the arguments easier to understand. Lee Pfannmuller provided both an overall perspective on the guide's ultimate purpose and unwavering moral and fiscal support for its creation, which, if the truth be known, was originally her idea.

The high-quality book design and graphics are the work of graphic designer Beth Petrowske and graphic artist Tom Klein, both from the Minnesota Department of Natural Resources. The maps are the work of professionals at several laboratories: Tim Aunan at the Natural Resources Research Institute, University of Minnesota, Duluth; Al Epp of the Minnesota Department of Natural Resources; Norman Anderson at the Minnesota Land Management Information Center; and Alan Willis of the University of Minnesota Cartography Laboratory. Good maps and illustrations are essential tools in explaining wildlife-habitat concepts, and I appreciate their professional help. The bird and habitat photographs are the work of many photographers, who are credited on each photograph. These images help define birds and forests.

Critical reviews of the text were kindly provided by many researchers and managers. Their many suggestions both modified and sharpened my ideas and writing. Thanks go to Doug Anderson, JoAnn Hanowski, John Haufler, Katherine Haws, John Mathisen, David Mladenoff, Gerald Niemi, Dave Schad, Mary Shedd, Bill Wall, Ben Wigley, and Steve Wilson.

I would also like to acknowledge gratefully the funding from diverse sources that has supported the preparation and publication of this book. First and foremost, I thank the people of Minnesota for supporting Minnesota's Forest Bird Diversity Initiative. This publication is a product of that initiative. A major source of funds for the project and this publication was approved by the Minnesota Legislature, 1993 Minnesota Laws, Ch. 172, Art. 1, Sec. 14, Subd. 6(b), as recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund. Additional state support for the publication was provided by the Minnesota Department of Natural Resources, and federal support came from the U.S. Environmental Protection Agency and the U.S. Fish and Wildlife Service. Individual gift donations from hundreds of Minnesota citizens also contributed to the final publication. The interest and enthusiasm of each of these supporters for Minnesota's rich diversity of forest birds has made this publication possible.

Finally, I give my fullest appreciation to the constant encouragement of my husband, John Green, who has been my companion in the woods and my patron through life. His financial and intellectual support has allowed me to make my own career path through the groves of natural history research and natural resources policy.

Duluth, Minnesota
May 1995

# Birds and Forests

Chapter 1

# Introduction

## Purpose and Scope

As scientists and resource professionals learn more about the natural world, the job of managing natural resources for sustainable public uses and products becomes far more challenging. The ecosystems that produce commodities, amenities, and necessary environmental services, like clean air, water, and soil, are extraordinarily complex, and the resource base that supports human socioeconomic activity is ultimately finite. The challenge of managing forests and wildlife is heightened by the many points of view that enter the debate over how to manage these resources. The public is concerned about recreation, old-growth forests, neotropical songbirds, and biodiversity. Researchers focus on intimidating topics like disturbance regimes, landscape and microspatial heterogeneity, patch dynamics, and population viability. Land managers try to put evolving knowledge to work on the ground and to satisfy both ecological and socioeconomic realities.

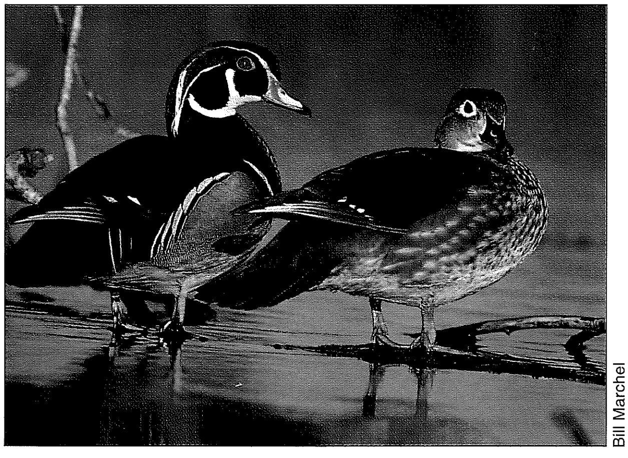
More and more land managers are turning to ecosystem-based management. This new approach is not a goal, but a method that seeks to integrate the best scientific understanding about all components of an ecosystem and to incorporate that knowledge into a wide framework of socioeconomic benefits and values. It is holistic, operates at multiple spatial and temporal scales, and is inclusive in its decision-making process. It provides both a daunting challenge and a tremendous opportunity as we enter a new century.

This guide is about birds and forests in Minnesota. Its purpose is to illuminate some of the issues involved in ecosystem-based management of forests and wildlife in Minnesota. Because birds are a diverse group of species, they offer a lens through which to examine the biodiversity of forest systems. Minnesota is fortunate in having diverse forests that possess the resilience and ecological integrity that natural systems need in the face of constant change. Using ecosystem-based management to maintain that biodiversity is the insurance for a sustainable future. To quote Aldo Leopold's telling phrase, "to keep every cog and wheel is the first precaution of intelligent tinkering" (Leopold 1966, p. 190).

Chapter 2 of this guide provides essential data and background about forest birds including distribution and abundance, migratory status, geographical patterns, rare species, and population trends. Chapter 3 discusses bird-habitat relationships at three spatial scales: stand, microhabitat, and landscape. The concepts of fragmentation, edge and area effects, and "interior species" are introduced in chapter 3. This information is followed by three chapters that provide suggestions for ways to incorporate the habitat needs of birds in ecosystem-based management plans. Chapter 4 discusses how to incorporate species information in management plans through inventories, monitoring, and establishing priorities for species. The advisability of using "indicator species" to monitor forest ecosystems is also explored. In chapter 5, landscape-level planning is discussed in relation to patch size configuration, fragmentation, conifer-dominated landscapes, contiguous mature forests, and riparian zones. Chapter 6 includes stand-level recommendations concerning plantations, berries and seeds, wildlife openings, and wildlife trees and residuals. None of these chapters gives what is sometimes called "cookbook" guidance; the situations are too complicated for that. Information is provided, however, that will give managers guidance in providing essential habitat for birds that need forests in many diverse ways.

Useful reference information is included in six appendixes. Appendix A brings together current information on the distribution and abundance by ecoregion of Minnesota's forest birds. Important life-history traits of forest-dependent birds are listed in appendix B. Appendix C shows the relative abundance of birds in 12 habitat types on the Chequamegon, Chippewa, and Superior National Forests. Appendix D explains the purpose and source of "management concern" lists developed by various agencies, and the information is compiled in a convenient table. The scientific names of birds mentioned in the guide are given in appendix E, and appendix F is a compilation of local and regional studies that are sources of lists of species for specific regions of the state.

Steve Wilson



Bill Marchel

Maslowski Photo

*The birds pictured here are only a small sample of the species that breed in Minnesota forests. American Woodcock (top), Wood Duck (middle), and Canada Warbler (immature).*

## Birds and Forests

Birds are an integral and also beautiful part of the mechanics of forest systems. To quote a recent headline to an article in the *New York Times* (Nov. 8, 1994, p. B11): "More than decoration, songbirds are essential to forests' health." Birds are also a major component of forest wildlife.

It is commonly recognized that forest management is also wildlife management. This idea is part of the definition of "forest resources," which in the Minnesota Forest Resources Management Act includes "wildlife habitat" and "rare and distinctive flora and fauna." The use of the term wildlife has expanded over time, first from an emphasis on game animals, then to all vertebrate species, and finally to acknowledgment that all wild animals, from microorganisms to warblers to eagles, constitute wildlife and that all are a necessary part of ecosystem function. Some definitions also include plants, which obviously are an integral part of ecosystems (see Hunter 1990). Forests are not static, and the processes that result in age and compositional change, whether they are produced by management actions or natural disturbance and succession, result in changes in wildlife populations.

Birds offer a useful approach to ecosystem-based management in Minnesota forests for several reasons. First, they are the most species-rich vertebrate group in forested areas. Statewide including all habitats, 64% of a total of 350 regularly breeding terrestrial vertebrate species are birds (Coffin and Pfannmuller 1988). In a subunit of the state, the heavily forested Superior National Forest (about 3 million acres), 155 resident birds (Green and Niemi 1980), 52 mammals (Collins et al. 1981), and at least 18 species of herpetofauna (M. Shedd, personal communication) occur in the mosaic of forest, wetland, lake, and open-country habitats (Figure 1).

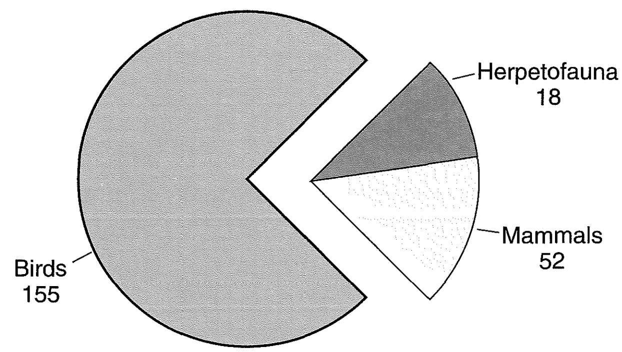
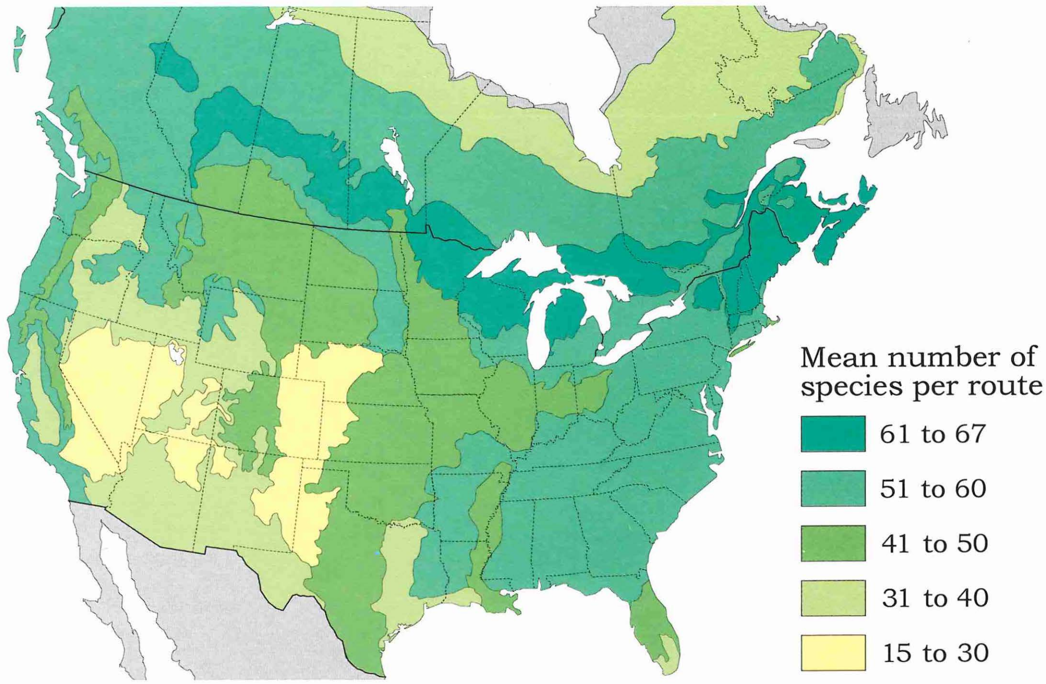



***Figure 1.*** *Vertebrate diversity in the Superior National Forest. Birds represent 69% of breeding vertebrate species in this heavily forested region. (Data from Green and Niemi 1980; Collins et al. 1981; M. Shedd, personal communication.)*

Minnesota's avian diversity during the breeding season is high not only in contrast to other vertebrate groups but also in comparison to other states and regions. This high diversity is evident in the results of the yearly continental Breeding Bird Survey organized by the U.S. Fish and Wildlife Service (Map 1). Minnesota is in the middle of a broad band of physiographic strata that stretch from the Maritime Provinces through northern New England and the Adirondack Mountains, and across the upper Great Lakes to the boreal mixed-wood of the Prairie Provinces in Canada. These regions have the highest bird species richness of any region north of Mexico,

*To keep every cog and*
*wheel is the first precaution*
*of intelligent tinkering.*
*— Aldo Leopold*



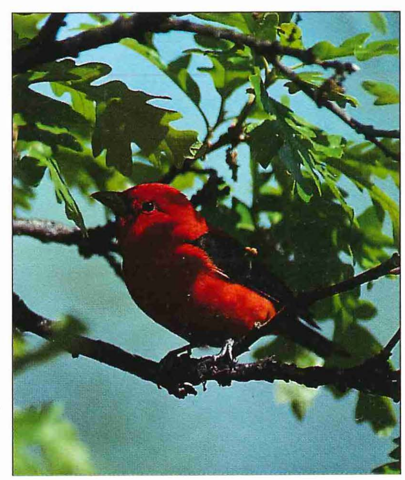

University of Minnesota Cartography Laboratory

***Map 1.*** *Breeding Bird Survey strata of diversity. Minnesota lies in a band of physiographic strata with the highest bird species richness of any region north of Mexico. (Adapted from Robbins et al. 1986.)*

averaging over 60 species for the 25-mile-long census routes (Robbins et al. 1986). This species richness reflects the high diversity of habitats in the ecotone between the northern boreal forest and the eastern deciduous forest. The open country, primarily agricultural lands, interspersed in these forests adds to the species richness.

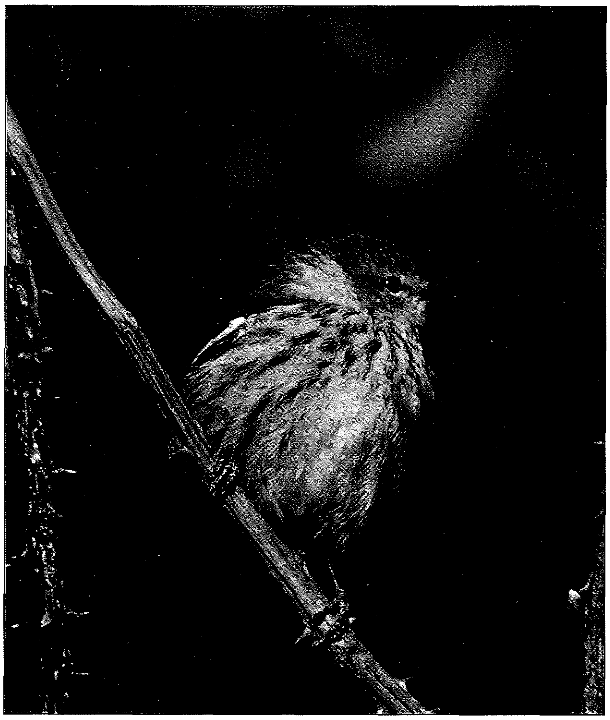
Monitoring these diverse populations of birds provides an index of habitat diversity for forest age, composition, and structure because each species has its own special combination of these habitat requirements. Thus, using the diversity of birds as a measure of ecosystem integrity allows for a measure of the diversity of forest conditions, including those that we do not yet understand, that can indicate that the ecosystem is varying within bounds that perpetuate species and communities. Changes in the diversity of birds can be an early warning that changes beyond the ecosystem's ability to adjust may be occurring.

The second reason for using birds in ecosystem-based



Lynn and Donna Rogers

*Birds are visually and aurally more conspicuous than other vertebrate groups and are consequently easier to study. Scarlet Tanager pictured.*



*The Cape May Warbler is one of four species of warblers that are very responsive to spruce budworm populations.*

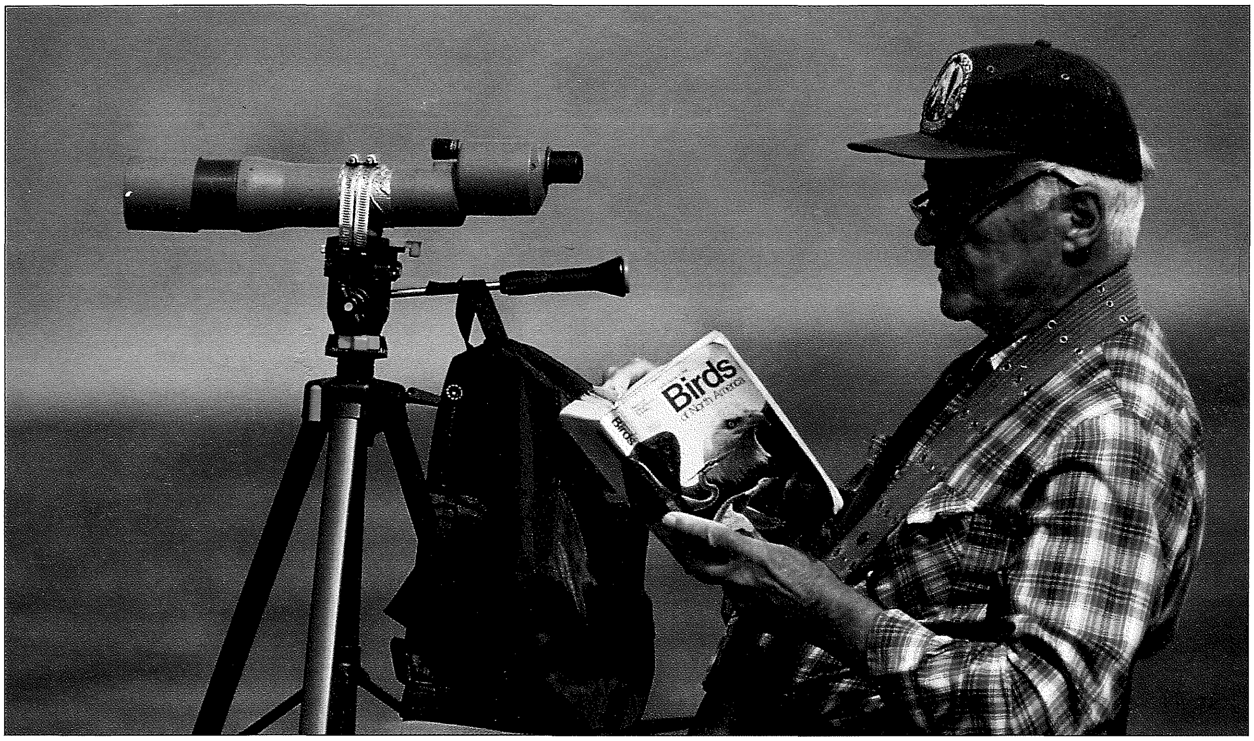
management is that they are visually and aurally more conspicuous than other animals and are consequently easier to study. Except for a few game mammal species, other forest vertebrates are not as well studied. Also, there is a rapidly expanding literature on breeding behavior, populations, and habitat relationships for birds throughout their ranges and increased monitoring information for Minnesota.

Third, birds have a vital, though poorly understood, role in the functioning of forested ecosystems. During the summer the diet of almost all forest birds is insects, primarily lepidopteran larvae in the northern forests. The role of birds as predators on forest insects has been studied most comprehensively with regard to one insect species, the spruce budworm (*Choristoneura fumiferana*). Forest songbirds, mostly warblers, have an effect in controlling populations of this insect at endemic levels but not at irruptive levels (Crawford and Jennings 1989); their predatory effect may also lengthen the time between budworm outbreaks (Holling 1988). Four species of warblers have been identified as very responsive to spruce budworm populations: Tennessee, Cape May, Bay-breasted, and Blackburnian. In the only study that put a dollar amount on the value of songbird predation on insects, the calculation showed a positive economic benefit: $1,820 per year per square kilometer ($4,720 per year per square mile) for predation by birds on the western spruce budworm (*C. occidentalis*) (Takekawa and Garton 1984).

Although budworms are the only insect pest that has been studied in any detail, bird predation probably affects the population regulation and the evolution of other insects as well (Holmes 1990a). A recent field exclosure experiment showed the indirect effect that predation by birds had on growth in an oak forest in Missouri, and the authors concluded that "over the long term observed declines in North American populations of insectivorous birds may reduce forest productivity because of potentially higher numbers of leaf-chewing insects and the concomitant negative effect on plant growth" (Marquis and Whelan 1994, p. 2007).

Birds are prey as well as predators; mammals, snakes, and other birds eat the eggs, young, and adults of many species. The part that birds play in food webs, in energy and nutrient cycling, and in the dissemination of seeds makes them an integral part of any forested ecosystem.

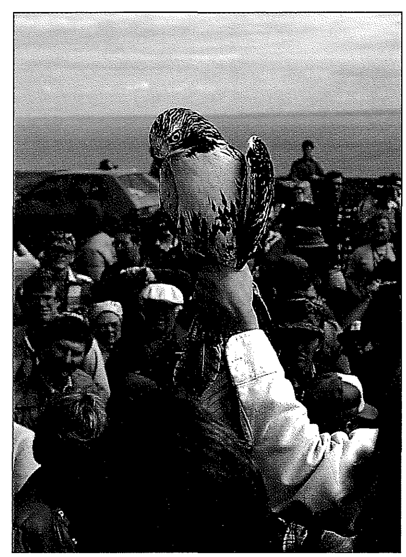
Finally, birds have a public constituency that is rapidly expanding. A 1991 U.S. Fish and Wildlife Service survey identified about 2 million people in Minnesota who either feed birds or are active bird-watchers (U.S. Fish and Wildlife Service




VIREO/A. Morris

*About 2 million people in Minnesota either feed birds or are active bird-watchers.*

*The widespread appreciation of birds adds understanding of and support for practices that consider all species. A holistic approach is the foundation for ecosystem-based management.*



Lynn and Donna Rogers

*A fascinated crowd looks on as Hawk Ridge naturalist Kim Eckert displays a captured Red-tailed Hawk.*

1993). According to a recent study prepared for a technical paper for the Generic Environmental Impact Statement (GEIS) on Timber Harvesting and Forest Management in Minnesota (Southwick Associates 1991), the economic gain from all wildlife photography, nature observation, and related travel in Minnesota is now about equal to that from more traditional hunting pursuits; a very high proportion of that economic activity involves birds. Because management as practiced by land-managing agencies includes a socioeconomic as well as a biological dimension, the widespread appreciation of birds adds understanding of and support for practices that consider all species. A holistic approach is the foundation for ecosystem-based management.

Birds are valuable and important for all of the reasons detailed in the preceding paragraphs—their diversity, the ease of studying them, their role in the function of forest ecosystems, and their popularity. Most important, however, is the unique species richness of birds in this region: diverse and viable forest bird populations are a key biological indicator of the health and stability of Minnesota's forest ecosystem.

Individual bird species have often been chosen as "management indicator species" by the U.S. Forest Service and other management agencies. The use of single species, however, to represent complex forest habitats has been repeatedly criticized (see discussion in chapter 4). What is needed is a comprehensive measure for assessing habitat qualities of forest ecosystems over a regional landscape. Forest birds provide just such a holistic measure of diversity because of the large number of species (150 statewide) and the wide variety of habitats they occupy, which define the whole range of forest and woodland conditions. Because of this diversity, it is impossible to consider habitat requirements species by species. Instead, the total species complement in a large area should be considered. The goal should be viable populations of all species, varying within sustainable limits.

We are presently in a time of transition from a species-centered approach to an ecosystem approach to management. Although the new emphasis is on ecosystems, most of what is known and quantified about birds is described by species. This paradox results from both our level of scientific understanding and the feedback loop between ecosystems and species composition. To quote a leading conservation biologist: "ecosystem protection reduces to species protection. This is hardly surprising, given that ecosystems are defined by their species" (Wilcove 1993, p. 327). We do know enough about ecosystems, however, to move toward incorporating ecological diversity at all scales in management and planning. The integration of species and ecosystem concepts should be accomplished with due consideration given to uncertainty and the need for future adaptation.

**Chapter 2**

# Distribution and Abundance of Forest Birds

The focus of this guide is forest/tree-dependent birds, that is, birds that depend either on forests, woodlands, or trees for some crucial part of their breeding cycle. Of the 413 species of birds that have been recorded in Minnesota, birds known to have bred in Minnesota number 255, but 5 of these are extirpated, and 23 are either sporadic or former breeders, leaving 227 regular breeding birds (Minnesota Ornithological Records Committee 1993). The 150 forest/tree-dependent species that are the focus of this guide are 66% of the total state breeding avifauna. These species are the regular, nesting species in all forest and brushland habitats. Brushland and peatland birds are included because these habitats are so intrinsically mixed with forests in many ecoregions. Three species usually associated with grasslands are included: Clay-colored Sparrow, Savannah Sparrow, and Bobolink. These birds are found in good numbers in brushy peatlands adjacent to the prairie in the northwestern and northern regions.

Given the size of the state, its inaccessible regions, the variety of habitats, and the large number of bird species, our knowledge of distribution and abundance is understandably incomplete. It would be ideal to have population data for each species that are mapped by density across the state, but those do not yet exist. Learning what birds occur when and where and thus expanding on the always imperfect current knowledge with personal observations adds the sense of discovery to the fascination of studying birds whether by birders, managers, or researchers.

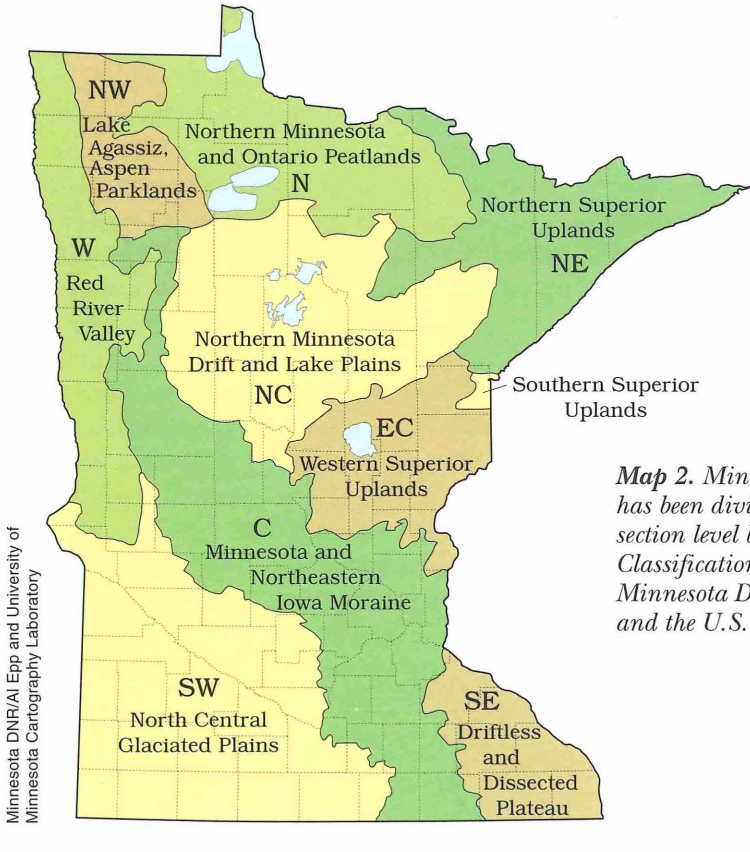
What we do have is a compilation of information, mostly collected by birders, that has been drawn together in a series of books published by the University of Minnesota Press: *The Birds of Minnesota* (Roberts 1932), *Minnesota Birds: Where, When, and How Many* (Green and Janssen 1975), and *Birds in Minnesota* (Janssen 1987). Appendix A, compiled from these books and updated with a few additional recent observations from the Minnesota Department of Natural Resources (DNR) County Biological Survey and the seasonal reports in *The Loon*, lists the 150 forest bird species and provides current information about their distribution during the breeding season, their abundance, and their migratory status. A basic list of bird species occurring in a particular area can be established by using this appendix. To compile a complete list of birds of a given area, including wetland and open-country species not covered by this guide, the references cited here should also be consulted.

The distribution information in appendix A is given by ecoregion. The state has been divided into nine ecoregions at the section level, using

*Table 1. Species by ecoregion*[a]

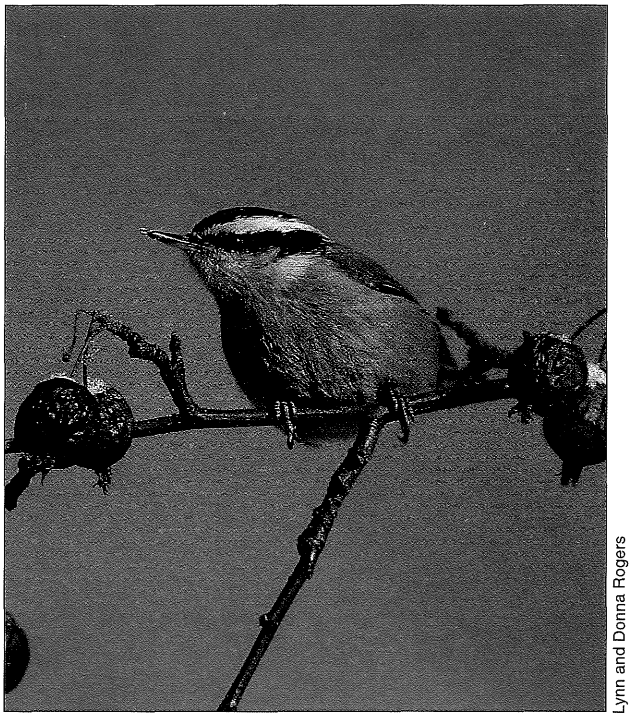
| Ecoregion | Number of species |
|---|---|
| NW (Lake Agassiz, Aspen Parklands) | 115 |
| N (N. Minnesota and Ontario Peatlands) | 115 |
| NE (Northern Superior Uplands) | 121 |
| NC (N. Minnesota Drift and Lake Plains) | 121 |
| EC (Western Superior Uplands) | 114 |
| C (Minnesota and NE Iowa Moraine) | 105 |
| SE (Driftless and Dissected Plateau) | 90 |
| SW (North-Central Glaciated Plains) | 64 |
| W (Red River Valley) | 66 |

[a]*The very small portion of the ecoregion called "Southern Superior Uplands" that touches Minnesota south of Duluth was not analyzed separately; the birds that occur there are included in the EC region.*




***Map 2.*** *Minnesota ecoregions. Minnesota has been divided into nine ecoregions at the section level based on the Ecological Classification System developed by the Minnesota Department of Natural Resources and the U.S. Forest Service.*

the Ecological Classification System developed by the Minnesota Department of Natural Resources and the U.S. Forest Service (Hargrave 1993; U.S. Forest Service 1993b; Map 2). For ease of reference, each ecoregion has been given a geographical designation using compass nomenclature. Table 1 lists the number of forest/tree-dependent species in each ecoregion.



Lynn and Donna Rogers

*Red-breasted Nuthatches are often attracted to feeders in wintertime and are a colorful addition to both rural and suburban backyards.*

## Migratory Status

The climate of Minnesota dictates that most birds, dependent as they are on insects for food, leave during the winter season. Breeding bird species can be divided into three groups according to the following standard classification:

- Permanent residents: occur in the state throughout the year, although some individuals may migrate within or outside the state,
- Continental (or short-distance) migrants: winter range is primarily north of the Mexican border, and
- Neotropical (or long-distance) migrants: winter range is almost entirely south of the Mexican border.

Of the 150 forest birds, 29 species (19.3%) are permanent residents, 56 species (37.3%) are continental migrants, and 65 species (43.3%) are neotropical migrants.

### Permanent Residents and Irruptive Winter Birds

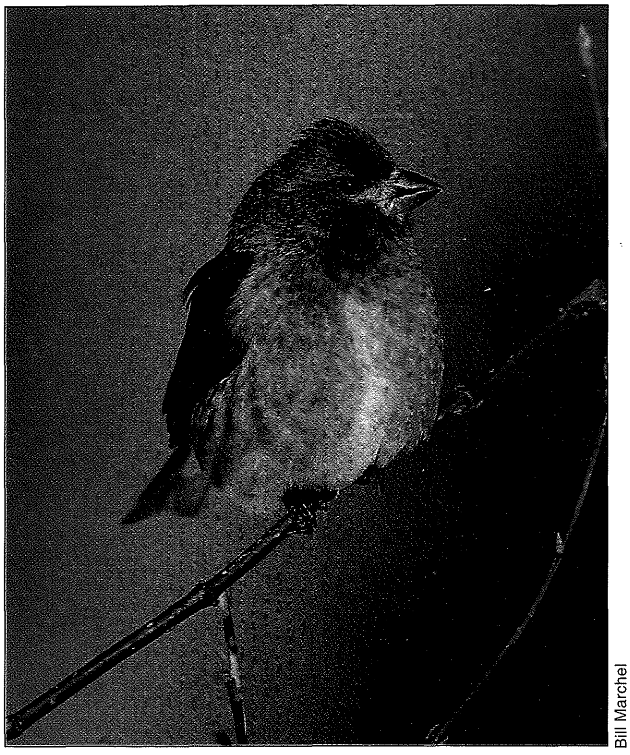
The few forest birds that are permanent residents are familiar to most people because they are easily attracted to feeders in wintertime. Jays, chickadees, nuthatches, woodpeckers, and some finches are a colorful addition to both rural and suburban backyards. The other permanent residents, which are several species of grouse and owls, are less familiar because they inhabit woodlands in relatively small numbers and are usually secretive in habits. In northern forests grouse will occasionally come to rural feeders, and owls sometimes appear in backyards where birds, mice, and shrews are tempting prey. Flushing a grouse or an owl from the winter woods always adds a thrill to any trek in the forest. Because winter is the crucial season for survival, these permanent residents have feeding and roosting strategies that allow them to live with snow and cold.

In most years these hardy species are joined by invasions of species from more northerly latitudes. Unlike the regular spring and fall movements of the continental and neotropical migrants, the winter invasions are erratic in both the numbers of birds and the species involved. Most of the irruptive species are boreal finches moving on a continent-wide scale to areas that have good sources of food. Seed-eating permanent residents also undergo erratic winter population fluctuations. Local populations can be increased by individuals from farther north, and in some years local populations also migrate. Without marked individuals it is difficult to trace the sources or destinations of these movements, but the population changes are relatively easy to spot. For example, Red-breasted Nuthatches, which breed in Minnesota's coniferous forests, can be numerous at feeding stations one year and completely absent the next. Irregular winter visitants and irruptive permanent residents are listed in Table 2.

Both seed-eaters and raptors are listed in Table 2 because both have a food base that is subject to extreme fluctuations. It is well known that the seed crops of trees have wide yearly variations and fail altogether in some years. These failures can occur on a continental scale in the boreal forest, forcing the species that depend on the seeds of pines, spruces, or birches to travel far and wide in search of food. Pine Grosbeaks and Common Redpolls are the most colorful invaders and become obvious in winter when they show up at feeders outside their breeding range.

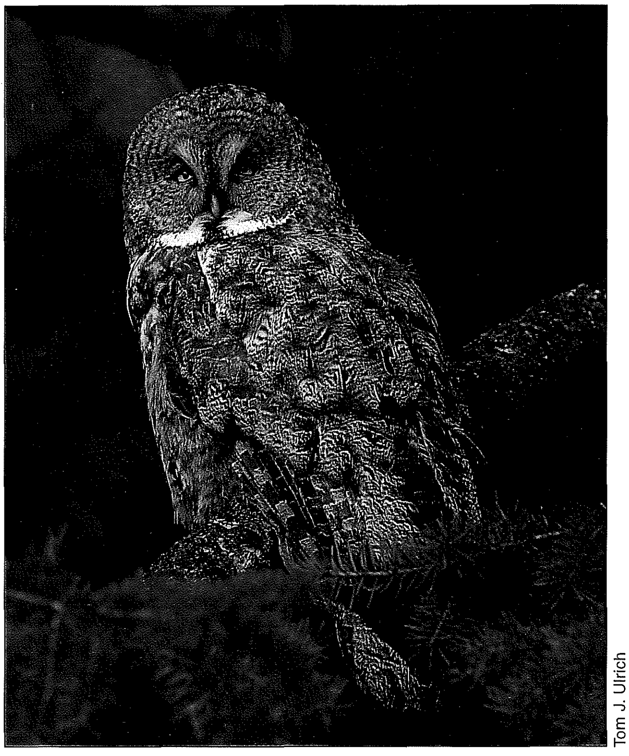
***Table 2.** Irruptive species present in winter*

| Continental migrants | Permanent residents | Winter visitants |
|---|---|---|
| American Robin | Northern Goshawk | Northern Hawk Owl |
| Cedar Waxwing | Great Gray Owl | Bohemian Waxwing |
| Purple Finch | Boreal Owl | Northern Shrike |
| American Goldfinch | Three-toed Woodpecker | Pine Grosbeak |
| | Black-backed Woodpecker | Common Redpoll |
| | Gray Jay | Hoary Redpoll |
| | Black-billed Magpie | White-winged Crossbill |
| | Boreal Chickadee | |
| | Red-breasted Nuthatch | |
| | Red Crossbill | |
| | Pine Siskin | |
| | Evening Grosbeak | |



Bill Marchel

*The Purple Finch is a continental migrant that occurs erratically in Minnesota in winter.*



Tom J. Ulrich

*Permanent residents like the Great Gray Owl undergo erratic population irruptions when their numbers are augmented by individuals from farther north.*

Tom Ala

*The Red Crossbill is a permanent resident that depends on conifer seeds in winter but, unlike other seed-eaters, is not attracted to feeders.*

Bill Marchel

*Populations of winter visitants like the Common Redpoll respond to variable food supplies in forested regions.*

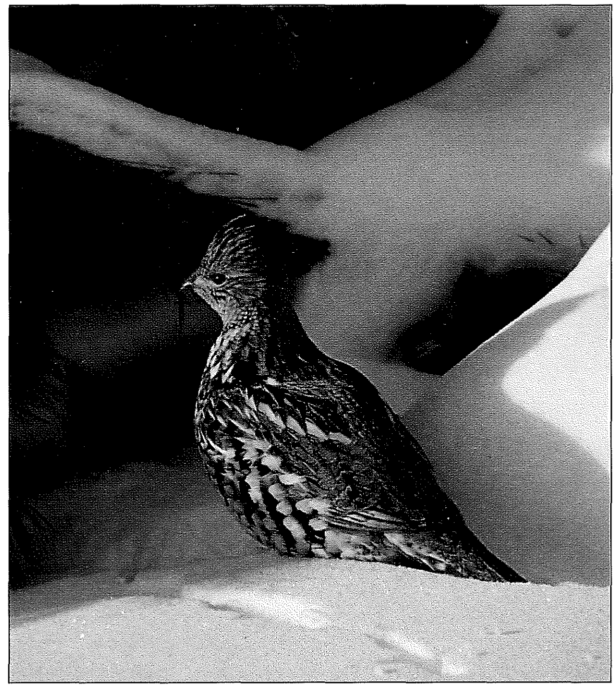

*Raptors are very dependent on the habitat conditions that produce their prey species. In these photos, a Northern Hawk Owl captures a vole.*

Raptors, mostly northern owls, that prey on vertebrates like mice and hares also are confronted with extreme fluctuations in their food base. Local resident raptors are scarce and rarely seen, but when northern individuals invade, they often are quite conspicuous because they are more numerous and are forced into open areas, like roadsides, in search of prey. One visitant, the Northern Hawk Owl, has occasionally been found nesting in the state after a winter invasion.

Four continental migrants are included in Table 2. Usually they migrate south of Minnesota but in some winters are found in good numbers if there is a good local source of food. The seed-eaters, Purple Finch and American Goldfinch, are most often seen at feeders, but their presence is very unpredictable. American Robins and Cedar Waxwings feed on berries and occur in flocks when there is a bumper crop of mountain ash berries. The winter visitants Bohemian Waxwing and Pine Grosbeak also depend heavily on mountain ash berries.

The irruptive species that feed on seeds (with the exception of crossbills) are often attracted to feeders, especially in rural areas. Feeding-stations also attract local populations of other permanent residents like woodpeckers, jays, and chickadees and probably contribute to their over-winter survival. However, the habitat surrounding feeder locations and the natural foods throughout the forest are still vital to the survival of resident and visitant birds in the winter woods.

Raptors that feed on vertebrate prey and species that consume berries are also very dependent for their survival in winter on the habitat conditions that produce these foods. Conifer cover is important for survival in winter for both residents and visitants alike. Hence, overall forest composition and structure is important for both breeding and wintering birds.



Stephen J. Maxson

*Conifer cover is extremely important for survival in winter for both residents and visitants alike. Ruffed Grouse pictured.*


*Both permanent residents and continental migrants like the Cedar Waxwing depend on seeds or winter fruits of northern trees and shrubs, principally pines, spruces, birches, and mountain ash.*

## Continental Migrants

A little over one-third of the forest birds in Minnesota are described as continental migrants (56 species). As a group these species winter anywhere from Minnesota to northern Mexico, although each species has a particular winter range. (The best range maps for both breeding and wintering distributions are in Peterson 1980.)

Waterbirds comprise one large group (11 species); they mostly winter either along the Gulf and Atlantic coasts (wading birds) or throughout the southeastern states (ducks). Both the Common Merganser and the Common Goldeneye are found in Minnesota in winter where there is sufficient open water and food. The other large group is raptors (9 species); their winter range encompasses most of the eastern states, including southern Minnesota for many species.

The blackbirds (3 species) and the sparrows (6 species) that are continental migrants are found throughout that same wide eastern range with the exception of Le Conte's Sparrow, which is more confined to the Gulf states. Several other blackbirds and sparrows that are defined as neotropical migrants also have part of their winter range in the southeastern states.

Although most of the songbirds that typify the north woods migrate to the tropics, a number of species from the same families winter in the forests of the southern United States. These species usually return earlier in the spring than other songbirds because they have a shorter distance to migrate. Included here are Eastern Phoebe, Brown Creeper, Winter Wren, Golden-crowned Kinglet, Ruby-crowned Kinglet, Hermit Thrush, Yellow-rumped Warbler, and Pine Warbler. Interestingly, several other north-woods breeding birds from the warbler and vireo families—Solitary Vireo, Nashville Warbler, Palm Warbler, Black-and-white Warbler, Ovenbird, and Wilson's Warbler—are defined as neotropical migrants because most individuals winter in the neotropical region, but some individuals in this group winter in the coastal fringe of the southeastern states.

### Neotropical Migrants

In Minnesota, 65 of the forest birds are species that breed in temperate or boreal forests and winter in the tropics. These birds are called neotropical migrants (Map 3). Neotropical migrants have received increased conservation attention because of declines in their numbers in the last three decades. The best evidence for that decline comes from radar studies of migrants crossing the Gulf of Mexico, which showed a 50% reduction in flights from the 1960s to the 1980s (Gauthreaux 1992; Figure 2). Trends from the Breeding Bird Survey in eastern forests also show declines (Robbins, Sauer et al. 1989), although the patterns for species in different geographical areas are not consistent (Askins et al. 1991). At this stage of our understanding of the problem, we can only say that there is evidence of decline and the causes are probably multiple. Exact causes of past population changes will never be determined because of the lack of good monitoring data. Identification of the problem, however, has stimulated research on songbirds, both residents and migrants. The increased research should lead to a better understanding of population trends, patterns, and dynamics and, as the data accumulate, to better management decisions.

Population declines among neotropical migrants have been attributed to multiple factors in the three geographical areas that are important to these birds: the wintering grounds, migration stopping places, and the breeding grounds. There is no question that forested habitat in tropical countries has declined, in some places dramatically (Map 4), as tropical forests are converted to


*Neotropical migrants that need undisturbed rain forest habitat on the wintering grounds are especially at risk.*

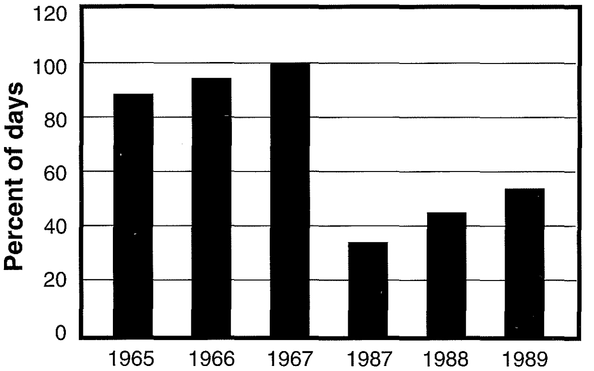
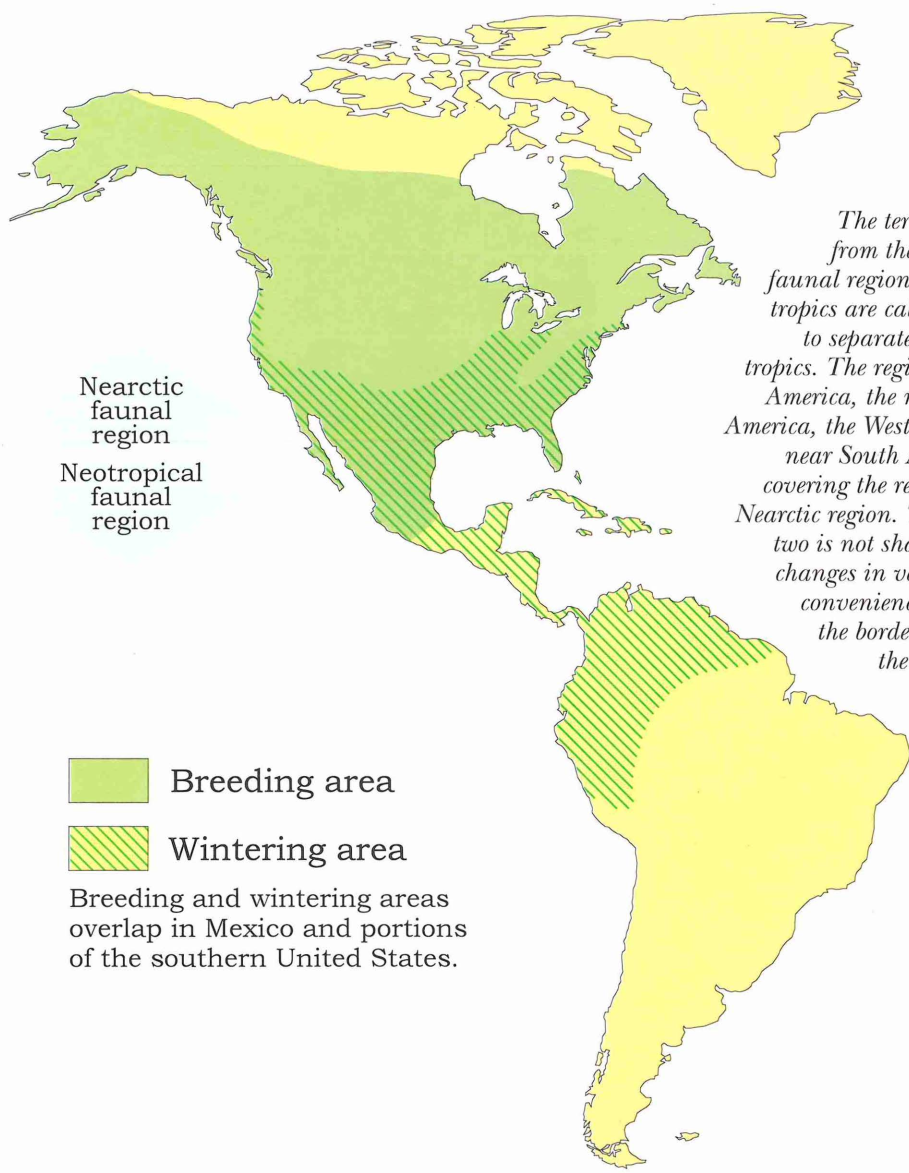



***Figure 2.*** *Trans-Gulf flights of migrating birds. Flights of migrant birds over the Gulf of Mexico have declined by almost 50% since the 1960s. (Data from Gauthreaux 1992.)*



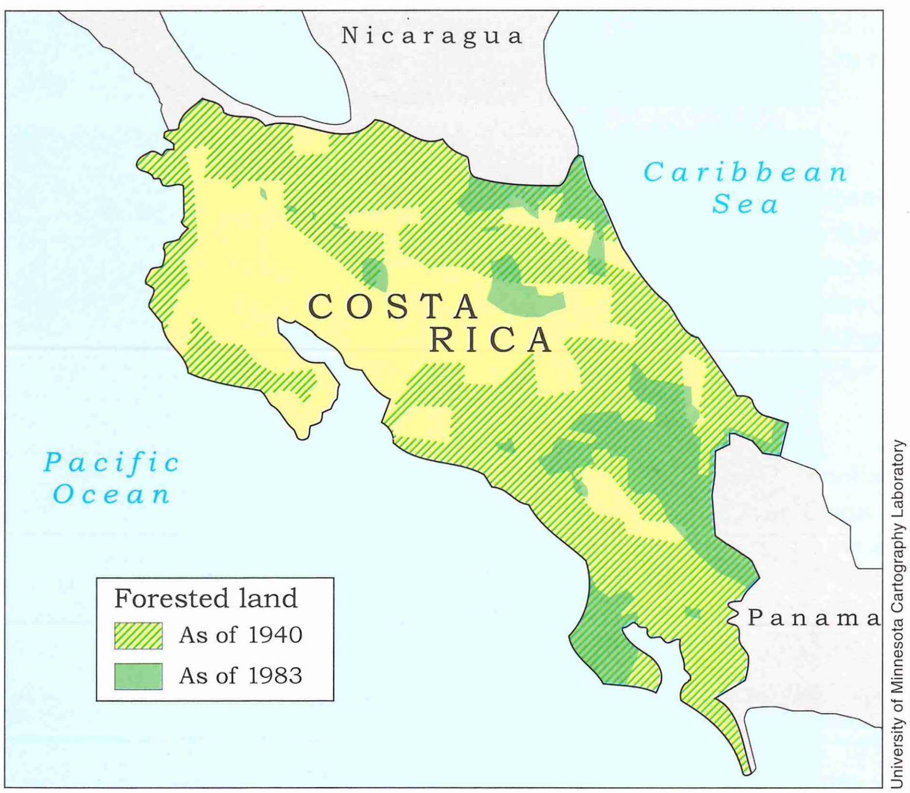

*The term* neotropical *is derived from the delineation of worldwide faunal regions in which the New World tropics are called the Neotropical region to separate them from the Old World tropics. The region includes all of tropical America, the nontropical parts of South America, the West Indies, and other islands near South America. The faunal area covering the rest of North America is the Nearctic region. The boundary between the two is not sharp because of the gradual changes in vegetation and climate. For convenience in classifying migrants, the border of Mexico was chosen as the best approximation of the faunal boundary, although some species have winter ranges that straddle the border. The key phrase is "winter primarily south of the United States."*

***Map 3.*** *Breeding and wintering areas of North American warblers. All but two of the 29 species of warblers that breed in Minnesota are neotropical migrants, wintering south of the northern border of Mexico. (Compiled from Curson et al. 1994.)*

pasture, cropland, and slash-and-burn agriculture. This loss has detrimental effects on wintering birds that spend up to nine months of the year in the tropics. Each species has its own wintering range, although there is much geographical overlap, and some are more tolerant of disturbed forest than others. Consequently the habitat loss is species specific, and some birds, like the Cerulean Warbler, are more severely affected than others.

During migration, habitat loss is also a problem especially in coastal areas, now heavily developed, where stressed migrants need quality natural habitats for feeding to recover from over-water or other long-distance flights. Collisions with human-made structures, like towers, tall buildings, cars, and windows, also take a heavy toll during migration. Habitat on the breeding grounds has also deteriorated, especially in areas of intense agricultural or urban development, either through direct habitat loss, habitat fragmentation, or habitat simplification.

In Minnesota, understanding these factors is crucial because 43% of the forest bird species are neotropical migrants. Just three families of birds make up two-thirds of that total: flycatchers (9 species), vireos (6 species), and warblers (27 species). These species represent a good part of the diversity of birds in the north woods.




***Map 4.*** *Deforestation in Costa Rica. There is no question that forested habitat has declined dramatically in some tropical countries. (Adapted from Partners in Flight 1992.)*

## Geographical Patterns

The availability of habitat is the main factor that determines the distribution of all species. What specifically constitutes suitable habitat, however, is not known for most species, because of the lack of detailed descriptions of floristics or vegetational structure. What size and distribution of habitat patches are necessary for the species to prosper are also not known. Some species are generalists and occupy many forested habitats; they are widespread and are usually common or abundant. Others are specialists, and their habitat requirements are much more specific. Other factors that influence the distribution of species include: regional population densities, climate and weather gradients, competition from other species, biogeographical origins, social behavior (colonial or clustering tendencies), and management (e.g., nest boxes, introductions).

### Minnesota

It is useful to sort the forest species by the extent of their ranges in the state (widespread or local) and their relative populations (common or scarce) because these patterns have great bearing on their vulnerability to population declines or extinction from habitat change.

#### Distribution

The following groups were delineated, using the classifications by ecoregion and abundance in appendix A. (A single species can occur in more than one group.)

- Throughout the state (all ecoregions): 52 species
- Throughout forested ecoregions (not W or SW): 66 species
- Throughout northern forest (NW, N, NC, NE): 103 species
- Restricted to northern border (N, NE): 7 species
- Restricted to southeastern corner (SE, part C): 9 species
- Restricted to southwestern corner (SW): 1 species

#### Abundance

These abundance categories were derived by considering range width and consolidating the descriptions in appendix A: common = abundant to common, uncommon = common to rare, and rare = very rare to rare.

- Common throughout most of range: 13 species
- Uncommon or variable throughout range: 82 species
- Rare throughout range: 55 species

Based on this analysis, the 13 most common species statewide are:

Mourning Dove
Blue Jay
American Crow
House Wren*
Veery*
American Robin
Red-eyed Vireo*
Yellow Warbler*
Ovenbird*
Common Yellowthroat*
Song Sparrow
Common Grackle
Brown-headed Cowbird

The neotropical migrants are listed with an asterisk. Three of these abundant species—Veery, Red-eyed Vireo, and Ovenbird—nest in upland deciduous or mixed forests and are emblematic of that community.


Lynn and Donna Rogers


Bill Marchel

*The Common Grackle (top) and the American Robin are among the 13 most abundant species in Minnesota.*

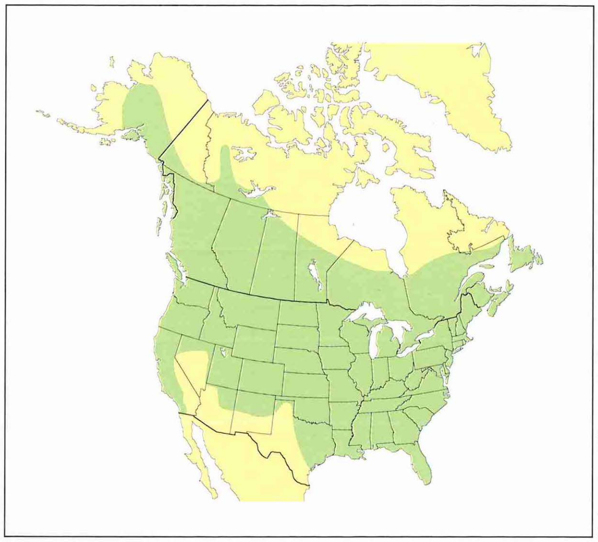
## North American Continent

Over half of the forest bird species are at the margin of their range in Minnesota because the state is at the intersection of three biomes: the prairie, the deciduous forest, and the boreal forest. It is useful to look at the complete continental range for each species and group them by areas that represent their geographical origin. These biogeographical affinities can be used in determining management priorities based on rarity or vulnerability in different Minnesota regions. For example, land-use changes that create drastic habitat loss have a greater effect on species with a southern origin than on species with a northern origin.

Sixty-eight species (45%) are pandemic, meaning that they have a wide continental geographical range (Map 5); these species also occur throughout all of the state with some minor exceptions for the extreme southwestern or northeastern tips. Fifty-five species (37%) are northern, meaning that most of their range is to the north of Minnesota, expanding eastward and/or westward across Canada (Map 6). Twenty-six species (17%) are southern, meaning that most of their range is to the south and east of Minnesota (Map 7). Because this list of forest-dependent birds does not include prairie species, only one bird (1%) (Black-billed Magpie) has a primarily westward distribution (Map 8).

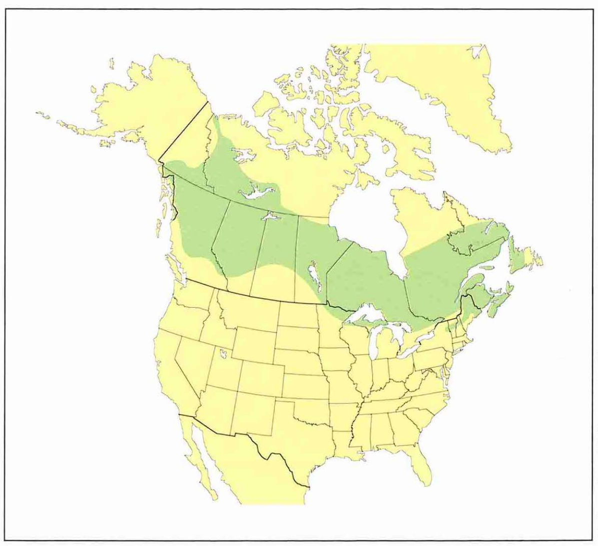
## Rare Species

Rare species deserve special mention because they are vulnerable to population declines and ultimate extirpation from the state. Some species in Minnesota were perhaps always rare, but others are rare because they have very specialized habitat requirements and that habitat is disappearing or deteriorating. Species that are classified as "very rare" throughout almost all of the state (see appendix A) need to be monitored closely and their



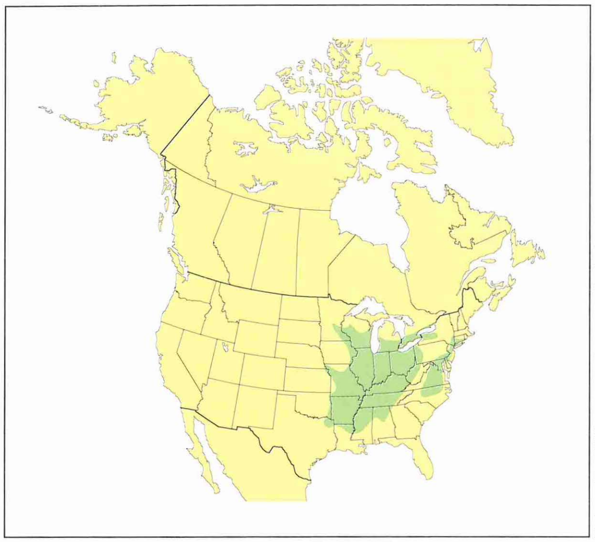
University of Minnesota Cartography Laboratory

***Map 5.*** *Continental range of the Downy Woodpecker. A pandemic species, the Downy Woodpecker has a wide continental geographical range (shown in green) and also occurs throughout Minnesota. (Range information from Peterson 1980, 1990.)*



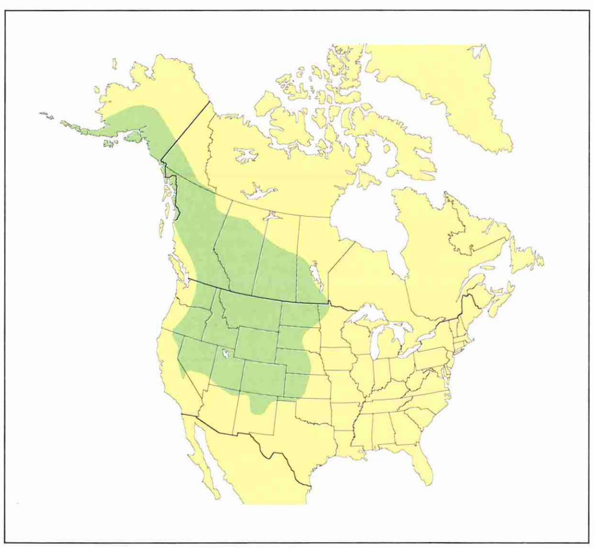
University of Minnesota Cartography Laboratory

***Map 6.*** *Continental range of the Tennessee Warbler. The Tennessee Warbler is a northern species. Most of its range (shown in green) is to the north of Minnesota, expanding east and west across Canada. (Range information from Peterson 1980, 1990.)*



University of Minnesota Cartography Laboratory

***Map 7.*** *Continental range of the Cerulean Warbler. A southern species, the Cerulean Warbler's range (shown in green) lies mostly to the east and south of Minnesota. (Range information from Peterson 1980.)*



University of Minnesota Cartography Laboratory

***Map 8.*** *Continental range of the Black-billed Magpie. The Black-billed Magpie is the only forest-associated species whose range (shown in green) is mostly to the west of Minnesota. (Range information from Peterson 1990.)*

habitat requirements carefully considered to make sure they are not extirpated from their local range. Those rare species that have restricted geographical ranges are especially vulnerable to extirpation because they tend also to have small populations (Lawton et al. 1993). Small, localized populations can be dramatically affected by random extremes of weather, disease, and predation as well as habitat change. The need to monitor rare species will be discussed further in chapter 4.

Most of the "very rare" species are at the margin of their range in Minnesota. Whether conservation of species at the periphery of their range is important is controversial. The best justification for paying attention to species at the edge of their range is to preserve genetic diversity. It is presumed that species at the margin of their range are likely to be genetically different from those adapted to conditions at the center of their range; thus they may have a genetic makeup that allows them to better adapt to future changes, for example, climate modification or environmental stress. Hunter and Hutchinson (1994, p. 1164) give another reason: "It is also possible that populations at the edge of a species' range are so genetically different from core populations that they can no longer interbreed with core populations and thus constitute a separate species. Cryptic or sibling species—morphologically indistinguishable from one another but genetically isolated—are probably far more common than we realize."

Using the geographical affinities given earlier, the following proportions were calculated:

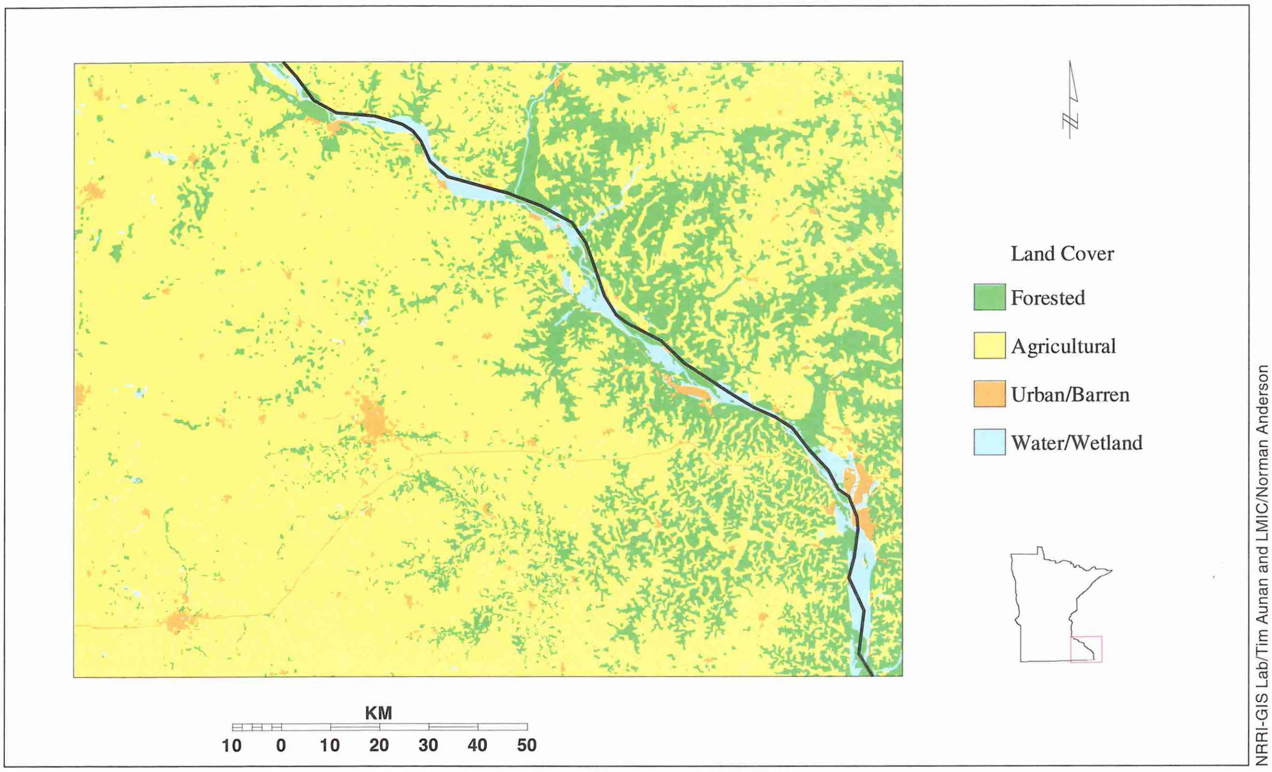
- 7% of pandemic species are very rare: 5 species (none passerines [songbirds])
- 38% of northern species are very rare: 21 species
- 46% of southern species are very rare: 12 species

| *Table 3. Very rare species in southeastern Minnesota* |
|---|
| Yellow-crowned Night-Heron |
| Red-shouldered Hawk |
| Northern Bobwhite |
| Acadian Flycatcher |
| Tufted Titmouse |
| Bell's Vireo |
| Blue-winged Warbler |
| Cerulean Warbler |
| Prothonotary Warbler |
| Louisiana Waterthrush |
| Hooded Warbler |
| Orchard Oriole |

Stephen J. Maxson

Maslowski Photo

*The Yellow-crowned Night-Heron (top) and Hooded Warbler (female pictured) are rare species in southeastern Minnesota.*




***Map 9.*** *Forest fragmentation in southeastern Minnesota. (Data from U.S. Geological Survey 1977.)*

It is not hard to discover why so many species that are at the northern margin of their range in southeastern Minnesota are vulnerable to extirpation (Table 3). A look at Map 9 shows how little extensive forest is left in that corner of the state. Degradation and loss of forest habitat has taken place not only in southern Minnesota but also all down the Mississippi River and its tributaries. The next very large block of contiguous forest encountered is in the Ozarks of Missouri (Powell et al. 1993). Populations of forest birds are probably much reduced in areas to the south and east of Minnesota as well, where habitat loss has been high. Low regional population densities are another important risk factor.

Climate probably also plays a role in the vulnerability of species on the northern periphery of their range. A few species that expanded their range into Minnesota under favorable climatic conditions in the past no longer regularly breed here: Bewick's Wren, Carolina Wren, Northern Mockingbird, and Yellow-breasted Chat (Green and Janssen 1975).

Most of the species with northern affinities that are very rare in most ecoregions are a different case (Table 4). Habitat loss, either within the state or farther north, does not seem to be a factor. Many of these species do, however, have specialized habitat requirements that are not very well understood. About half of these very rare northern species are not passerines (songbirds).

Several of these northern birds have very localized occurrences in the state, and their status as regular breeding species is not determined:

B. D. Cottrille

VIREO/Steven Holt

*The Black-throated Blue Warbler (top) and Wilson's Warbler are rare species in northern Minnesota.*

***Table 4.*** *Very rare or rare species in northern Minnesota*

Common Goldeneye
Bufflehead
Northern Goshawk
Spruce Grouse
Sharp-tailed Grouse
Great Gray Owl
Boreal Owl
Three-toed Woodpecker
Black-backed Woodpecker
Boreal Chickadee
Philadelphia Vireo
Cape May Warbler
Black-throated Blue Warbler
Palm Warbler
Bay-breasted Warbler
Wilson's Warbler
Lincoln's Sparrow
Rusty Blackbird
Red Crossbill
Pine Siskin

Bufflehead (northwest); Wilson's Warbler, Rusty Blackbird, and Red Crossbill (northeast).

There are a few rare pandemic species. They are either raptors or have very specialized habitat requirements. These species are Hooded Merganser, Sharp-shinned Hawk, Cooper's Hawk, Long-eared Owl, and Whip-poor-will.

## Population Trends

What is the actual pattern of species trends in Minnesota in recent decades? The best source of information to address that question is data from the Breeding Bird Survey (BBS) of the National Biological Service (formerly the U.S. Fish and Wildlife Service), which was begun in 1966 and includes 53 routes (increased in 1993 to 82 routes) randomly chosen to cover the whole state. The BBS produces trend estimates using a statistical method developed by the BBS staff (Sauer and Droege 1990). The trends were analyzed for Minnesota forest species, using data only for statistically significant ($p < .1$) trends and only for those species that occur on at least 14 routes. The data give only statewide trends. Forty percent of the forest species cannot be analyzed, either because they are not adequately counted by the BBS routes or because the data fall below the 14-route threshold. In Tables 5 and 6, declines or increases refer only to the significant trends, and "steady" is used for species whose trend, either positive or negative, was not significant. Data from two time periods are displayed in Tables 5 and 6 to show long-term and short-term trends.

A look at the two time periods in Table 5 shows that more species are declining in the more recent period, although the change is not great. In both time periods most species do not show significant trends. Note also that a large component of the forest birds cannot be analyzed because of insufficient data. These would include the least common species, which may be at greatest risk of significant population declines.

Scott W. Sharkey

*The Long-eared Owl is a rare pandemic species.*

A similar analysis can be done for forest birds based on their migratory status (Table 6). Again, there is a slight change from the long-term to the short-term period; the more recent trends show both more continental and more neotropical species declining. These results are essentially the same as a similar analysis done by the BBS staff for "woodland birds" on a continental scale. Their discussion stated that "the proportion of woodland species with decreasing trends generally rose during 1982–1991, especially for Neotropical migrants. Should these declines continue, they could result in changes in the composition of the woodland bird communities in portions of the continent" (Peterjohn and Sauer 1994, p. 163).

When one looks at individual species in Minnesota, some interesting clusters appear. For both time periods the most significant ($p < .05$) declines have been for continental migrants that winter in the southern states, specifically Red-headed Woodpecker, Northern Flicker, Ruby-crowned Kinglet, Brown Thrasher (recent only), and Brown-headed Cowbird. For neotropical migrants, the most significant ($p < .01$) declines have come in the more recent period only (with the exceptions noted later) and include Common Yellowthroat, Indigo Bunting, and Bobolink. There is an interesting group of neotropical species whose decline shows up only in the longer time period: Eastern Wood Pewee, Least Flycatcher, and American Redstart—all species of the eastern deciduous forest with a fly-catching habit.

Species that have increased most significantly ($p < .01$) include the Eastern Bluebird and Northern Cardinal during both time periods and the Pileated Woodpecker and White-throated Sparrow in the recent time period. Several permanent residents show increases over the longer period but not in the near term: Downy Woodpecker, Hairy Woodpecker, Blue Jay, American Crow, Black-capped Chickadee, and White-breasted Nuthatch. Increases for neotropical migrants are noteworthy only in the near term, when the following species showed increases: Wood Thrush, Red-eyed Vireo, Magnolia Warbler, and Blackburnian Warbler.

It is difficult to derive any hypotheses for

***Table 5.*** *Population trends for Minnesota forest birds*

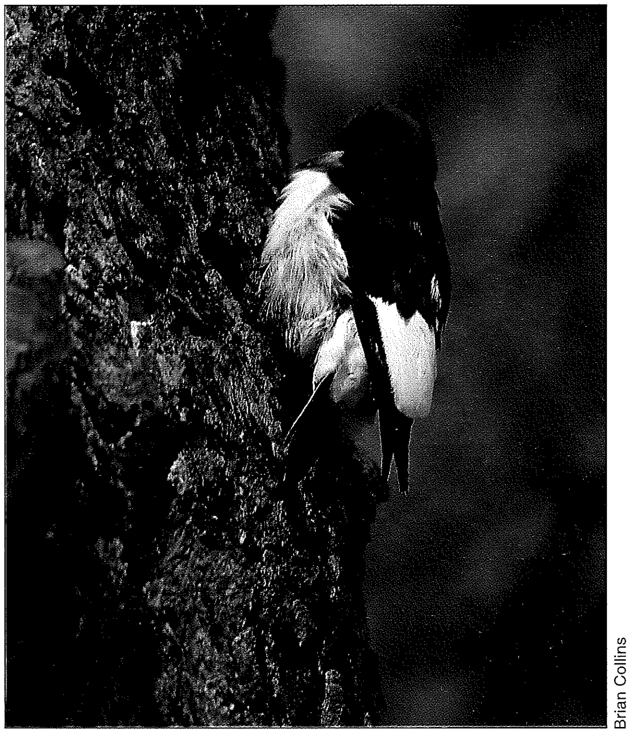
| **Population trend** | **1966–91** | **1982–91** |
|---|---|---|
| Decline | 10 species (7%) | 18 species (12%) |
| Increase | 24 species (16%) | 13 species (9%) |
| Steady | 65 species (43%) | 56 species (37%) |
| Insufficient data | 51 species (34%) | 63 species (42%) |

***Table 6.*** *Population trends by migratory status for Minnesota forest birds (number of species)*

| **Population trend** | | **1966–91** | | | **1982–91** | |
|---|---|---|---|---|---|---|
| | Permanent | Continental | Neotropical | Permanent | Continental | Neotropical |
| Decline | 2 (6%) | 5 (9%) | 3 (5%) | 1 (4%) | 9 (16%) | 8 (12%) |
| Increase | 8 (28%) | 12 (21%) | 4 (6%) | 3 (10%) | 5 (9%) | 5 (8%) |
| Steady | 4 (14%) | 21 (38%) | 40 (61%) | 9 (31%) | 19 (34%) | 28 (43%) |
| Insufficient data | 15 (52%) | 18 (32%) | 18 (28%) | 16 (55%) | 23 (41%) | 24 (37%) |
| Total species | 29 | 56 | 65 | 29 | 56 | 65 |


James H. Jensen

*Breeding Bird Survey data show that the most significant declines among birds that breed in Minnesota have been for continental migrants like the Brown Thrasher (top) and the Red-headed Woodpecker, both of which winter in the southern states.*


Brian Collins

*The extensive forests of the upper Great Lakes region have been identified as one of three or four areas in the United States where conservation of songbirds might occur.*

most species from these patterns except for the three deciduous forest species (pewee, least flycatcher, and redstart), which may be responding negatively to habitat destruction and fragmentation from land-use changes in the expanding metropolitan Twin Cities area, and for the Eastern Bluebird, which is probably responding positively to the recovery projects using nest boxes. One can speculate that the increase in the permanent residents, five of which are common feeder birds, may be the result of increased backyard bird-feeding.

Negative population trends for songbirds have most often been associated with neotropical migrants in both the popular press and the research literature. As mentioned earlier, although there has been a documented decline in trans-Gulf migration and in breeding populations of songbirds in the eastern deciduous forest in the mid-Atlantic region, causal connections with tropical deforestation or local land use are confounded by multiple factors and little data. Most of the work on declining songbirds has been done along the East Coast or in the central hardwood forest of the Ohio River valley; both are areas of deciduous forest that have been heavily fragmented by agriculture and suburban development. Large, contiguous forested regions (like northern Minnesota) are postulated to be the best hope for conservation of both resident and neotropical songbirds. The extensive forests of the upper Great Lakes region have been identified as one of three or four areas in the United States where conservation might occur (Terborgh 1992).

Tom J. Ulrich

*The American Redstart is one of three declining species that forage by fly-catching.*

Bill Marchel

*According to Breeding Bird Survey data, the Eastern Bluebird has increased in both the long and short term, probably as a result of recovery projects that provide nest boxes.*

Lynn and Donna Rogers

*Population increases among common feeder birds like the Hairy Woodpecker may be the result of increased backyard bird feeding.*

**Chapter 3**

# Species-Habitat Relationships

Habitat is the important requirement for viable bird populations, and each species has its own unique combination of environmental and physiological needs. Important ecological questions are: how are these requirements expressed by vegetational characteristics and at what scale? Important management questions are: how much variation within species and how much overlap among species are there for these vegetational and spatial requirements? There are no formulas yet to answer these questions, but it is important to begin by sorting through some ideas about habitat requirements for birds.

It is not easy thinking like a bird, particularly when it comes to looking at a forest and identifying what makes it quality habitat for each species. Presumably each species has a search image that helps it select appropriate habitat. The trick is to sort out the components of that image and put them in a framework that people can understand and use. Classifications that are in place now and are used by managers (forest types) or ecologists (plant communities) do not necessarily mean much when applied to birds. These two classifications do not even overlap fully with each other, never mind being adequate to describe bird (or other wildlife species) habitat.

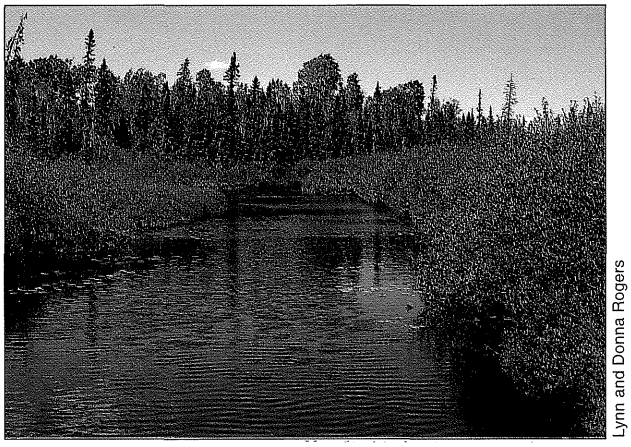
To show how birds and their choice of habitat confuse people, consider the example of the Gray Catbird. This neotropical migrant nests in settlements where there are abundant ornamental shrubs and open spaces of lawn or field. It also nests along the shrubby borders of slow-moving wilderness streams, or even in early regenerating clear-cuts. Thick shrubs are a unifying feature for the catbird, but habitat classifications developed by people are not organized around the spacing, composition, and density of shrubs.

Another problem is that forest conditions, described by age, composition (trees), and structure (layers of different vegetation), are infinitely variable, particularly in northern forests, and our classification schemes create artificial pigeonholes that are not always recognizable in the field. We blithely use the word "habitat" to cover these difficulties, and this guide will do the same. Just bear in mind that phrases like "habitat selection" and "habitat requirement" are just first approximations of the real situation. Most importantly, the term "wildlife habitat" has no meaning unless species or conditions are specified.

Habitat requirements can be addressed at three levels: landscape, stand, and microhabitat. How to organize a presentation of these levels is a dilemma: to start smallest to largest, largest to smallest, or familiar to unfamiliar? This discussion will begin at the stand level because it is the scale most traditionally used in forest management.

Richard Hamilton Smith

*The Gray Catbird can be found nesting in settlements where there are abundant ornamental shrubs and open spaces of lawn or field.*



Lynn and Donna Rogers

*The catbird is also found along the shrubby borders of slow-moving wilderness streams and even in early regenerating clear-cuts.*

Lynn and Donna Rogers

*Thick shrubs are a unifying habitat feature for the Gray Catbird, but habitat classifications developed by people are not organized around the spacing, composition, and density of shrubs.*

## Stand Level

*Vegetation forms the substrate for feeding, shelter, and nesting. The greater the volume and variety of vegetation, the greater the potential for niches for many species.*

Most work on habitat requirements for birds has been done at the stand level. This research has shown that birds are more responsive to the physiognomy, or structure, of the vegetation than to the floristics, or actual plant species. The density and number of vegetational layers in the vertical profile of a stand have been shown to correlate with bird species richness. This correlation makes sense when one considers that vegetation forms the substrate for feeding, shelter, and nesting and that the greater the volume and variety of vegetation, the greater is the potential for niches for many species. Structure can be defined by the herbaceous, shrub, subcanopy, and canopy layers and by the mixture of deciduous and coniferous trees. Structurally simple habitats like clear-cuts, even-aged conifer plantations, and closed-canopy pole-timber have fewer species than uneven-aged or mixed species stands or older forests with broken canopies and shrubby gaps. The reason for fewer species in simple habitats is that the few species of trees and the few vegetational layers in simple habitats do not offer enough variety for resource partitioning and avoidance of competition by multiple bird species. A study in England showed that both species richness and bird density were reduced in stands of only one or two tree species (Peck 1989).

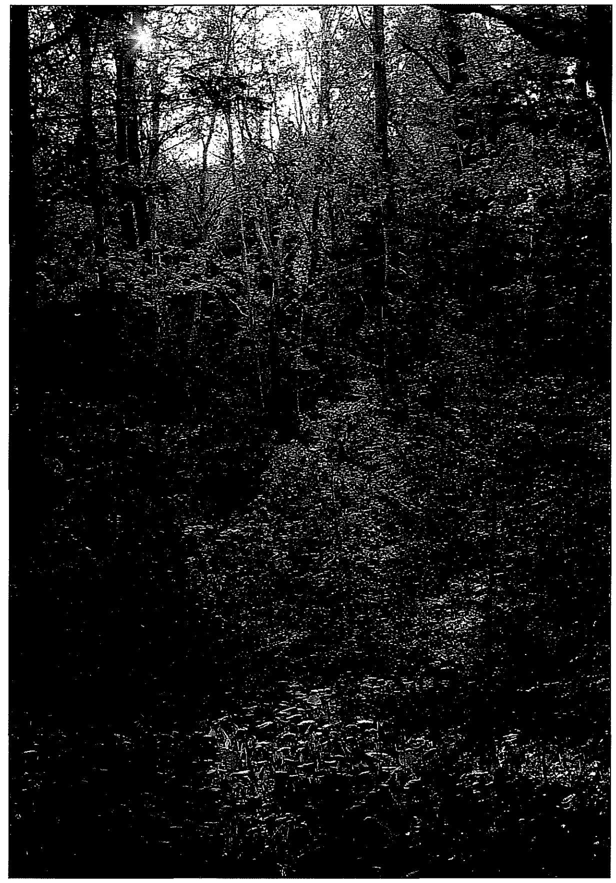
Richard Hamilton Smith

*Closed-canopy pole-timber tends to be structurally and vegetationally simple, providing few niches for birds.*

Different birds specialize on different layers for foraging and nest placement, and on needles or deciduous leaves for feeding. These feeding and nesting preferences are given in appendix B. It is important to note that these are just predominant preferences. Like anything else in these complex forest systems, there is variation within and between species on how stereotyped their life-history attributes are. For example, in a long-term study in a New Hampshire northern hardwood forest, Ovenbird nests were found 100% of the time on the ground, but nests of the Veery were found 36% of the time on the ground and 64% in shrubs (Holmes 1990b). Variations like this are the norm for species and avian communities that have been intensively studied. These studies are remarkably and disturbingly few considering the wide range of species and habitats.

For all these reasons, there are no exact correlations between bird species and habitat preferences. Most attempts to delineate habitat preferences for forest birds involve censusing bird species and numbers in a variety of forest types. This kind of monitoring of birds by habitat-specific forest types was conducted in the Chippewa and Superior National Forests in Minnesota for four years and in the Chequamegon National Forest in Wisconsin for three years by researchers at the Natural Resources Research Institute (NRRI), University of Minnesota, Duluth (Hanowski and Niemi 1991a, b, 1992, 1993; Hawrot et al. 1993, 1994; Montgomery et al. 1993; Pearson et al. 1993). This work is the basis for the habitat preferences displayed in appendix C.

This monitoring did not give strong preferences for most species. These results underline the complexity of the relationship between bird species and habitat. Several reasons account for the lack of strong preferences. First, many species are habitat generalists and occur



Lynn and Donna Rogers

*A structurally and vegetationally diverse forest has the potential for niches for many species.*

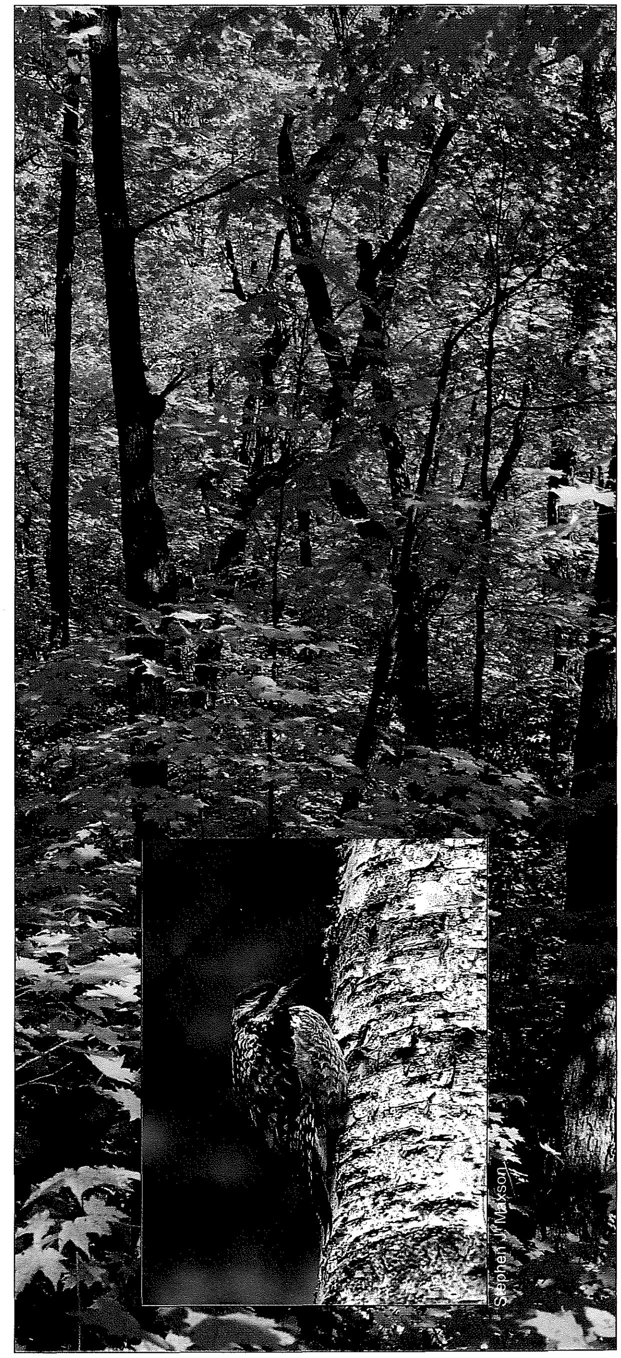
in a number of habitat types. Common species, in particular, are often generalists, and this characteristic is probably the reason for their high numbers. Second, forest stands described by timber types and ages do not give enough information on structure to define habitat variables that are important to birds. For example, the density of the shrub and herbaceous layers and the amount of dead and down woody material are not part of traditional forest typing. Third, most of the forest type designations used by managers are actually mixtures of several tree species; thus deciduous-forest birds are found in stands that are typed conifer, and conifer-dependent species are found in stands that are typed deciduous.

In spite of these difficulties, it is instructive to look at the results of the NRRI habitat-specific monitoring for the national forests. The tabular display in appendix C shows the wide range of habitats used by most species as well as some obvious preferences for a few species. The strong associations for species that are fairly specialized in habitat usage are as follows:

- Yellow-bellied Sapsucker in mature deciduous forest
- Yellow-bellied Flycatcher in lowland conifers
- Brown Creeper in lowland deciduous forest
- Yellow-rumped Warbler in lowland conifers
- Pine Warbler in pole-sized or mature pines
- Connecticut Warbler in lowland conifers

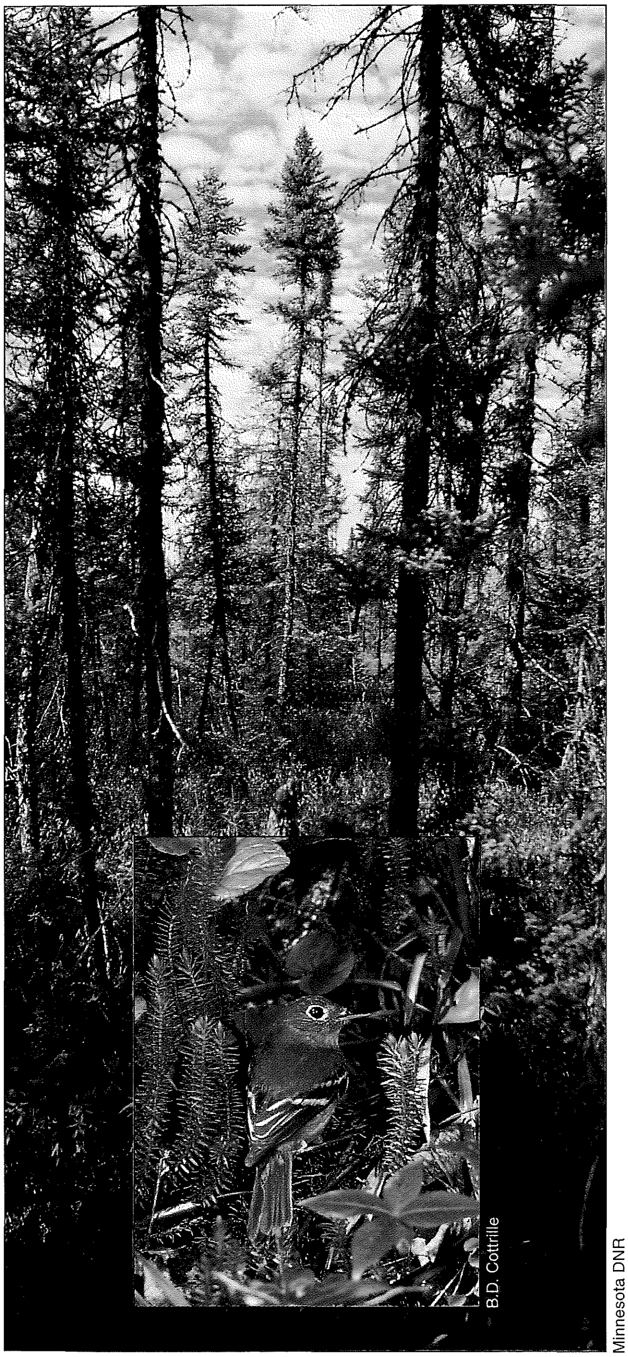
These are the preferred habitats for these species, but as examination of appendix C shows, they are not restricted to them.

*Most work on habitat requirements for birds has been done at the stand level.*

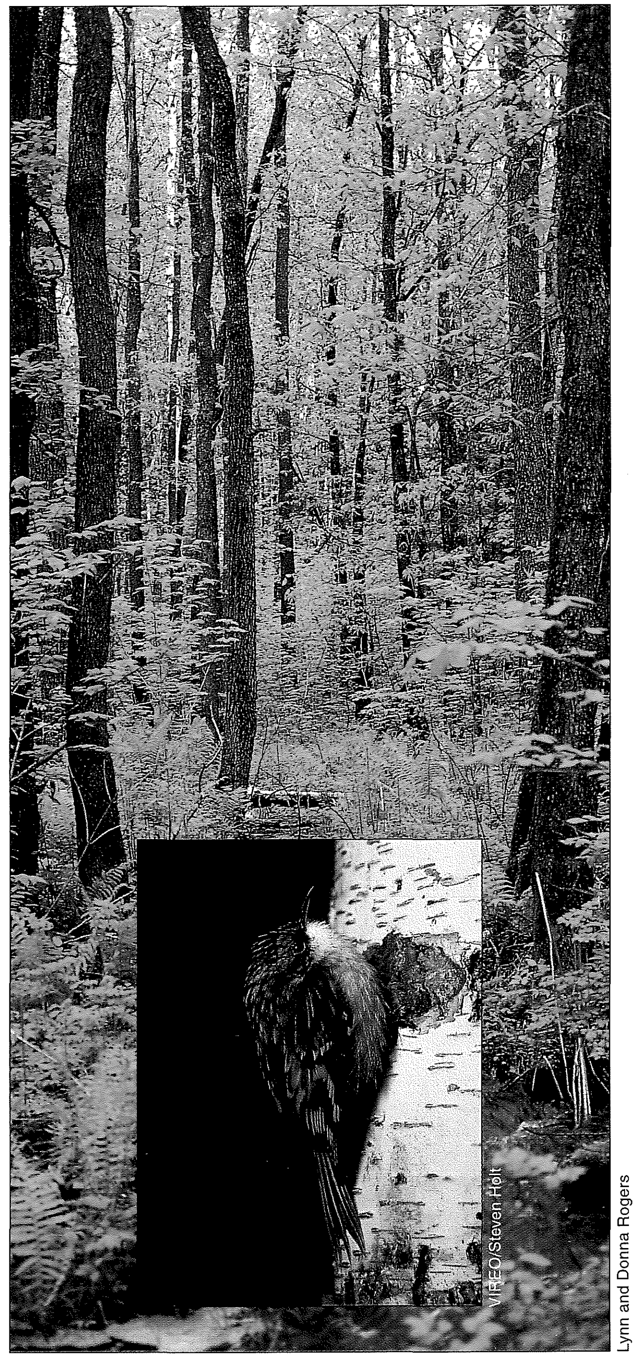


Minnesota DNR/K. Rusterholz

*The Yellow-bellied Sapsucker is strongly associated with mature deciduous forest.*




*Yellow-bellied Flycatchers are most often found in lowland conifers.*




*The Brown Creeper is associated with lowland deciduous forest.*

*Table 7. Birds associated with wetland communities*

**Sedge fen**
- Sedge Wren
- Bobolink (northwestern Minnesota only)
- Savannah Sparrow
- Le Conte's Sparrow

**Ericaceous-muskeg bog (open canopy)**
- Tennessee Warbler
- Nashville Warbler
- Palm Warbler
- Connecticut Warbler
- Lincoln's Sparrow

**Black spruce-tamarack (closed canopy)**
- Spruce Grouse
- Yellow-bellied Flycatcher
- Gray Jay
- Boreal Chickadee
- Golden-crowned Kinglet
- Ruby-crowned Kinglet
- Swainson's Thrush
- Hermit Thrush
- Nashville Warbler
- Cape May Warbler
- Yellow-rumped Warbler
- Bay-breasted Warbler
- Connecticut Warbler
- Chipping Sparrow
- Dark-eyed Junco

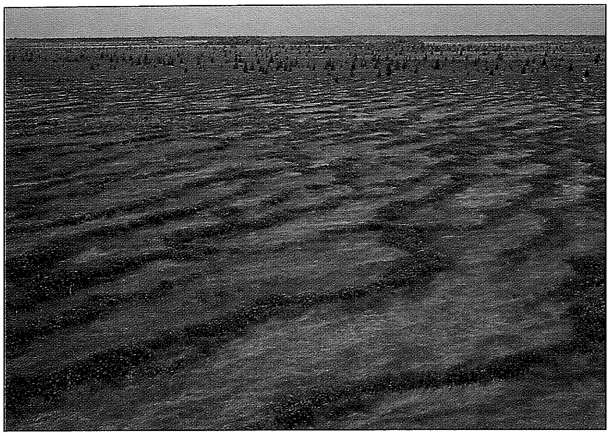
**Alder-willow (stream edge and shrub peatlands)**
- Alder Flycatcher
- Gray Catbird
- Golden-winged Warbler
- Yellow Warbler
- Northern Waterthrush
- Common Yellowthroat
- Clay-colored Sparrow
- Song Sparrow
- Swamp Sparrow
- American Goldfinch

*Sources:*
Green and Niemi (1980); Niemi and Hanowski (1992).

Stronger associations between species and habitat types do occur for structurally uniform habitats. Peatlands, shrub wetlands, and forested wetlands are some of the most uniform habitat types, and the birds associated with them form distinctive bird communities. The characteristic birds in these communities are listed in Table 7.

In addition to habitat-type censuses, another way to research habitat relationships is to collect vegetational information surrounding the singing perches of selected species during the breeding season. A study like this was done for warblers at Itasca State Park, Clearwater County, Minnesota (Collins et al. 1982). The resulting associations, derived from cluster analysis of average habitat variables, are given in Table 8. Defining habitat in this descriptive fashion is more readily appreciated by field biologists and birders than is the more traditional classification of forest types. Future research is needed to meld the two techniques or to create other schemes that better relate species to their preferred habitats.

*Peatlands, shrub wetlands, and forested wetlands are some of the most uniform habitat types, and the birds associated with them form distinctive bird communities.*


Minnesota DNR/B. Coffin

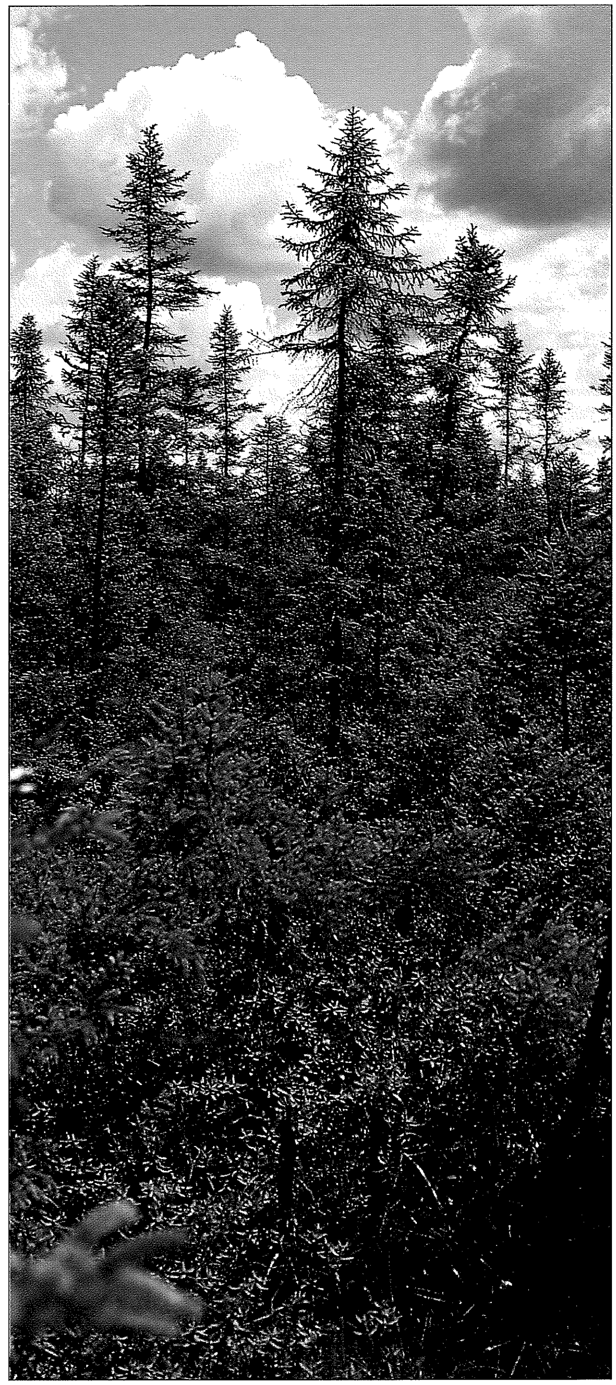
*Sedge fen.*


Minnesota DNR/D. Sheridan

*Alder-willow shrub peatland.*


Stephen J. Maxson

*Ericaceous-muskeg bog (open canopy).*


Minnesota DNR/B.Djupstrom

*Black spruce-tamarack (closed canopy).*

**Table 8.** *Warblers in upland habitats, north-central Minnesota*

| |
|---|
| **Open shrub with dense ground cover and moderate shrub cover:** |
| Chestnut-sided Warbler |
| Golden-winged Warbler |
| Mourning Warbler |
| Common Yellowthroat |
| Yellow Warbler |
| **Second-growth forest with edge habitat and a high percentage of shrubs:** |
| American Redstart |
| Black-and-white Warbler |
| Nashville Warbler |
| Canada Warbler |
| Magnolia Warbler |
| **Mature forest, mostly undisturbed and containing conifers:** |
| Blackburnian Warbler |
| Northern Parula |
| Ovenbird |
| Black-throated Green Warbler |
| Pine Warbler |
| Yellow-rumped Warbler |

*Source:* Collins et al. 1982.


*Open shrub.*


*Second-growth forest with edge and a high percentage of shrubs.*


*Mature forest, undisturbed, with conifers.*

## Microhabitat Level

Although in avian community ecology, stand structure has been given the most attention, there is some evidence that plant species composition also plays a part in habitat use. Birds are adapted to glean, probe, or catch insects from different surfaces depending on the shapes of their bills and feet. The availability of insects depends in part on their distribution by plant species. Therefore, it is reasonable to expect that plant species composition also influences habitat selection. There has been little research on exactly which foraging substrate is used by forest birds. The best research in eastern North America is from a northern hardwood forest in New Hampshire, where a study of foraging frequencies of canopy birds showed that some tree species were differentially selected for feeding, especially yellow birch (Holmes and Robinson 1981). Nesting sites for some species also may be selected based on narrow preferences for certain plants.

Other examples of microhabitat features are drumming logs for mating displays by Ruffed Grouse, uprooted trees or other tangles for nesting sites for Winter Wrens, loose bark usually on larger trees as nest sites for Brown Creepers, conifers for conifer-dependent species, and "wildlife trees" ("snags") for cavity-nesting species. Because cavity trees and conifers are two microhabitat features that are commonly identified in management prescriptions, those structures and the birds that are dependent on them will now be discussed in detail.

### Cavity Trees and Snags

The microhabitat characteristics that have been investigated the most are dead and dying trees for cavity-nesting and bark/bole/limb-foraging birds. In management jargon these trees are usually called "snags," although "wildlife tree" is a better descriptive term for a general audience.


Bill Marchel

*Large down logs are a microhabitat feature used by Ruffed Grouse to perform courtship displays.*

Trees in this category can be dead, dying, or alive. Their primary function is to serve as a source of nesting or roosting cavities for hole-nesting birds. Hollow limbs and trees are also used for drumming in territorial displays.

Thirty-two cavity-nesting species are listed in Table 9 and categorized as either primary cavity excavators or secondary cavity users. The secondary hole-nesters can occupy either woodpecker-excavated holes or decay cavities. Some species either excavate, if the wood is softened enough by decay, or use other available cavities. White-breasted Nuthatches and Tufted Titmice are not known to excavate their own holes, although Red-breasted Nuthatches sometimes do. Brown Creepers usually place nests in the cavity behind flaking bark of large dying trees. The primary excavators are the bigger woodpeckers; they prefer trees with firm sapwood but heartwood decay (live but decayed trees). The decay is obviously a factor in ease of excavation, and the firm wood of the outer part of the tree protects the nest from predators or collapse. Winter roost holes are also excavated. Holes are usually used only for one season although a new hole may be drilled in the same tree.

Several species that are sometimes included as cavity species are not on this list: Red-breasted Merganser and Turkey Vulture nest most often

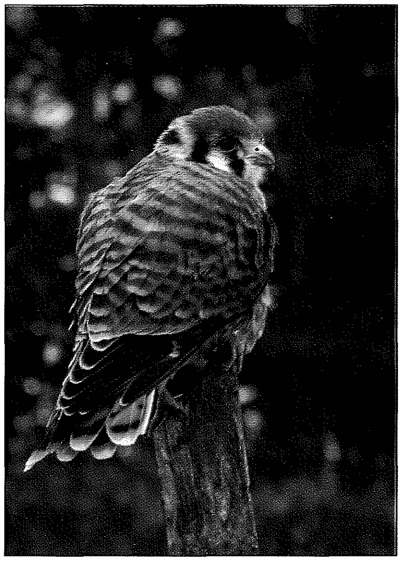
*Table 9. Cavity-nesting species*[a]

| | |
|---|---|
| Wood Duck | S |
| Common Goldeneye | S |
| Bufflehead | S |
| Hooded Merganser | S |
| Common Merganser | S |
| American Kestrel | S |
| Eastern Screech-Owl | S |
| Barred Owl | S |
| Boreal Owl | S |
| Northern Saw-whet Owl | S |
| Chimney Swift | S |
| Red-headed Woodpecker | P |
| Red-bellied Woodpecker | P |
| Yellow-bellied Sapsucker | P |
| Downy Woodpecker | P |
| Hairy Woodpecker | P |
| Three-toed Woodpecker | P |
| Black-backed Woodpecker | P |
| Northern Flicker | P |
| Pileated Woodpecker | P |
| Great Crested Flycatcher | S |
| Tree Swallow | S |
| Black-capped Chickadee | P & S |
| Boreal Chickadee | P & S |
| Tufted Titmouse | S |
| Red-breasted Nuthatch | P & S |
| White-breasted Nuthatch | S |
| Brown Creeper | S |
| House Wren | S |
| Eastern Bluebird | S |
| European Starling | S |
| Prothonotary Warbler | S |

[a]P = Primary excavator
S = Secondary user

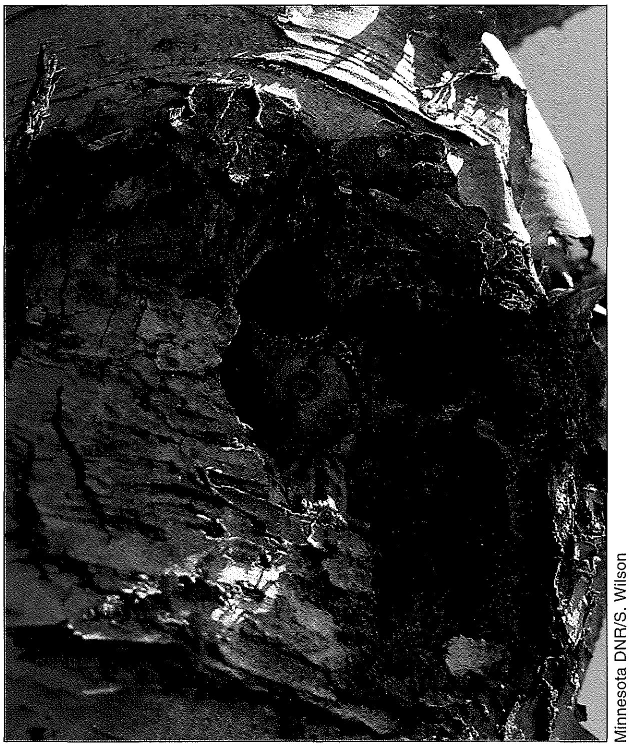
Warren Nelson

*Primary cavity excavators are mostly woodpeckers. The Pileated Woodpecker creates impressive holes!*

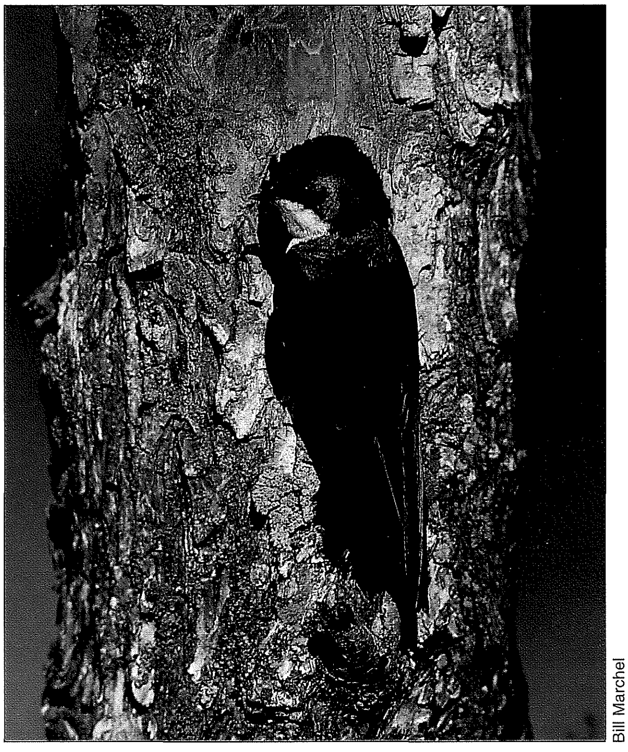


Bill Marchel

*American Kestrel.*


Minnesota DNR/S. Wilson

*The Boreal Owl is a secondary cavity user.*


Bill Marchel

*Tree Swallow.*


Lynn and Donna Rogers

*Woodpeckers are the best-known cavity nesters, but other species like Hooded Mergansers (shown here), American Kestrels, and Tree Swallows also use cavities.*

Scott W. Sharkey

*Blue Jays nest in conifers but can find suitable habitat in suburban areas as well as in forests.*

in sheltered nooks on the ground; Great Horned Owl, Great Gray Owl, and Long-eared Owl use abandoned stick nests of hawks or corvids; the Northern Hawk Owl, which does use a cavity, is only a casual nesting species in Minnesota.

Dead and dying woody material also provides the main feeding substrate for woodpeckers that drill, scale, probe, or excavate for insects on bark or wood. Black-backed and Three-toed Woodpeckers are a special case. They are nomadic, moving to take advantage of dead conifer stands, usually killed by fire or budworm infestations. They can become numerous in these stands as long as the supply of wood-eating insects lasts.

Isolated snags, dead or not, are also used as hunting and resting perches in open areas, particularly by kestrels, flickers, kingbirds, and the Olive-sided Flycatcher. Sturdy dead trees near water are the prime nest sites for Ospreys. In addition to live trees, colonial birds nest also in dead trees (often killed by their excrement) in swamps, beaver ponds, or on islands. For hole-nesting ducks the availability of big trees with decay or woodpecker-drilled cavities in riparian areas is an important limiting factor for their populations in remote areas or in areas where nesting boxes cannot be consistently provided. The size, condition, and spacing of wildlife trees are discussed in chapter 6.

### Conifers

Conifers are important at all spatial scales: as microhabitat features for nest sites, as habitat components in a stand, and as a defining characteristic of the regional landscape. The table of life-history characteristics in appendix B lists the species that are confined mostly to conifer trees for a nest site. A number of other species occur in conifers and appear to select the habitat because of the presence of conifers, but the reason for their selection of conifer-dominated habitat is not well understood.

Habitat data collected at monitoring sites in the Superior and Chippewa National Forests by researchers at NRRI show that some species are found only in conifer-dominated stands (60–100% conifer). Other species, for example, Blue Jays and Chipping Sparrows, nest in conifers but can find suitable habitat in suburban areas as well as in forests. Most of the species in Table 10, however, are found in the northern forest where conifers predominate. These 42 species represent 33% of the combined total of 128 forest birds in the north-central and northeastern regions. Rare species are a very important component: 31% of the conifer-dependent species are rare, and 65% of species that are rare in northern Minnesota are conifer-dependent (see Table 4).

Conifer-dominated landscapes are discussed in chapter 5, and stand-level recommendations for conifers are provided in chapter 6.

## Landscape Level

Habitat requirements for birds at the landscape level are the least studied aspect of habitat selection. The question of scale becomes a very important consideration here. The effects of the heterogeneity of the landscape (patchiness) on bird populations can operate at multiple scales with differing responses by individual species. One is faced with the need to understand complex relationships in the absence of sufficient research, especially at long enough time intervals and large enough spatial scales to be relevant to the dynamics and viability of bird populations. Rather than wait for definitive answers, however, one can use theory and available studies to sort through some issues surrounding habitat for birds at the landscape (hundreds to thousands of acres) and regional (hundreds to thousands of square miles) scales. These scales are adopted from the

***Table 10.*** *Conifer-dependent species*

Sharp-shinned Hawk
Northern Goshawk
Merlin
Spruce Grouse
Great Gray Owl
Boreal Owl
Three-toed Woodpecker
Black-backed Woodpecker
Olive-sided Flycatcher
Yellow-bellied Flycatcher
Gray Jay
Blue Jay
Common Raven
Boreal Chickadee
Red-breasted Nuthatch
Winter Wren
Golden-crowned Kinglet
Ruby-crowned Kinglet
Swainson's Thrush
Hermit Thrush
Solitary Vireo
Tennessee Warbler
Nashville Warbler
Northern Parula
Magnolia Warbler
Cape May Warbler
Yellow-rumped Warbler
Black-throated Green Warbler
Blackburnian Warbler
Pine Warbler
Palm Warbler
Bay-breasted Warbler
Connecticut Warbler
Chipping Sparrow
Lincoln's Sparrow
White-throated Sparrow
Dark-eyed Junco
Rusty Blackbird
Purple Finch
Red Crossbill
Pine Siskin
Evening Grosbeak

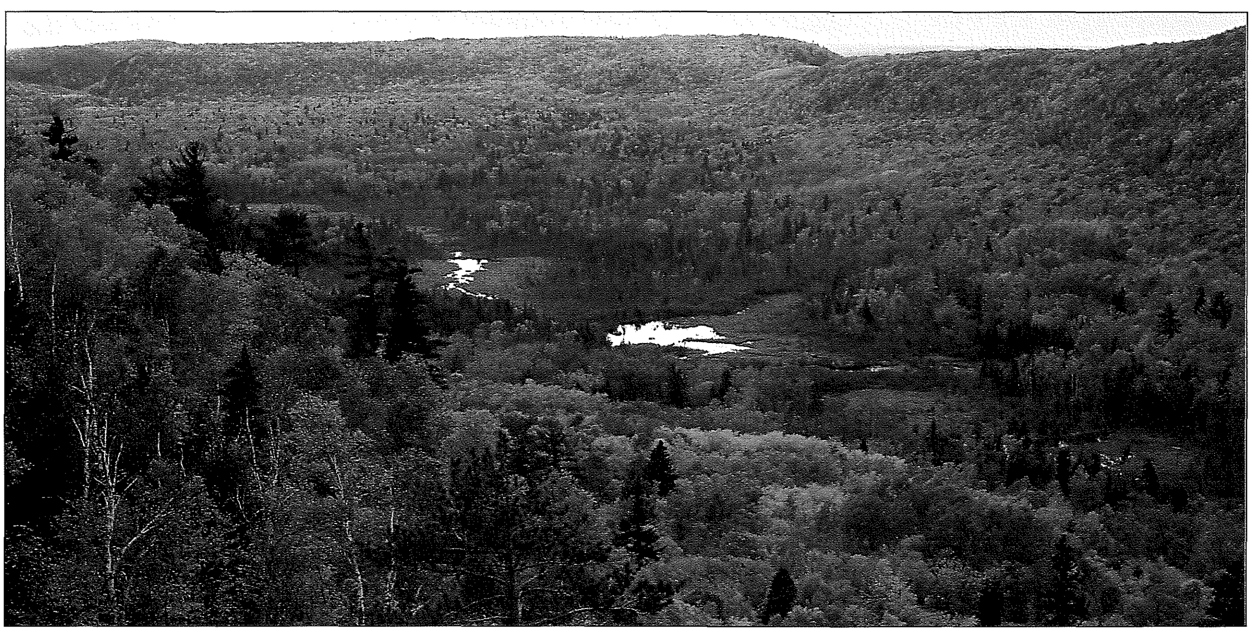
*Sources:* Green (1991); Pearson (1994).

Ecological Classification System of the Minnesota DNR (Hargrave 1993) and the U.S. Forest Service (1993b).

The natural geography of Minnesota is very heterogeneous, especially in those parts of the state that were heavily influenced by glacial action, both erosional and depositional. Swamps, bogs, rivers, and lakes punctuate a rolling, wooded terrain in the northeastern third of the state. Topography is the most dissected along the Border Lakes, the North Shore of Lake Superior, and the southeastern stretch of the Mississippi River. Superimposed on the landforms was a natural disturbance regime driven by insect infestations and fire as well as wind in the north and wind events and fire in the south. The result was a forested mosaic of diverse plant communities at different seral (age) stages with patch configurations of varying size and shape.

This diversity of habitats produced a species-rich avifauna that was adapted to a patchy environment. Flying gives birds a dispersal ability in an ever-changing forest mosaic, and their populations have adapted to variations in forest age and patch heterogeneity. What the biological limits are to that adaptive ability is the crucial question for both researchers and managers.

The pre–European settlement forest underwent changes during the decades at the turn of the century that were far beyond the scale of natural events. Heavy logging of the big, old trees was the primary disturbance; about half of the original forest was old growth (Jaakko Pöyry Consulting 1992a; Frelich 1995). Logging was followed by huge slash and land-clearing fires gone wild, and massive conversion of forest in the central and southern parts of the state to agriculture. These events produced the forest that we have today (Stearns 1990). The "Big Woods" forest formation is almost completely gone, the rest of the forest in the southern half of the state is heavily fragmented, and forests in the north



John C. Green

*Swamps, bogs, rivers, and lakes punctuate a rolling, wooded terrain in the northeastern third of Minnesota.*


*Natural disturbance regimes of wind and fire events superimposed on glacial landforms have resulted in a forested mosaic of diverse plant communities in northeastern Minnesota.*

are younger and dominated by the early-successional hardwoods (aspen and birch) rather than by the original old-growth pines and other conifers.

In spite of these drastic changes, the species richness of the avifauna in the forested part of the state is intact although population numbers have changed. Ranges of many species have contracted toward the north, and some populations are at risk in the south. Only one forest species has been lost, the Passenger Pigeon, which became extinct in 1914.

The resilience of bird populations to forest change in the ecotone that forms the Minnesota north woods offers a flexible framework for forest change directed by management decisions. But that framework does have boundaries, some of which are being revealed through research on the effects of forest fragmentation, particularly edge, area, and isolation effects.

## Fragmentation Effect

In an extensively forested terrain, fragmentation as a conservation issue appears superficially to be irrelevant. Forests in Minnesota, however, are composed of a mosaic of forest types and ages determined by climate, landforms, natural disturbance, and management. All of these factors "fragment" the landscape into different forest patches. But is a forest landscape composed of a patchwork of forest types and ages a fragmented landscape? Nomenclature is part of the problem in discussing fragmentation. Ecologists have a simple definition of fragmentation: the breaking up of a large and contiguous ecosystem into patches separated from each other by different ecosystem types. This definition is too simple to describe the types of fragmentation that occur in Minnesota.

Because of this problem, it is useful to make a distinction between *forest fragmentation* and *habitat fragmentation*. Most studies of the effects

Minnesota DNR/D. Wovcha

*Forest fragmentation is evident in southeastern and east-central Minnesota where conversion of forests to agricultural uses and urban development has been extensive.*

*It is useful to make a distinction between forest fragmentation and habitat fragmentation.*

Janet C. Green

*In this guide the term* habitat fragmentation *is confined to the extensively forested regions where conversion of one type or age of forest to another can fragment what was once a more homogeneous or continuous habitat.*

of forest fragmentation on birds have been done in areas where the contrast between adjacent land uses was great, primarily where forests had been fragmented and converted to agriculture or settlement, both of the suburban and recreational development type. This type of landscape occurs in Minnesota, particularly in the southeast and in the east-central and central parts of the state, and in this guide the term *forest fragmentation* is used to describe this situation. In the extensively forested regions in northern Minnesota, however, where conversion of forest to different types or age classes can fragment what was once a more contiguous and homogeneous natural habitat, *habitat fragmentation* is a more appropriate term. For example, old-growth pine stands once extended over a much larger proportion of the landscape. Today, however, the remaining acreage has been extensively fragmented by conversion to other forest types, such as aspen-birch.

Since the late 1970s, numerous studies have been done in the eastern deciduous forest on the effects of forest fragmentation on birds. The conclusions of these studies, summarized by Wilcove and Robinson (1990, p. 319), are relevant to the situation in both the southeast and at the forest-agricultural transition zone in the central part of the state:

*Many species of neotropical migrants either do not occur or show declining populations in small, isolated woodlots. There appear to be several reasons for this. First, small woodlots often lack key microhabitats such as permanent streams. Second, edge species invade the interior of small fragments. Among them are numerous predators, brood parasites, and possible competitors of neotropical migrants. Many of these predators and parasites have increased greatly in numbers in recent years in response to agricultural and suburban development. Third, small, isolated*

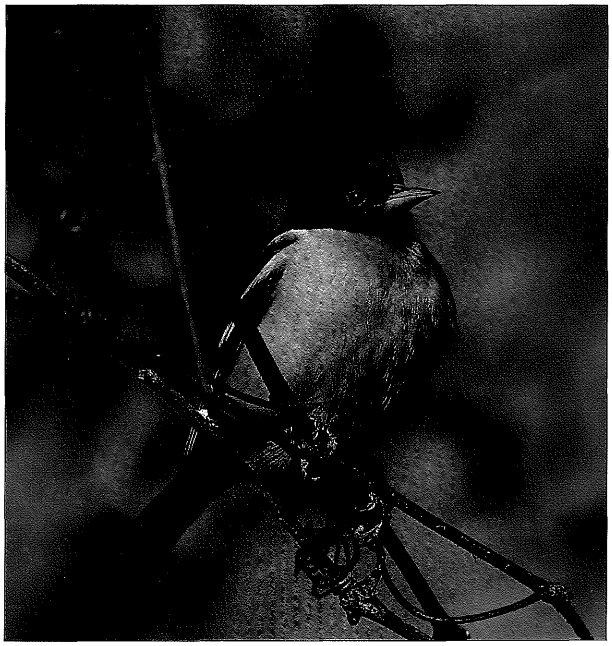
***Table 11.*** *Species tolerant of human-modified wooded landscapes*

| | |
|---|---|
| Green Heron | American Crow |
| Wood Duck | Black-capped Chickadee |
| Red-tailed Hawk | Tufted Titmouse |
| American Kestrel | White-breasted Nuthatch |
| Northern Bobwhite | House Wren |
| Mourning Dove | Eastern Bluebird |
| Black-billed Cuckoo | American Robin |
| Yellow-billed Cuckoo | Gray Catbird |
| Eastern Screech-Owl | Brown Thrasher |
| Great Horned Owl | Cedar Waxwing |
| Chimney Swift | European Starling |
| Ruby-throated Hummingbird | Warbling Vireo |
| | Yellow Warbler |
| Red-headed Woodpecker | Common Yellowthroat |
| Red-bellied Woodpecker | Northern Cardinal |
| Downy Woodpecker | Rose-breasted Grosbeak |
| Hairy Woodpecker | Indigo Bunting |
| Northern Flicker | Rufous-sided Towhee |
| Eastern Wood-Pewee | Chipping Sparrow |
| Willow Flycatcher | Song Sparrow |
| Eastern Phoebe | Common Grackle |
| Great Crested Flycatcher | Brown-headed Cowbird |
| Eastern Kingbird | Orchard Oriole |
| Tree Swallow | Northern Oriole |
| Blue Jay | Purple Finch |
| Black-billed Magpie | American Goldfinch |

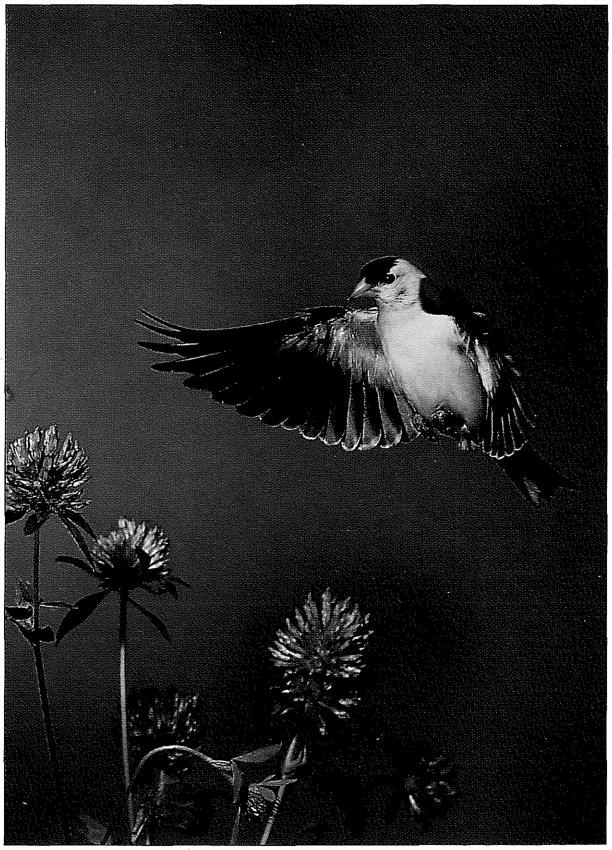
*Sources:* Freemark and Collins (1992); Stauffer and Best (1980); Robbins, Dawson, and Dowell (1989); Janssen (1987); Veit and Petersen (1993); Green (1991).


*Yellow Warbler.*


*Northern Cardinal.*




*Species tolerant of human-modified woodlands include the Yellow Warbler, Northern Cardinal, Northern Oriole, and American Goldfinch.*




*American Goldfinch.*

*woodlots may not receive sufficient numbers of colonists from surrounding woodlots to sustain breeding populations of some neotropical migrants. Data from a series of small woodlots in Illinois suggest that brood parasitism and nest predation, which overwhelm local reproduction, may be the most important factors.*

There have been a number of attempts to classify species based on their sensitivity to the effects of forest fragmentation. The assignment of species to categories has not been uniform, because of geographical differences in behavior and population densities and also in the landscape context and scale at which the studies were carried out. The result is differences in the area, isolation, and composition of the fragments studied. Because of these difficulties, it is fruitful to look at the problem from the opposite perspective and to categorize species by their tolerance to forest fragmentation. Species that appear to be tolerant of human-modified wooded landscapes are listed in Table 11. This list was derived partly from the literature, partly from maps that show presence of the species in wooded suburban areas surrounding the Twin Cities and Boston, and partly from personal field experience. Further investigation could probably add other species to this list.

A comparison of these species with their geographical distributions shows, as one would expect, that most of the species either breed throughout the state or have a widespread range in the forested ecoregions. Only eight have restricted ranges: two in only one ecoregion (Northern Bobwhite and Black-billed Magpie), two in two ecoregions (Tufted Titmouse and Orchard Oriole), and four in three ecoregions (Eastern Screech-Owl, Willow Flycatcher, Red-bellied Woodpecker, and Northern Cardinal). Except for the magpie, all have a range extension into Minnesota from a more southerly distribution. All of these species can be described as habitat generalists.

The impact of habitat fragmentation on bird populations is probably a species- and habitat-specific problem. It depends on the magnitude of the change from the natural forest mosaic of patches, including their sizes and shapes, to which the birds were adapted. In the north there are some fairly homogeneous landforms with uniform vegetation expressions, particularly on the glacial lake beds with their black spruce and tamarack forests or shrub and sedge brushlands. Forest cover or land-use conversions within these lake beds would result in habitat fragmentation. The size of patches in more heterogeneous landscapes also becomes important if the patch size is reduced beyond a threshold suitable for breeding for the species that are habitat specialists. For example, the Pine Warbler, whose specialized habitat is mature red and white pine forest, needs a minimum patch size of 25 acres of mature pine for suitable habitat (Schroeder 1985); breaking up a contiguous mature pine forest into smaller patches renders it unsuitable for breeding for this warbler. The suitability of habitat also involves forest age and composition as well as patch size. This problem is discussed further in the section on area effects and in chapter 5.

## Edge Effect

There is a lack of precision about the terms used in describing the effects of forest fragmentation, especially *edge*. This term is used to describe a structural feature in a landscape, a type of habitat, and species that are found in that habitat. To describe habitat, the term is usually used to refer to early-successional forest or brush adjacent to more mature habitat, but there are no standards to describe the width or height of edge habitat. As a descriptor of bird-habitat relationships, the term edge is even less useful. A "true" edge species would be one that is found only at edges because it needs resources of both the forest and the open habitat. The American Robin is the only species that research has shown to be an edge specialist (Elliott 1987). Most so-called edge species are really shrub specialists. They are found at the forest edge because shrubs are a structural feature there, but they are not confined to edges. Shrub specialists are equally common in other brushy habitats like scrub, regenerating clear-cuts, brushlands, and small gaps in the forest. Many other species found along the edge are there only incidentally and are actually using mostly the open habitat or mostly the forested habitat. Because of the imprecision of using the term edge to describe both habitat and species, it is preferable to confine use of the term to a structural feature, the boundary between two habitat types. The most comprehensive definition of edge as a place comes from Hunter (1990, pp. 101–2):

*Edges are simply the places where two ecosystems come together. They are never a perfectly sharp line; there is always a transition zone from one set of environmental conditions to another, from one set of plants and animals to another. These transition zones are called ecotones. Some edges are so abrupt that the ecotone is hard to recognize; a lake and a forest separated by a shoreline cliff would be a good example. In other cases the ecotone is a very gradual transition; e.g., one forest type grading into another on the side of a mountain.*

Although historically biologists have considered edges to be beneficial to wildlife, recent research has shown that edges can have adverse effects on bird populations in forests that have been fragmented by development or agriculture

Maslowski Photo

*This Blue-winged Warbler is feeding a cowbird fledgling.*

NRRI/T. Fenske

*A motion-sensitive camera was used to capture this photo of a skunk preying on an artificial nest.*

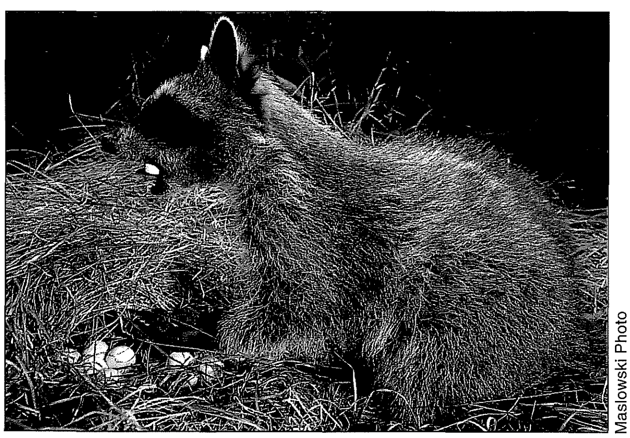
(see Paton 1994 for a review of the effect of edge on avian productivity). Negative impacts on breeding success can result from competition from other species (usually habitat generalists), changes in microclimate and microhabitat, increased predation from animals that use edges for hunting, and brood parasitism from Brown-headed Cowbirds, which preferentially use perches along edges to prospect for nests of other species in which to lay their eggs. The predation problem is particularly acute in fragmented landscapes with ubiquitous increases in populations of mammals like foxes, skunks, raccoons, dogs, and cats and in predatory birds like crows and jays.

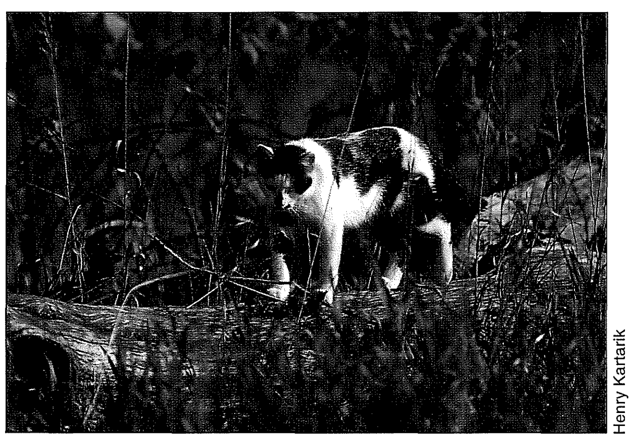
Some species are more sensitive to the biological interactions at edges than others. Research has identified neotropical migrants as the most vulnerable group. Many of these species are absent from small forest fragments in disturbed landscapes. Certain life-history traits of neotropical birds have been identified that make them vulnerable to increased predation and parasitism and hence to decreases in their productivity to the point where their populations cease to exist:

- long migrations and hence a short time on the breeding ground
- production of only a single brood of young a year
- comparatively small clutch size
- short life span (average 1 to 2 years)
- placement of nests on or close to the ground
- open cup nests

**"Forest-Interior" Species**

Some songbirds have been labeled "forest-interior" species because their populations disappear from small woodlots and the periphery of larger forest patches as forested landscapes are fragmented by settlements or agriculture (Askins et al. 1991). These species require relatively large blocks of contiguous forest to successfully breed (Robbins, Dawson, and Dowell 1989). The list of species that are classified as forest-interior is very dependent on the landscape context. No two lists of forest-interior birds are completely the same in places where the effect of edge has been most closely studied, for example, Maryland (Lynch and Whitcomb 1978; Robbins, Dawson, and Dowell 1989), Illinois (Blake 1983; Blake and Karr 1984, 1987), Connecticut (Askins et al. 1987), and




*The predation problem is acute in fragmented landscapes with ubiquitous increases in populations of mammals like skunks, raccoons, and cats.*

Wisconsin (Ambuel and Temple 1983; Brittingham and Temple 1983).

Forest-interior bird is also a confusing descriptive term in heavily forested areas where the detrimental edge effects are less severe or absent. There these "forest-interior" species do occur at edges if it is the appropriate habitat, or they occupy territories that can include a forest edge as a boundary. For example, labeling Ovenbird as a forest-interior species in Minnesota's forests is counter to everyone's birding experience when Ovenbirds can be heard singing along the edge of almost any forest road, regardless of width, in the northeastern quarter of the state. This is not to contradict research that has shown them suffering from edge effects in other parts of North America (see Gibbs and Faaborg 1990; Villard et al. 1993; Porneluzi et al. 1993). It just points out that the effects of fragmentation and edge depend on the forest context and do not apply continent-wide to the species wherever any type of edge is found. Therefore, as is the case for the term *edge*, it is clearer to use *interior* to describe a place rather than a species or habitat.

The term *neotropical species* is often used to mean forest-interior species, which adds to the confusion. Neither term defines a suite of species that in total can be related explicitly to fragmentation and edge effects. The list of warblers in upland habitats in north-central Minnesota (see Table 8) shows that different warbler species occupy different forest successional stages, which are often described too simply as either "edge" or "interior." It is best to avoid using terms that do not have precise meaning.

The confusion about forest-interior species is illustrative of the overall problem of forming conclusions about the effect of edge on breeding populations of birds. At the present time the results of studies cannot be generalized into a predictive model. There is too much variation in the landscape context (e.g., the amount of fragmentation and distances between patches) of the individual studies, and in the type of edge (e.g., permanent or temporary, high or low contrast in vegetation, interior or exterior in a patch) under investigation. This ambiguity is frustrating for managers, but, as in most natural systems, each situation is unique. A review summarized the difficulties well and called for better research designs: "Although the general notion that edge effects are deleterious for forest fragments is widely accepted, there is little consensus on what an edge is, how to measure edge effects, or how deleterious they are" (Murcia 1995, p. 58).

### Area Effect

The most obvious consequence of both forest and habitat fragmentation is the direct loss of the amount of habitat. The loss of a patch of woods or particular forest type has a local impact, and many local losses have a cumulative impact on the landscape. The size of a woodlot in an agricultural area or the size of a suitable habitat patch embedded in a contiguous forest may become too small to encompass the territorial needs of certain species, usually the larger birds. This effect has been termed "habitat dilution" by Huggard (1994, p. 108), who explains that "if home ranges [territories] of a species contain a fixed amount of a resource associated with the forest, then forest harvesting will dilute the usable habitat and necessitate expansion of the home range. Larger home ranges may increase travel distance of foraging animals, leading to energetic, and ultimately, fitness costs. . . . Woodpeckers, forest owls, and medium-sized carnivores are some potential examples."

The necessary size of a territory is strongly related to the size of the species (Schoener 1968),

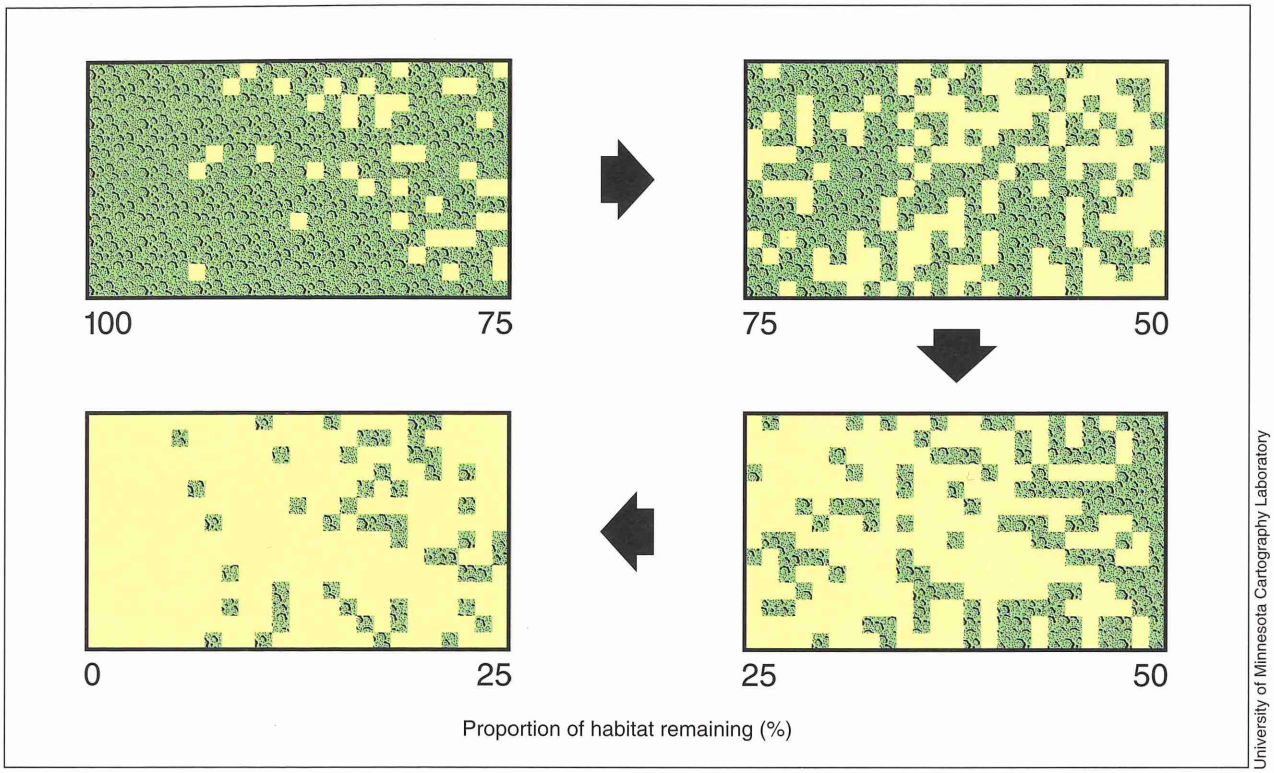



*Figure 3. Schematic of progressive fragmentation and loss of habitat. There are threshold effects in fragmentation that depend on the species and its habitat requirements. Habitat generalists are better adapted to survive in fragmented landscapes than habitat specialists. (Adapted from Andren 1994.)*

and a compilation of body mass from the literature is given in appendix B as a guide. Large birds (crows, hawks) require from 100 to 1,000+ acres for a territory, medium-sized birds (woodpeckers, jays, thrushes) require 5 to 20 acres, and small birds (warblers, vireos) require 1/2 to 5 acres. Even though these figures are ranges, they are not absolute because much depends on the quality of the habitat. The population density of a species or the size of an individual territory is very dependent on the prey base (insects, small mammals), which can be quite variable from year to year.

Area sensitivity can occur when the total amount of forest or suitable habitat in a landscape may not be enough to support a breeding population over time and space. One of the least understood aspects of population dynamics, especially for small birds, is dispersal distances and interactions among individuals. How an individual bird perceives suitable habitat and finds a mate and what size landscape is utilized in this territory search are important research questions. They will be very difficult to answer because once a bird moves away from its natal site where it was banded, it is very difficult to find in the expanse of forest. The interactions of habitat loss, patch size, and isolation (i.e., distance between suitable habitat patches) were analyzed by Andren (1994, p. 362) (Figure 3), who

| *Table 12. Area-sensitive species* |
| --- |
| Sharp-shinned Hawk |
| Cooper's Hawk |
| Northern Goshawk |
| Red-shouldered Hawk |
| Broad-winged Hawk |
| Sharp-tailed Grouse |
| Wild Turkey |
| Barred Owl |
| Great Gray Owl |
| Pileated Woodpecker |
| Ruby-crowned Kinglet |
| Palm Warbler |
| Connecticut Warbler |
| Le Conte's Sparrow |
| Lincoln's Sparrow |

Lynn and Donna Rogers

*Wild Turkey.*

B. D. Cottrille

*Connecticut Warbler.*

VIREO/A. & E. Morris

*Palm Warbler.*

concluded that:

*in landscapes with a high proportion of suitable habitat, the configuration of the habitat is less important. The negative effects of patch size and isolation on the original sets of species may not occur until the landscape consists of only 10–30% of the original habitat. For mobile organisms, the effects of isolation may appear only in landscapes with very fragmented habitat. In landscapes with highly fragmented habitat, a further reduction in habitat results in an exponential increase in distances between patches. Thus, in landscapes with highly fragmented habitat, the spatial arrangement of habitat is very important.*

The important point is that there are threshold effects in fragmentation that depend on the species and its habitat requirements. Habitat generalists are better adapted to survive in fragmented landscapes than habitat specialists.

Another aspect of area that should be considered is breeding behavior, because some species breed colonially or else have a population dynamic that requires adjacent multiple territories. For some species the habitat requirements seem to be larger than a normal territory. This requirement is particularly obvious for sedge or muskeg peatland species in the northern part of the state; similar observations have been made in Wisconsin (Howe et al. 1992). Table 12 is a tentative list of area-sensitive species that includes both large-bodied birds that require large territories and those that are peatland specialists.

There are probably other factors in breeding behavior or habitat requirements that are related to the area effect of fragmentation. A better understanding of the natural history and suitable habitat requirements of birds is necessary to make a more comprehensive list of area-sensitive species.

**Chapter 4**

# Using Species Information in Management

As the foregoing chapters have made apparent, this guide does not provide species-by-species suggestions for management. To consider species separately would go against the grain of the new paradigm—ecosystem-based management or integrated resource management. It would also be an intellectual and physical impossibility because there are so many species (each forested ecoregion has from 90 to 121 forest-dependent birds; see Table 1) and their niche, habitat, and landscape requirements either overlap, conflict, or are poorly understood. Ideally we should have enough good information on life histories, population dynamics, and habitats for all species to ensure that management maintains their populations in natural configurations and abundance. That state of knowledge is far in the future. We are going to have to reason from what we do know about avian biology and about historic patterns of forest change. Because the population dynamics of forest bird species are a response to forest vegetation, self-sustaining populations of birds are one measure of ecosystem function and health.

Creating an inventory, or a description of a baseline condition, is an obvious first step in ecosystem-based management. An inventory of species present combined with information about the landscape is the basis for development of management plans at all levels. Information about species also provides a basis for establishing priorities for species based on their rarity and vulnerability.

A conundrum of ecosystem-based management is how to measure results. Monitoring can be used to follow trends in the populations of birds and can thus address that problem. The techniques are the same as those used for baseline inventories, but with the difference that monitoring is carried out consistently over established time periods, using research designs that are statistically valid. Trends in the abundance of a bird species or a bird community indicate the direction that further management should take. For example, adverse trends are a sign that something is amiss. Following the forest health metaphor, a probable cause can be diagnosed, and a new management direction can be prescribed.

This chapter describes inventory and monitoring techniques for gathering information about species, and sources of additional information that can be used to establish priorities for species. Chapters 5 and 6 describe landscape-level planning and stand-level prescriptions. Used together, these three chapters provide a comprehensive way to perpetuate biodiversity, using all birds as an indicator of ecosystem health.

## Inventory

An inventory, or a list of birds that occur during the breeding season in a designated land management unit or an ecological unit of an ecological classification system (ECS), is one component needed to understand the ecological function of the unit. A baseline inventory measures conditions at the time of the survey, providing a description of baseline conditions; it does not necessarily reflect the best or optimum conditions.

Compiling a list of birds is not as straightforward as it might seem because of the variety of habitats and the lack of comprehensive surveys. Appendix A is a guide to what species are present at the ECS section-level scale. This information is a starting point. Most management units, however, are smaller than the ecological unit at the section scale, which is 1,000 square miles, so other approaches must be taken. Some inventories or species lists for particular places have been published, and references appear in appendix F. Local birders, bird-banders, and clubs also may keep site-specific lists, and they should be consulted. The Minnesota Ornithologists' Union (c/o the Bell Museum of Natural History, University of Minnesota) is a point of contact for active birders throughout the state. Although they are usually amateurs, good birders have identification skills that often exceed those of resource professionals, and their field knowledge should be used.

More formal methods of inventorying breeding species use several techniques; the most common ones, briefly described, follow:

- Roadside surveys, using the protocol of the Breeding Bird Survey (BBS) now managed by the National Biological Service, U.S.

Minnesota DNR/D. Ruda

*Lee Pfannmuller and Mary Miller conduct a roadside survey using the protocol of the Breeding Bird Survey.*

Department of Interior. These involve three minutes of listening at one-half-mile intervals along narrow, back roads during the three to four hours after dawn in June when birds are in full song. (For an evocative description of what experiencing the dawn chorus in the name of science entails, read Pfannmuller's article in the *Minnesota Volunteer* [1992].)

- Point counts, either habitat-specific or random, and conducted off-road or on-road. The standard for these counts is 10 minutes of listening, during early morning in June.
- Playback calls, using taped recordings of calls of targeted species, usually raptors (both diurnal and nocturnal) or rare species.
- Migratory game bird surveys, conducted by state and federal agencies, for waterfowl and upland game birds.
- Colonial nesting bird surveys, covering waterbirds that breed together (grebes, herons, cormorants, gulls, and terns).

With the heightened interest in monitoring birds in recent years, driven by the observed decline of many songbirds, several good guidebooks have been published that cover in detail rationales and techniques for inventory and monitoring. These books should be consulted before programs are developed. Citations are given here and, more fully, in the Literature Cited.):

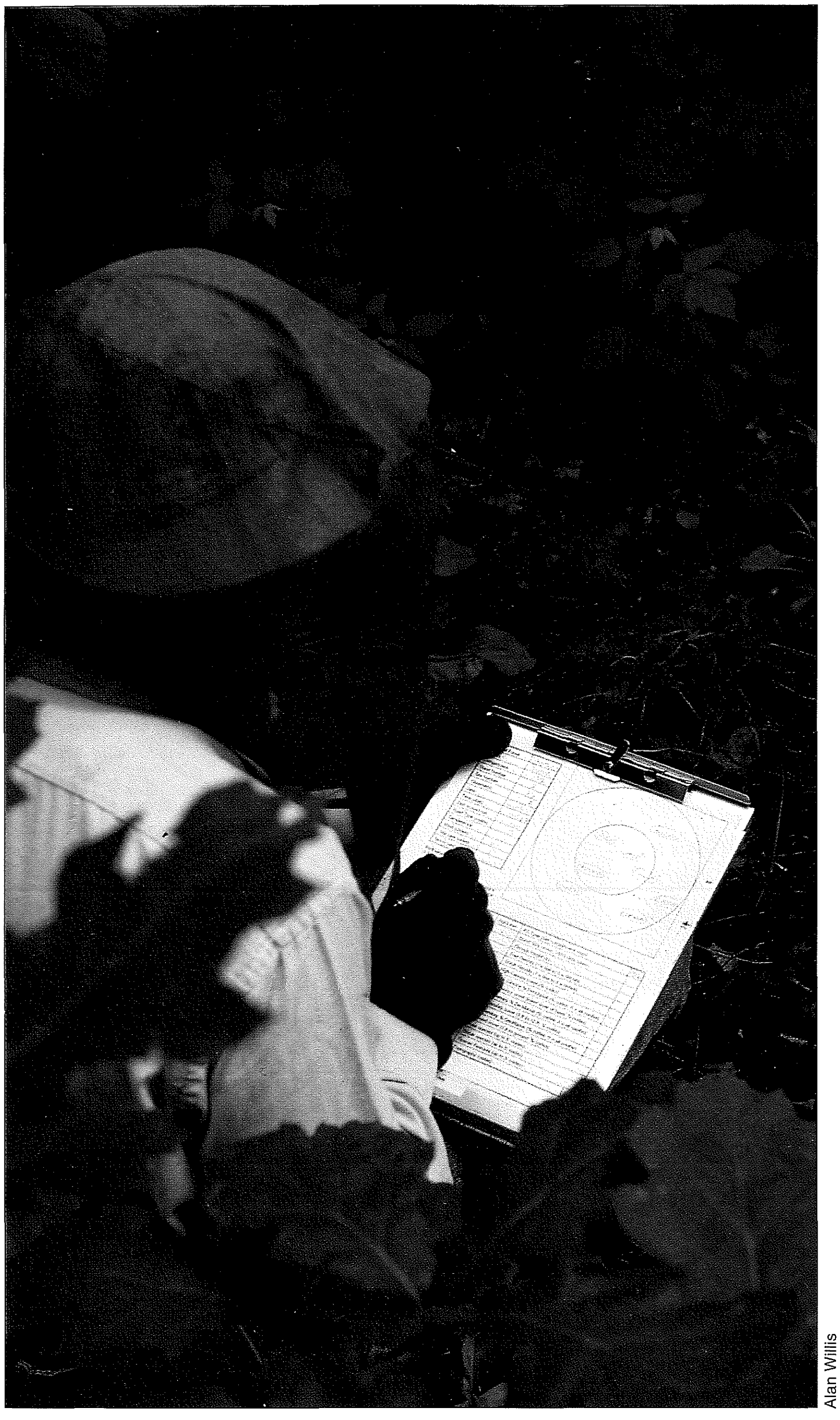
- Ralph, C. J. et al. 1993. *Handbook of field methods for monitoring landbirds.*
- Sauer, J. R., and S. Droege, editors. 1990. *Survey designs and statistical methods for the estimation of avian population trends.*
- U.S. Forest Service. 1993a. *Guidelines for monitoring populations of neotropical migratory birds on National Forest System lands.*

## Monitoring

Monitoring land birds in a management area may seem like a daunting task, but efficient and effective methods have been developed by researchers at NRRI for the national forests in Minnesota as part of the Minnesota Forest Bird Diversity Initiative (Hanowski and Niemi 1994b). For these large forest units (661,000 acres in the Chippewa National Forest; 2,135,000 acres outside the wilderness in the Superior National Forest), about 85% of the expected forest-dependent birds were detected by this monitoring strategy (101 species detected in the Chippewa with 121 expected in the NC Region; 104 species detected in the Superior with 121 expected in the NE Region). Very rare species or species with very specific habitat needs (e.g., riparian/wetland-associated species) were the ones not accounted for by this forest-type/habitat-specific monitoring. About half of the species in each forest were abundant enough to allow statistical analysis for trends in abundance for the three years covered by the monitoring.

An analysis (Niemi et al., in preparation) of the monitoring results for the national forests showed that a 10% annual population change could be detected for 29 species in the Chippewa and 22 in the Superior. A 50% annual change could be detected for an additional 27 species in the Chippewa and an additional 29 species in the Superior. This monitoring strategy can pick up significant annual changes for 42 to 46% of the forest bird species in these large forest areas.

It is important to remember that a long-term monitoring program (10–15 years) is needed to compare annual fluctuations that are a normal part of the variations in bird populations, particularly those in northern forests, with the long-term changes that result from land use or management actions. In boreal forests (Europe and North America) this year-to-year variation in



Alan Willis

*Carol Pearson conducts a point count for the National Forest Bird Monitoring Program.*

bird populations on the same plots can be as much as 25 to 30% (Mönkkönen 1994).

Short-term population declines are commonly the result of weather; some examples are drought, adverse weather during migration, and severe winters. A drought in the upper Great Lakes region in 1986–88 was correlated with a 35% decline in bird populations, mostly neotropical migrants, from census years 1985 to 1989 (Blake et al. 1992). Continental migrants that winter in the southern states, like the House Wren, Winter Wren, both kinglets, and White-throated Sparrow, can suffer excessive mortality when prolonged cold spells extend far to the south; such abnormal winter weather is reflected in declines in breeding populations in subsequent years (Robbins et al. 1986). Short-term, local declines of breeding populations have also been correlated with disastrous weather conditions during migration; an often-cited example is the decline of Scarlet Tanagers in New England in 1974 (Zumeta and Holmes 1978).

To have a baseline that represents variation caused by the effects of weather, predation, food availability, or other natural biotic or abiotic influences is important if birds are used as a bioindicator of forest diversity and ecosystem health. The monitoring program that was referenced earlier for the national forests can be augmented with data from migratory waterfowl and upland game species surveys. To accomplish complete coverage of all forest bird species, special monitoring techniques can be developed that are targeted toward the groups missed by random point counts conducted in June. Specifically, early-nesting permanent residents, nocturnal species, all raptors, and rare or secretive species need special coverage. Rare species are particularly difficult to census. Their rarity makes them difficult to locate, and great effort is needed to produce a statistically valid sample. Suggestions

Tom Ala

*Continental migrants that winter in the southern states, like the White-throated Sparrow (right) and Golden-crowned Kinglet (female, above), can suffer excessive mortality when prolonged cold spells extend far to the south.*


for establishing priorities for rare species are provided later in this chapter.

### Indicators

A technique that is sometimes used to monitor the health of an ecosystem is to monitor *bioindicators,* a term that is now much in vogue. The new Minnesota Environmental Indicators Initiative (1994) offers the following definition: "Environmental indicators are measurable characteristics of the environment that provide evidence of ecosystem health and trends in environmental quality." It is important to make a distinction between indicators of environmental contamination and indicators of ecosystem health. The "canary in the coal mine" to warn of polluted air has an ancient lineage, and species are still sometimes used as indicators of environmental contamination.

Deriving indicators of ecosystem health involves a broader concept. Ecosystems provide resources as well as services, such as nutrient and water cycling. To safeguard this essential provision by natural systems for human well-being, some measure of ecosystem integrity must be used to avoid unpleasant, or even catastrophic, surprises. In the book *The Third Chimpanzee* (1992, p. 337), Diamond states the problem well:

*What has to be remembered is that it's always been hard for humans to know the rate at which they can safely harvest biological resources indefinitely, without depleting them. A significant decline in resources may not be easy to distinguish from a normal year-to-year fluctuation. It's even harder to assess the rate at which new resources are being produced. By the time that the signs of decline are clear enough to convince everybody, it may be too late to save the species or habitat.*

It is to reduce the risk of missing the signs of decline that bioindicators are being formulated.

The use of a single species to represent the health of a complex ecosystem has been adopted by some agencies because of its simplicity, although it has been repeatedly questioned. The best criticism of this approach was summarized in an evaluation of vertebrate indicator species:

"The implicit assumptions in this use of indicators are that they provide a reliable assessment of habitat quality, and that if the habitat is maintained for the indicator, conditions will be suitable for other species. . . . These assumptions fail on conceptual and empirical grounds. . . . Because neither conceptual nor empirical considerations support use of indicators as surrogates for population trends of other species, this approach to wildlife assessment should be avoided" (Landres et al. 1988, pp. 318–19).

A good discussion of the same topic in a local context is provided by Niemi et al. (1994). They conclude that some support exists for the use of indicator species for a few species that are habitat specialists. However, because each species responds to habitat attributes that satisfy that species' needs for survival and because these autecological responses lead to inconsistent patterns of habitat association for most indicator species, it is doubtful that a few species can be used as indicators of the well-being of a variety of other species, especially those that are uncommon and difficult to monitor. The best advice for using single bird species as indicators in these complex northern forests is to choose only those species that are proven habitat specialists for the forest community of interest. Otherwise, avoid using single species.

**U.S. Forest Service Indicators**

Given the previous discussion, it may seem counterproductive to discuss in detail the U.S. Forest Service's use of birds as indicators. However, their indicator monitoring programs are part of their adopted 10-year plans and will remain in place until their plans are amended or revised. People outside the Forest Service are confronted with trying to understand their approach and how it is used; thus a discussion of its history and objectives seems warranted.

In the planning process that followed the National Forest Management Act (NFMA) of 1976, both National Forests in Minnesota, in accordance with the rules that were developed at that time (and are unfortunately still in place), made a selection of vertebrate species, mostly birds, to use as management indicators to measure their responsibility under NFMA to "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives." The rules that were set up to implement NFMA specified that "fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area" (36 CFR 219.9).

To implement the law and the rule, the Forest Service devised categories to consider when choosing indicators (from Noss 1991):

- threatened and endangered species
- species sensitive to intended management practice
- game and commercial species
- nongame species of special interest
- ecological indicator species that suggest the effects of management practices on a broad set of species

In fulfilling this mandate the Chippewa National Forest selected eight Management Indicator Species (MIS) for monitoring populations to determine if forest plan objectives were being met or if changes in forest plan standards and guidelines were needed (J. Mathisen, personal communication). The Superior National Forest chose two categories: Management Indicator Species (MIS) and Viability Indicator Species (VIS). The choice of MIS and VIS follows closely the language of the rule (36 CFR 219.9). All of these species are presented in Table 13.

A look at this table points up a couple of problems. One, the choice of species in each forest was different although they share much in ecological condition. Some of the difference can be explained by different management objectives and some differences in the amount and distribution of forest types. Even so, more coordination would help in understanding the total forest condition in a large forested area like northern Minnesota. Another problem that needs a better explanation is why one forest used both VIS and MIS and the other used only MIS. That difficulty can probably be traced to the lack of clarity in the rules that guide actions implementing the National Forest Management Act.

The Forest Service is aware of these problems, and future amendments to the forest plans will adopt a more realistic approach. The use of the monitoring data for the national forests now being carried out by NRRI will provide a baseline for a new monitoring scheme. Any use of indicators, whether comprehensive or simple, requires an ongoing monitoring program to show results and to validate assumptions that underlie management activities. The resources needed for this should be factored in to any monitoring plan.

*Table 13.* *U.S. Forest Service indicators*

| | **Superior National Forest** | **Chippewa National Forest** |
|---|---|---|
| Hooded Merganser | MIS | |
| Osprey | MIS | |
| Bald Eagle | VIS | MIS |
| Red-tailed Hawk | VIS, MIS | |
| Spruce Grouse | MIS | |
| Ruffed Grouse | MIS | MIS |
| Sharp-tailed Grouse | VIS | |
| American Woodcock | MIS | MIS |
| Barred Owl | | MIS |
| Boreal Owl | VIS | |
| Red-headed Woodpecker | VIS | |
| Black-backed Woodpecker | VIS, MIS | |
| Pileated Woodpecker | VIS, MIS | MIS |
| Brown Creeper | MIS | |
| Golden-crowned Kinglet | MIS | |
| Swainson's Thrush | MIS | |
| Northern Parula | | MIS |
| Magnolia Warbler | MIS | |
| Blackburnian Warbler | | MIS |
| Pine Warbler | VIS | MIS |
| Scarlet Tanager | VIS, MIS | |
| Savannah Sparrow | VIS, MIS | |
| Bobolink | VIS | |

*Sources:* U.S. Forest Service 1986a, b.

## Establishing Priorities for Species

Establishing conservation priorities is an additional means of approaching management from a species perspective. Priorities often highlight rare species for the obvious reasons that they are the most vulnerable to endangerment because their small populations may not be able to recover from the extremes of demographic (birth and death rates) fluctuations. Many forest species are short-lived (2 to 4 years is the usual longevity for warblers); thus the risk of extirpation of local populations is increased if the number of individuals in the area is insufficient to produce replacements for local breeding failures. Because birds can fly, they are usually considered to be less vulnerable to local extirpations than other vertebrates. But dispersal ability cannot overcome the risks to small populations of habitat specialists in fragmented environments, because they must find both mates and isolated patches of suitable breeding habitat. Chances of finding them are obviously increased if the bird numbers are larger and the patches closer together.

The goal of establishing priorities based on rarity and vulnerability is to ensure that individual species are not threatened by habitat loss or degradation through management actions that would lead to increased endangerment. Establishing priorities is a safety net that protects species and ecosystems from needing more draconian and expensive measures of rehabilitation and restoration. A good example of a process carried out at the state level to set priorities for species is described in Millsap et al. 1990.

One approach to analyzing rarity is to use the size of the geographical range of a species, its population density, and the specificity of its habitat requirements together to create a matrix of vulnerability that establishes a priority species list (Niemi 1982; Droege and Peterjohn 1991). This method uses the eight-cell model of rarity developed by Rabinowitz et al. (1986) (Figure 4).

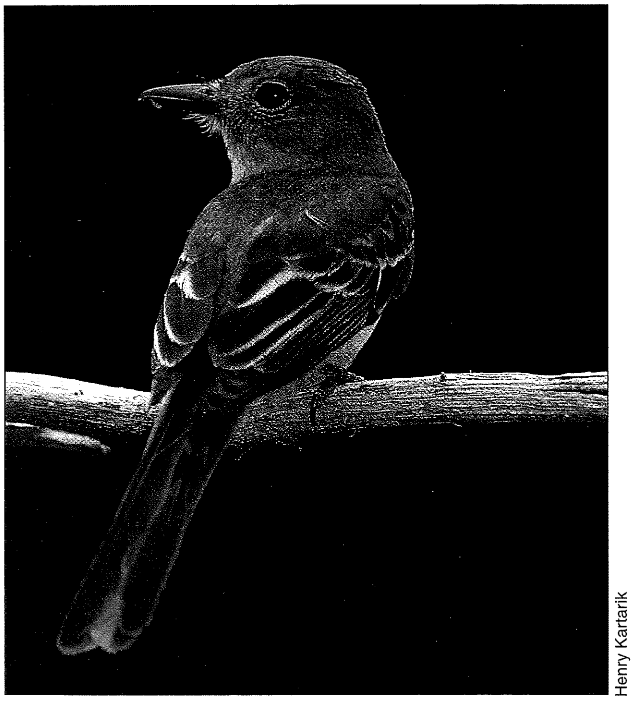
Problems arise when the model is applied to birds because there are no agreed-upon standards or data for the matrix components. Consequently, the values become best estimates, and the priority rankings do not necessarily come out the same if done by different individuals. In the two papers cited earlier, only one-third of the same species analyzed ended up in the same cell. The greatest variation in judgment involves what constitutes habitat specificity. If a better definitional standard for habitat were established, then this model would be a useful approach because range and density can be measured.

| Geographical distribution | | Wide | | Narrow | |
|---|---|---|---|---|---|
| Habitat specificity | | Broad | Restricted | Broad | Restricted |
| Local population density | Occurs at high density | | | | |
| | Always at low density or total population size is very low | | | | |

DNR Graphics/Beth Petrowske

***Figure 4.*** *Eight-cell model of rarity. In analyzing rarity, the size of the geographical range of a species, its population density, and the specificity of its habitat requirements have been used together to create a matrix of vulnerability. (Adapted from Rabinowitz et al. 1986.)*

Maslowski Photo



Henry Kartarik

Warren Nelson

*Several species are especially at risk as a result of tropical deforestation, among them the Golden-winged Warbler (above left), Great Crested Flycatcher (below left), and Chestnut-sided Warbler.*

Rarity, which depends on the size of the range and the density of populations, does not by itself indicate all the aspects of risk to increased endangerment. Other warning signs to consider are steady population declines, range contractions, disjunct populations, restricted dispersal ability, habitat deterioration, fragmentation or loss, migration habitat condition, and winter habitat condition,

The last two factors are an acute problem for birds that winter in the tropics. Partners in Flight, the interagency program for the conservation of neotropical birds, has tried to put many of these factors together in a single numerical index of priorities for the Midwest (Thompson et al. 1993), but this process suffers from the same deficiencies of measurement and weighting of variables as the Rabinowitz rarity index.

Because there is no handy, off-the-shelf priority list developed to help decide which species or forest habitats need special management attention in Minnesota, two sources of information can be used to tailor site-specific lists of vulnerable species. One source is the management categories that identify species of concern, which have been created by management agencies and programs:

- Endangered species lists –"Listed Species"
  Federal: endangered, threatened, candidate
  State: endangered, threatened,
  special concern
- Migratory Nongame Birds of Management Concern – U.S. Fish and Wildlife Service
- Sensitive Species – U.S. Forest Service (Chippewa and Superior National Forests)
- Breeding season vulnerability – Generic Environmental Impact Statement (GEIS) analysis
- Significant trends from the Breeding Bird Survey
- Winter vulnerability in the tropics

The purpose and source of these management categories are described in detail in appendix D, and the information is compiled in a table.

The other source of information is the lists in this guide:

- Very rare species in southeastern Minnesota (Table 3)
- Very rare or rare species in northern Minnesota (Table 4)
- Birds associated with wetland communities (Table 7)
- Conifer-dependent species (Table 10)
- Area-sensitive species (Table 12)

These lists can be used in conjunction with local knowledge about forest conditions and human impacts, thus incorporating the ideas about rarity presented earlier. For example, the Boreal Chickadee shows up on three of the lists, which indicates that its risk from habitat alteration is high. This risk should be taken into account when plans or treatments of its lowland conifer habitat are developed.

## Chapter 5

# Landscape-Level Planning

The way forests are actually managed is the result of decisions that are made at the stand level and by plans that are developed at the landscape level. Traditionally silvicultural prescriptions for different forest types have been carried out stand by stand, and the resulting forest condition was the sum of all the local stands. More recently, plans at a larger scale have been developed by management agencies. This activity has been called landscape-level planning.

The scale of the units that are covered by plans varies from a USFS opportunity area in a ranger district or a DNR area plan to whole national forests, counties, or DNR regions. The unifying aspect of these plans is not the scale but the approach, which seeks to describe a desired future composition of the forest into which the individual stand prescriptions will fit. Many details have yet to be worked out in this planning process, but the idea is to create a vision of the future forest that is more explicit than the cumulative result of many stand prescriptions.

Because many ecological processes, like population dynamics, operate at the larger landscape scale rather than at the stand level, it is appropriate to discuss management concerning birds first at the landscape level. Suitable habitat includes more than stand type or microhabitat features. Crucially important to habitat is the landscape pattern of size, shape, composition, extent, and juxtaposition of forest communities. How this pattern changes over time and how bird populations respond dynamically to that change are the crux of the problem of providing habitat for the persistence of all forest bird populations.

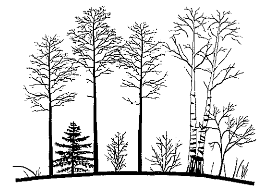
The investigations into spatial and temporal configurations of different forest types and ages for forest birds are not yet far enough developed to come up with models for land-unit planning. Such models need to quantitatively describe forest community objectives, rotation length, and stand harvest schedules to provide suitable habitat for multiple species. There is enough information, however, to describe the landscape analysis that is a necessary part of landscape-level planning and to identify some landscape-level issues that need attention: patch size configurations, fragmentation, conifer-dominated landscapes, contiguous mature forests, and riparian zones. Before addressing landscape analysis and landscape-level issues, a discussion of biodiversity follows that gives some conceptual and practical background that can be used in constructing landscape-level responses to the issues raised.

## Biodiversity

The perpetuation of biodiversity is the goal of all actions that are taken to create sustainable landscape conditions. The meaning of biodiversity in the context of landscape-level planning encompasses more than the familiar concept of species richness. As the much-quoted definition produced by the Society of American Foresters (1991) states, "*Biological diversity* refers to the variety and abundance of species, their genetic composition, and the communities, ecosystems, and landscapes in which they occur. It also refers to the ecological structures, functions, and processes at all of these levels. Biological diversity occurs at spatial scales that range from local through regional to global." The term *biological integrity* as commonly used is synonymous with this definition of biodiversity. Biological integrity was coined by Angermeier and Karr (1994) to avoid confusion with the use of the term biodiversity to mean only counting ecological elements (e.g., species and communities).

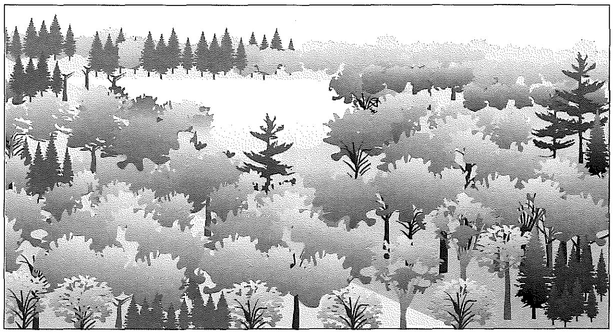
A key point, then, in considering biodiversity in landscape-level planning is that all of the ecological elements within an ecosystem serve a function and are part of ecological processes. For example, the function of leaves is photosynthesis, and birds function to consume insects that consume leaves. Ecological processes include nutrient cycling, disturbance regimes, succession, and herbivory. These aspects of the definition of biodiversity are important when considering landscape-level planning because disturbances that change the structural and compositional character of a forest over time, like wind and fire, operate at the landscape level.

Equally important is the fact that biodiversity occurs at many spatial scales. Ecologists commonly use this three-level scheme (Figure 5):



Within-habitat diversity

Between-habitat diversity



Minnesota DNR/Tom Klein

Regional diversity

***Figure 5.*** *Diversity at different scales. An important biological consideration is the meaning of diversity at the landscape scale. It is helpful to look at a definition for the different scales of diversity.*

- within-habitat (or stand): diversity within a relatively homogeneous habitat; often measured by the number of species.
- between-habitat (or stand): diversity measured by the change in species composition between habitats; or number of species that are added when additional habitats are sampled across a forest gradient.
- regional: diversity measured by number of species in a large area containing many different kinds of habitats.

These definitions seem counter to the emphasis on process and function as part of biodiversity, but they are used to establish an easy way to measure biodiversity, which is done by counting some element at a defined scale. More sophisticated approaches have yet to be developed.

The emphasis in the past has been on enhancing diversity at the stand scale, usually measured by species richness (number of species). With the increased evidence of the detrimental effects of fragmentation that benefit forest generalists at the expense of specialists, the focus for enhancing diversity has widened to include both between-habitat diversity and regional diversity (Figure 6). Encouraging between-habitat diversity involves maintaining a variety of patch size distributions and successional and compositional stages. Strategies to maintain regional diversity focus on rare species and communities that might otherwise be overlooked. Addressing biodiversity at these scales is a critical component of landscape-level plans.

## Landscape Analysis

The goal of landscape-level planning is to perpetuate biodiversity by developing spatially explicit management plans at the landscape level

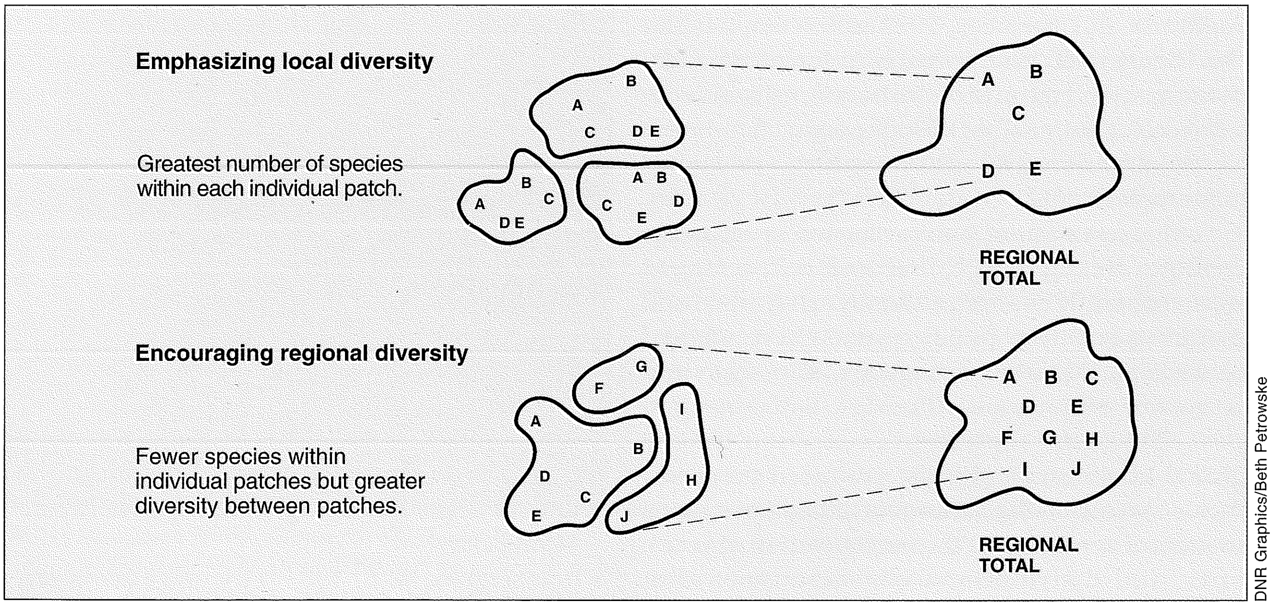



*Figure 6. Maximizing diversity. Most past management emphasis has been on enhancing diversity at the stand scale, usually measured by species richness. Recently the focus has widened to include both between-habitat diversity and regional diversity.*

that define the forest condition (type, age-class distribution, and patch size distribution) over the lifetime of the forest communities. To reach this goal requires landscape analysis that addresses the topics of patch size, fragmentation, conifer composition, mature forest, and riparian zones. The basic tools of analysis are accurate forest-stand descriptions that can be mapped and a geographical information system (GIS) that can model the landscape configurations under different harvest scenarios. Dynamic GIS-based simulation models that can analyze the spatial structure of the forest patch mosaic need to be developed and used.

The challenge for forest managers is to choose the harvest scenario that best fits the landscape's capability for producing habitat and forest products at a level that is sustainable and addresses biodiversity concerns. In confronting this problem papers presented at the International Forest Biodiversity Conference in Canberra, Australia, in December, 1994, often emphasized the theme that "an approach to forest management based on natural disturbance regimes is the most ecologically sound basis for ecosystem-based management" (K. Rusterholz, personal communication).

Conservation of habitat for forest birds fits well into this approach. Because native forests were constantly changed either by aging or natural disturbance, bird populations must have adapted to variable disturbance regimes. The scale and frequency of these disturbances, both pre– and post–European settlement, coupled with the glacial landforms and soils, produced the forest mosaic present today. The most difficult questions to answer are, what is the configuration of patch sizes and distributions of forest types that naturally provided habitat for the state's rich avifauna and how can that configuration be mimicked by management?

To help answer the question of landscape patch size for a particular area, two reference points are useful: the pre–European settlement vegetation (the DNR has digitized information for both the Marschner map [Heinselman 1974] and the original surveyors' notes), and the current vegetation for an ecological unit (e.g., hierarchical unit of an Ecological Classification System) at a resolution that defines forest communities relevant to bird habitat. Examining these two benchmarks gives some sense of the suitability of the landscape for different forest communities and their patch size configurations. It also gives boundaries to the extent of forest change as we know it.

For spatial planning, benchmarks need to be integrated with the results of research on natural disturbance regimes. Kaufmann et al. (1994) have listed the following examples of reference materials that can be used to elucidate past disturbance regimes and patch configurations: palynology, tree rings, archival literature and photographs, historical records, natural areas, potential and existing natural vegetation, and predictive models. Useful references for the results of studies on the dynamics of natural disturbance for Minnesota forests are listed here (full citations appear in the Literature Cited):

- Frelich, L. E. 1992. The relationship of natural disturbances to white pine stand development.
- Frelich, L. E. 1995. Old forest in the Lake States today and before European settlement.
- Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota.
- Heinselman, M. L. 1981. Fire and succession in the conifer forest of northern North America.

Lynn and Donna Rogers

*In the Boundary Waters Canoe Area Wilderness a "natural fire rotation of about 100 years prevailed in pre–European settlement times, but many red and white pine stands remained largely intact for 150 to 350 years, and some jack pine and aspen-birch forests probably burned at intervals of 50 years or less" (Heinselman 1973).*

- Lorimer, C. G., and L. E. Frelich. 1994. Natural disturbance regimes in old-growth northern hardwoods.
- Mladenoff, D. J., and J. Pastor. 1993. Sustainable forest ecosystems in the northern hardwood and conifer forest region.
- Stearns, F. 1990. Forest history and management in the northern Midwest.

The types of disturbance are wind (e.g., common windfall gaps and very rare tornadoes in northern hardwoods) and fire (e.g., low-intensity ground fires and catastrophic crown fires in conifers); the geographical expression of these disturbances is complicated. For example, in the Boundary Waters Canoe Area, Heinselman (1973, p. 329) found that a "natural fire rotation of about 100 years prevailed in presettlement times, but many red and white pine stands remained largely intact for 150–350 years, and some jack pine and aspen-birch forests probably burned at intervals of 50 years or less."

When considering natural disturbance as a template for forest management, it is imperative to bear firmly in mind that the large fires that were the disturbance force for much of the border country left vast residuals in the form of standing dead trees, some live trees, and many unburned patches. Traditional clear-cuts do not replicate fire (see Niemi and Probst 1990), but newer practices that leave residual trees and patches of live vegetation in the harvest site are a much better approximation of fire. The factors that determine viable populations of birds—territory size, dispersal, productivity, abundance (rarity especially), and habitat—need to be overlain on the disturbance regimes (Figure 7); much research is needed on this topic.

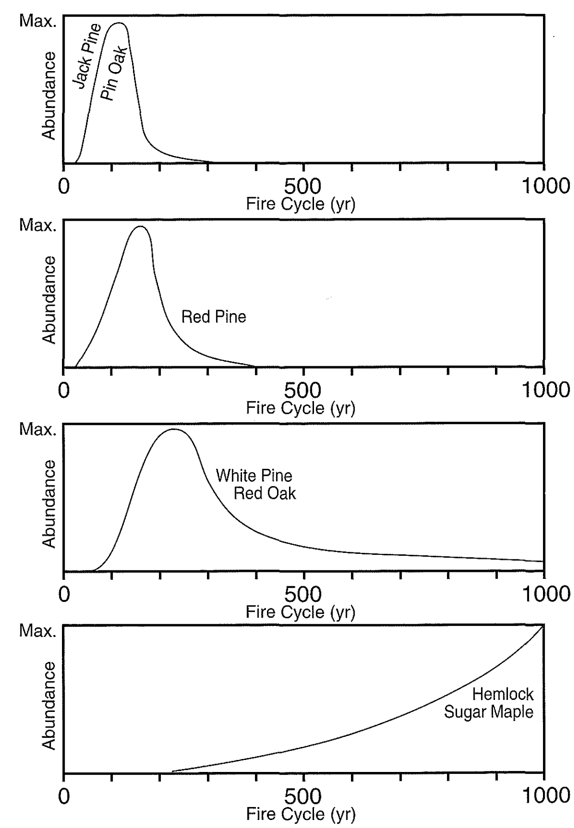
The type of comprehensive forest landscape analysis and planning outlined here has yet to be used in Minnesota, but both the DNR (NW Region

Lynn and Donna Rogers

Steve Wilson

*Clear-cuts (right) do not actually replicate fire. The large fires that were the disturbance force for much of the border country left vast residuals in the form of standing dead trees, some live trees, and many unburned patches.*

*The factors that determine viable populations of birds—territory size, dispersal, productivity, abundance (rarity especially), and habitat—need to be overlain on the disturbance regimes.*




DNR Graphics/Beth Petrowske

***Figure 7.*** *Disturbance regimes. (Adapted from Frelich 1992.)*

Natural Resources Plan) and the U.S. Forest Service (Chippewa NF, Pine Flats Ecosystem Management Area) are experimenting along these lines. Some recent research in Wisconsin that looks at natural spatial patterns can be of assistance in landscape-level planning in managed forests. Two recommended papers are Mladenoff, White, and Pastor 1993 and Mladenoff et al. 1994.

## Patch Size Configuration

Because much of forested Minnesota is naturally heterogeneous due to its glacially created topography, it seems paradoxical that patchiness should be of management concern. It is best to consider it a problem of scale as well as geography. In a forest mosaic molded by glaciers and disturbance there is a variety in the heterogeneity—not all landforms and disturbance regimes operate at the same scale. A pine flat subjected to frequent fires has a different patch configuration than a deciduous moraine where blowdowns create single-tree gaps.

Overlain on the forested topography are the myriad species of wildlife, each with its own habitat requirements for resources (food, cover) and ecological conditions (climate, competitors, predators). These habitats must be well distributed, both in time and space, so that successfully reproducing populations thrive.

The size and juxtaposition of habitat patches required depends on the species. An individual bird species does not range over the variety of habitat types that the large mammalian carnivores (wolves, for example) do, but many species are habitat generalists and are not confined to a single habitat-type of forest. Others, however, are habitat specialists and need, to give an example, mature lowland conifer patches large enough or close enough together to support a breeding population.

The relationship of scale to the issue of habitat diversity was well described by Hunter (1990, p. 82):

*First, on a very small scale, where a single tree could constitute a habitat, diversity is probably greatest in an old forest of mixed species composition in which some of the largest trees are starting to die, thus breaking up the canopy and allowing small groups of younger trees to prosper. Second, on a larger scale, one measured in hundreds of hectares, a mosaic of small stands of different ages and species compositions would have the richest diversity. Finally, on the largest scale, that at which industrial and governmental policy makers operate, forest diversity would be greatest if the landscape were covered by stands of many different sizes (1, 10, and 100 ha), ages, and species compositions.*

Many configurations of cutting patterns are possible. As examples, some common methods of allocating harvest units and their strengths and weaknesses are described (Figure 8):

- Dispersed: many small units of varying ages, usually created by 10- to 40-acre clear-cuts, producing a quiltlike pattern. When applied to a homogeneous landscape or uniform habitat type, this method produces an unnatural Swiss cheese effect that results in habitat fragmentation with unknown consequences.
- Clustered: large units, usually replicating fire-generated disturbance but seldom more than 100- to 200-acre clear-cuts, although larger patches are sometimes used if justified by ecological conditions. These large clear-cuts are controversial because of aesthetic and wildlife considerations and need a very good analysis on a large landscape basis before they are put into place. This landscape analysis should also represent the pattern of what is not being cut.

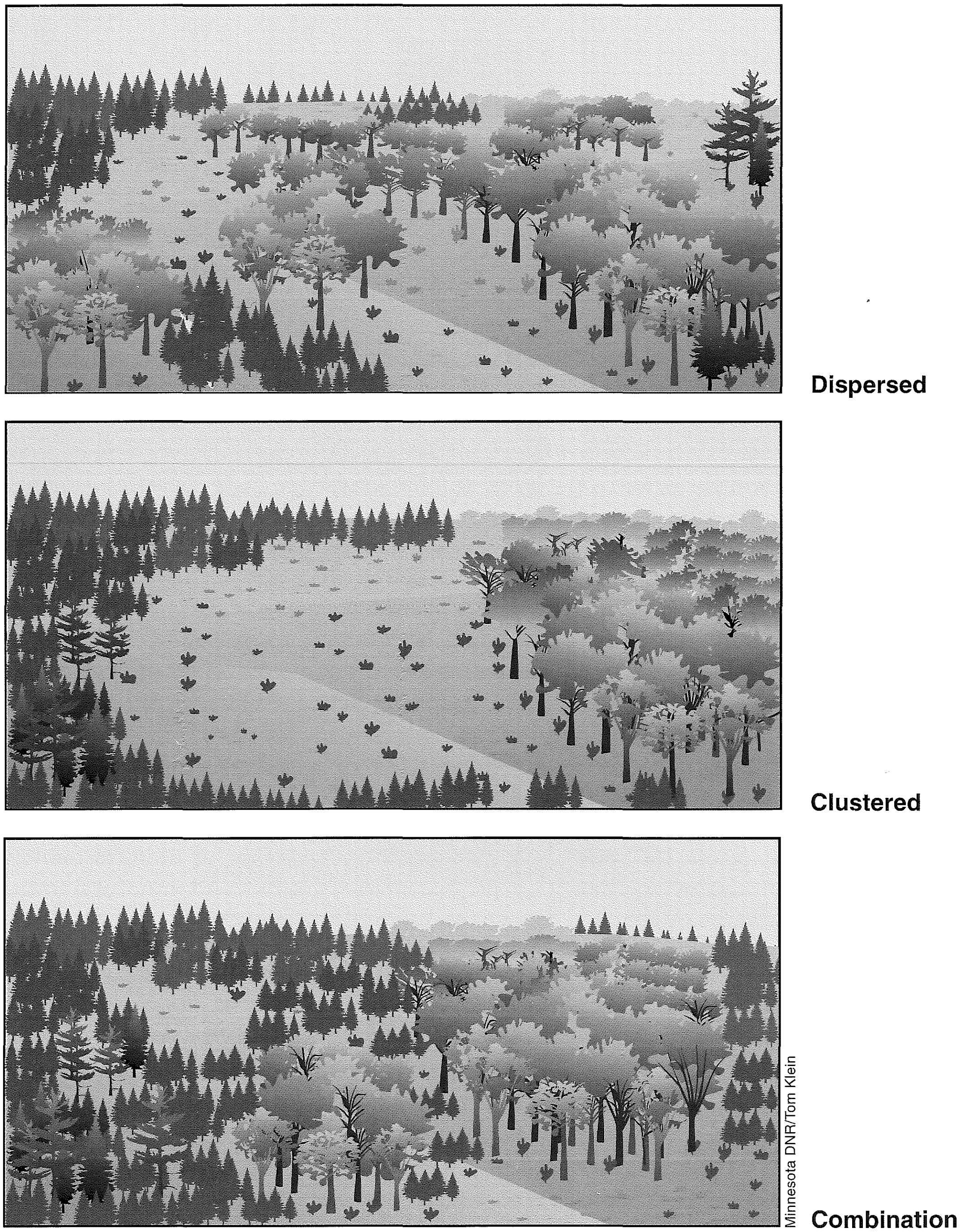



*Figure 8. Patch size configuration*

Large harvest units need to use the placement of residuals to mimic fire disturbance.

- Combination: a mixture of small as well as large treatment units attempting to capture a range of diversity in the absence of an obvious natural template to determine the appropriate scale.

It is also important that a management strategy takes into account both a suitable silvicultural practice (e.g., selection cut, patch cut, shelterwood, or thinning) as well as the allocation of the size and juxtaposition of harvest units over time. Preliminary background investigation should be done to determine which strategy is appropriate in which landscape context and for which species and community types. There is obviously room here for experimentation with monitoring of results and modification of practices as needed.

Another perspective on size, configuration, and dispersion of patches is presented in an amendment to the Chippewa National Forest's plan (U.S. Forest Service 1994): "The objective is to create relatively small well-dispersed stands which closely coincide with topographic boundaries and other natural features and which avoid artificial geometric patterns. Stand boundaries should be aligned with ecological unit boundaries. Forested stands will generally be at least ten acres in size. Nonforested wetlands will be at least two acres and permanent openings at least one acre."

Although ecological or habitat considerations should be foremost in a spatial and temporal plan for harvest scheduling if ecosystem management is the method used, economic and social conditions play a role that may either augment or contradict the ecologically derived desired future condition. For example, some environmentally minded people were shocked at the suggestion in the Generic Environmental Impact Statement (GEIS) technical paper on biodiversity (Jaakko Pöyry Consulting 1992a) to have large blocks of mature conifer forest as Biodiversity Maintenance Areas of at least 75 to 150 square miles created by treatment patches of 10,000 acres, which would be established by clear-cuts with residuals. This proposal mimics the scale of natural disturbance, but the scale is beyond what people are accustomed to seeing.

The planning process should make explicit what economic and social factors are addressed and what their influence is on the final choice of a future forest condition. Aesthetic rationales for small clear-cuts or practical reasons for grouping harvest sites into large patches should be directly stated and go beyond a mere reference to "wildlife habitat." As has been emphasized previously, there is no single type of forest that is better or worse for all wildlife. Managed forests are a mixture of ages, compositions, and patch configurations that with good planning can replicate a natural system.

The dilemma of balancing objectives was summarized by Hunter (1990, p. 100) as follows:

*Because there is such a great variety in the home range sizes of various organisms, spanning 8 to 12 orders of magnitude, it is important that forests be managed at a variety of scales. This will involve making silvicultural decisions on a landscape basis, not just stand by stand. Ideally, the management regime should range from the very fine-scale management represented by selection cutting to the coarse-scale management effected by sizable clearcuts. The maximum size of clearcuts should be determined by considering issues such as size of the management unit, the home range requirements of large animals, aesthetics, nutrient loss, and natural disturbance regimes. If wildlife managers condemn clearcuts as bad for wildlife, and foresters write off selection cutting as* *uneconomic, public policy and law may arrive at a compromise strategy that will promote the extensive use of small clearcuts. A forest managed in this fashion will lack an important component of structural diversity—spatial heterogeneity.*

This passage speaks more to mammals than to birds but the conclusion, especially the last sentence, is equally important for both.

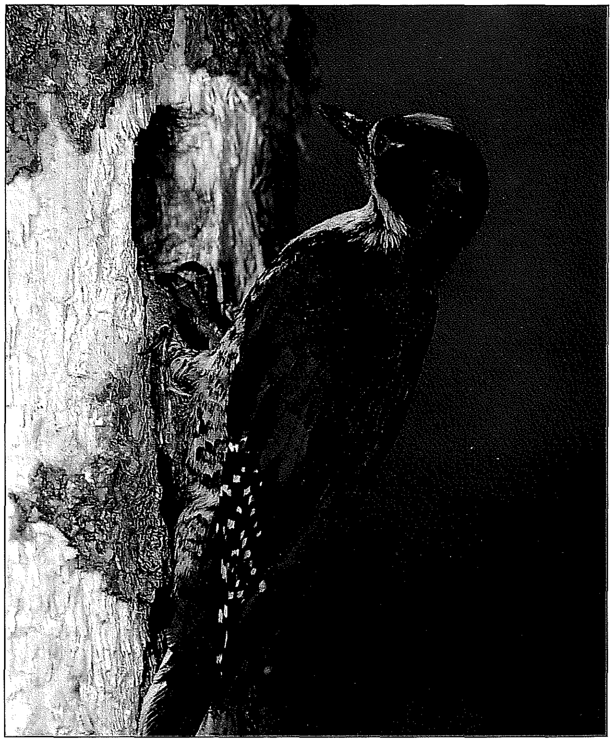
## Population Dynamics

The spatial heterogeneity in forests determines the spatial dynamics of a species' population. What constitutes a population is the key question: "A biological population is a cluster of individuals with a high probability of mating with one another as compared with the probability of mating with members of other populations. . . . A collection of interacting populations, linked through dispersal, is known as a metapopulation" (Ruggiero et al. 1994, pp. 366–67).

It is easy to say that a viable population means one that continues to exist over long time periods in a specified area, but quantifying either the geographical scale or the number of individuals is much more difficult. For birds in northern heterogeneous forests there are not even any estimates. Moreover, little is known about how spatially interactive breeding pairs need to be.

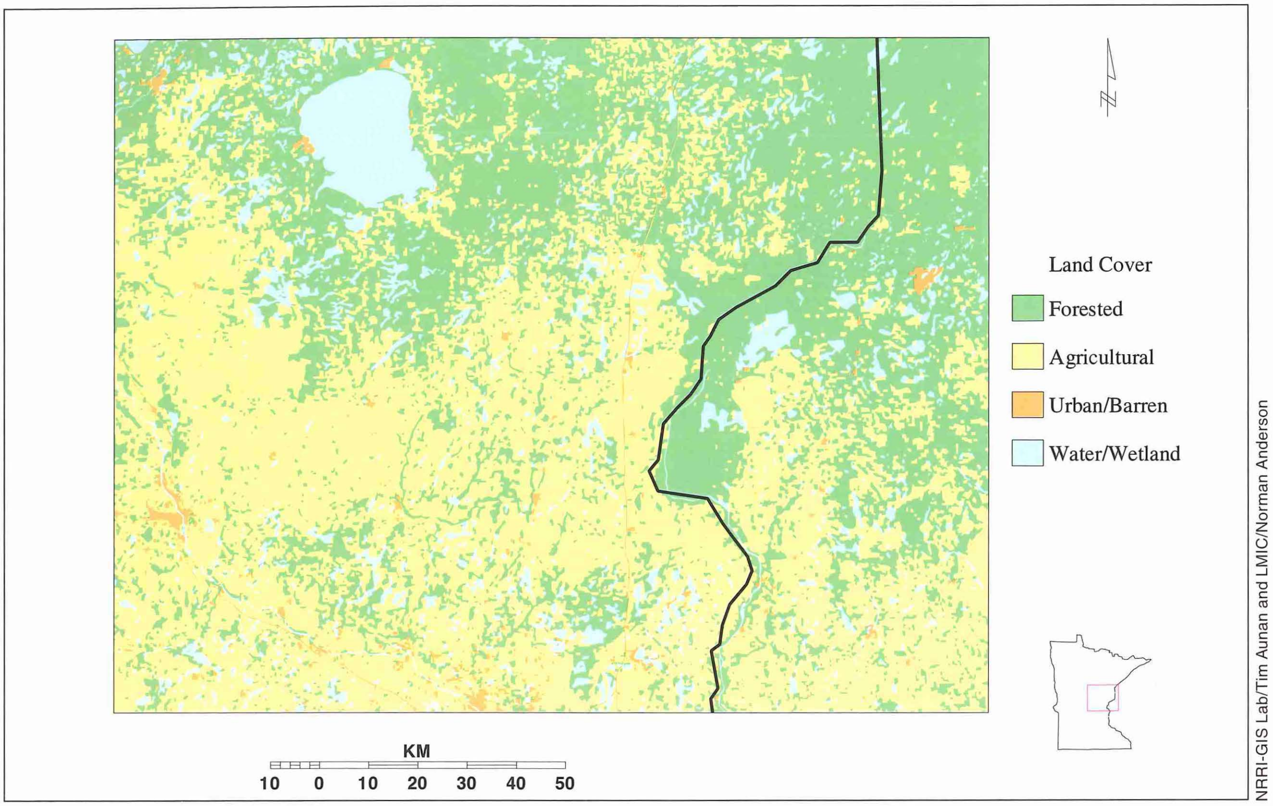
There is a lot of research on the persistent site fidelity of adult breeding forest passerines but little about dispersal of young birds from the site where they were hatched. In the vast expanse of forest it is very difficult to find banded first-year birds who have established breeding territories removed from the natal site where the banding took place. The best information on dispersal distance for warblers comes from intensive studies of the Kirtland's Warbler in Michigan, where some first-year birds established territories in the local area (up to 1.6 km [1 mile]) whereas others traveled as far as 33 kilometers (20.5 miles) (average 20.4 km ± 12.6 km [12.7 miles ± 7.8 miles]) from where they were hatched (Walkinshaw 1983). Obviously, great difference in dispersal behavior exists among individuals and probably among species as well. The importance of dispersal coupled with habitat suitability to population demographics remains unknown.

Habitat sufficient to maintain persistent breeding populations is unlikely to be a problem for habitat generalists and for species that are adapted to disturbed forest landscapes. But for habitat specialists or those that are area-sensitive or require large territories, the problem of providing large enough habitat blocks becomes more difficult in the face of harvesting that is



Tom J. Ulrich

*The Black-backed Woodpecker is an example of a habitat specialist dependent on large patches of conifers, including many that are dead or dying.*




***Map 10.*** *Forest fragmentation in east-central Minnesota. (Data from U.S. Geological Survey 1976.)*

rapidly changing the spatial configurations of forest area, type, and age. The Barred Owl is an example of an area-sensitive species that needs large contiguous habitat areas. The Black-backed Woodpecker is an example of a habitat specialist dependent on large patches of conifers (many of which are dead or dying). More information about territory size can be gleaned from the life-history data in appendix B, in which body size serves as a surrogate for territory size (see chapter 3).

## Fragmentation

Several parts of the state show the dominant pattern of mixed agriculture and forest land that constitutes forest fragmentation, as was discussed in chapter 3. The following will expand on that discussion in relation to landscape-level planning. The issues surrounding habitat fragmentation will be addressed in the sections on conifer-dominated landscapes and contiguous mature forests.

Map 9 (southeastern Minnesota; see chapter 2) and Map 10 (east-central Minnesota) illustrate the pattern of forest fragmentation. Other areas where fragmentation of formerly contiguous forest occurs are the southern and western fringes of the north-central region, the North Shore near Duluth, and the Mesabi Range. These areas in the state are the type of landscape that has been studied in the eastern United States, where the deleterious effects of fragmentation on many bird species have been demonstrated. Specific landscape-level guidelines, providing the size of

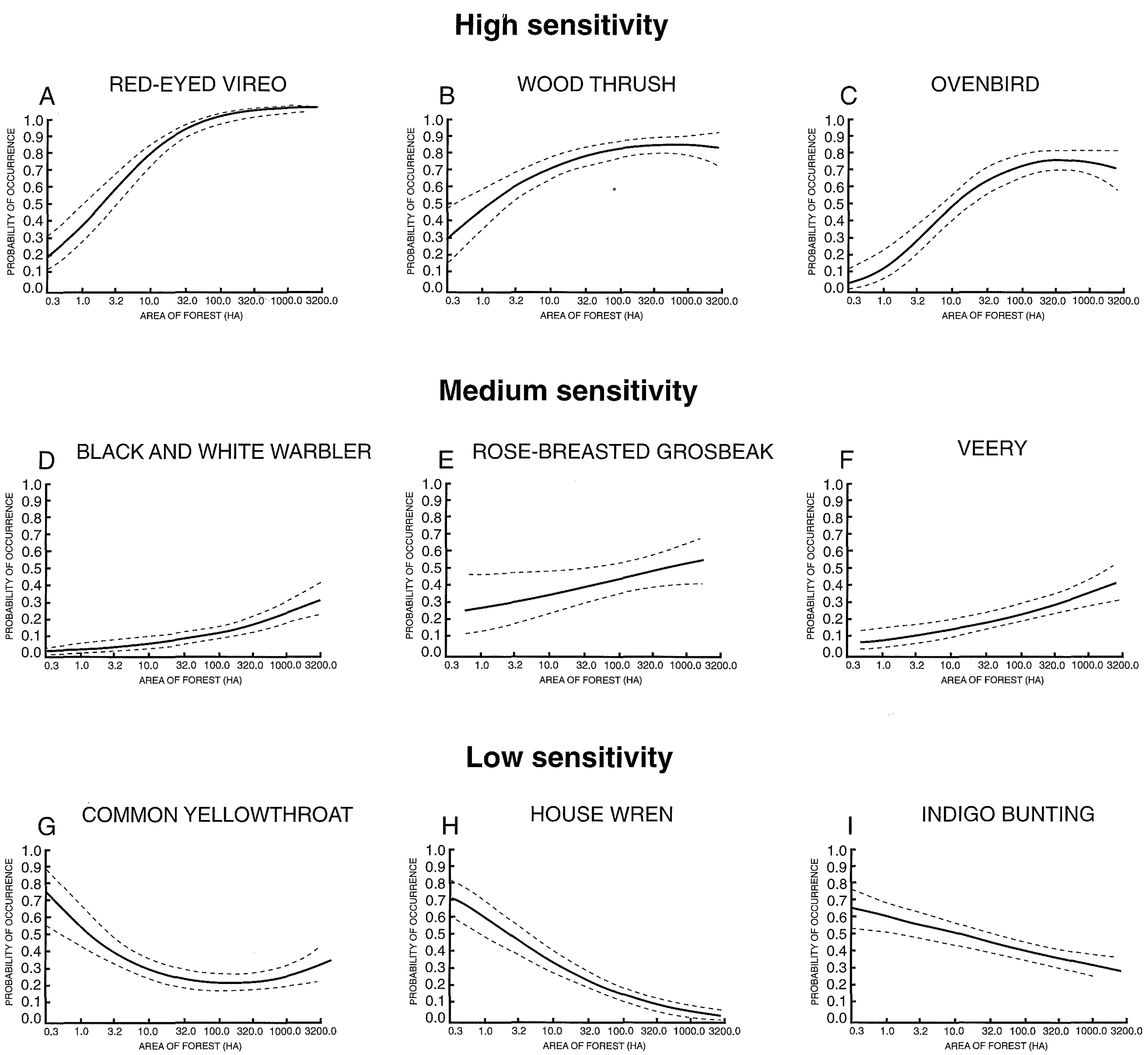



*Figure 9. Degree of area sensitivity of several bird species. (Reprinted from Robbins, Dawson, and Dowell 1989, by permission of the Wildlife Society. All rights reserved.)*


*Cowbirds feed in open areas, often feedlots, pastures, mowed rights-of-way, or campgrounds, and fly to forests to search for nests to parasitize. One way to assess the risk from "cowbird edge effect" in fragmented landscapes is to monitor the abundance of cowbirds.*

a forest patch needed by many species for successful breeding, were formulated from the results of a study done in Maryland (Robbins, Dawson, and Dowell 1989). Most of the species in the study are also present in southern Minnesota. The size of an area with the maximum probability of occurrence for most of these forest species was determined to be 3,000 hectares (about 7,000 acres)—this represents the contiguous forested condition where persistence of a breeding population is considered secure. When the probability of occurrence in a forest patch is reduced by 50%, there is a gradation in individual species' response, indicating their sensitivity to area and edge effects. Examples from Robbins, Dawson, and Dowell (1989) are shown in Figure 9. These diagrams show the size of a contiguous forest necessary for the persistence of species sensitive to forest fragmentation. They also illustrate the differences in the response to forest area by different species.

One major influence on the breeding success and hence the persistence of many forest species is parasitism by the Brown-headed Cowbird. There is much variability in the impact of cowbirds on breeding success of other birds depending on the extent of the fragmentation of the landscape and the abundance of cowbirds. Some agricultural landscapes are saturated with cowbirds, but others, although fragmented, have lower populations. Cowbirds feed in open areas, often feedlots, pastures, mowed rights-of-way, or campgrounds, and fly to forests to search for nests to parasitize. The distances that cowbirds fly from roosting to feeding to breeding sites have been found to be as great as 6 to 7 kilometers (about 4 miles) (Robinson et al. 1993), showing that landscape context and agricultural practices are important factors in cowbird abundance. One way to assess the risk from the "cowbird edge effect" in fragmented landscapes is to monitor the abundance of cowbirds as part of a bird monitoring program.

The other area in the United States where fragmentation of forests by agriculture or development has been intensively studied is in the Midwest. A summary of many research projects was published in *Science* (March 31, 1995). The study areas were in Wisconsin, Missouri, Illinois, and Indiana, and the report gives statistics on the size of the forest area and its relation to breeding success for nine forest birds. The results of the studies (Robinson et al. 1995) showed that cowbird parasitism was negatively correlated with percent forest cover for all species and that correlations were significant for five of the species (Indigo Bunting, Ovenbird, Red-eyed Vireo, Worm-eating Warbler, and Wood Thrush). In addition, the levels of nest predation declined with increasing forest cover for all species. The landscapes studied have analogs in Minnesota both for fragmented forests and contiguous forests. Thus, the researchers' conclusions have relevance for landscape-level planning (Robinson et al. 1995, p. 1989): "Our results suggest that a good regional conservation strategy for migrant songbirds in the Midwest is to identify, maintain, and restore the large tracts that are most likely to be population sources. Further loss or fragmentation of habitats could lead to a collapse of regional populations of some forest birds." In Minnesota some of the fragmented landscapes at risk were identified earlier. The largest areas of contiguous forest are in the North, North-central, and Northeast Ecoregions.

In designing land-unit harvest plans or other development in areas of mixed land use, the concern about fragmentation can be addressed through answers to the following questions (modified from Frost 1993):

- How much will the proposed activities fragment existing contiguous forest habitats?
- How much forest fragmentation has already taken place in the regional landscape?


Janet C. Green

*A distinctive characteristic of the forests in northern Minnesota is the dominance of conifers in many communities such as the mixed conifer uplands of the northeast (Northern Superior Uplands Section).*


Janet C. Green

*The spruce-fir type of conifer forest, which has its best expression in Cook, Lake, and northern St. Louis Counties, can exist as fairly pure stands in lowlands or be mixed with other conifers and boreal deciduous trees.*

- Are the ecological changes associated with edge effects in forest habitats analyzed?
- What is known about predator and cowbird abundance?
- Is a minimum fragmentation alternative possible that retains large blocks of habitat with functional linkages between them?
- Is adequate consideration given to those species that are most vulnerable to the negative effects of forest fragmentation? Are they rare and will viable populations persist?

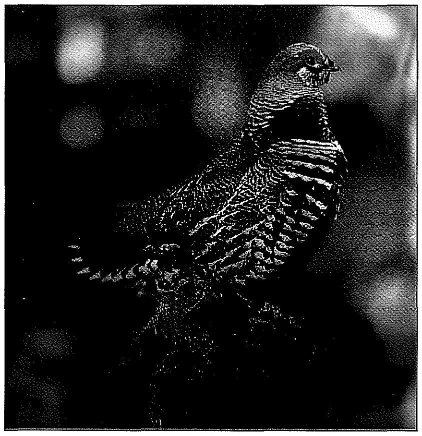
## Conifer-Dominated Landscapes

A distinctive characteristic of the forests in northern Minnesota is the dominance of conifers in many communities such as the large areas of lowland conifers, the pine flats, and the mixed conifer uplands of the northeast (Northern Superior Uplands Section). In the other upper Great Lakes states the conifer component is not as great. The expanses of both open- and closed-canopy lowland conifers (black spruce and tamarack) that have developed on the former glacial lake beds are a particularly distinctive Minnesota feature. Jack pine also occurs in extensive stands on coarse glacial deposits in the north-central area (Pine Moraines and Outwash Plains Subsections) and on bedrock ridges in the northeast (Border Lakes Subsection). The spruce-fir type, which has its best expression in Cook, Lake, and northern St. Louis Counties, can exist as fairly pure stands in lowlands or be mixed with other conifers and boreal deciduous (aspen, birch) trees.

These forests also account for the fairly lengthy list of conifer-dependent birds in Table 10 (see chapter 3). Pearson (1994) has shown that the percentage of conifers in a stand required for these species varies. Winter Wren, Black-throated Green Warbler and White-throated Sparrow find mixed conifer stands (40–70% deciduous) suitable for breeding. Another species group, however, required more conifers (>70%) in the stand: Red-breasted Nuthatch, Brown Creeper, Golden-crowned Kinglet, Swainson's Thrush, Hermit Thrush, Nashville Warbler, Northern Parula, Magnolia Warbler, Blackburnian Warbler, and Chipping Sparrow. There are probably several other species that belong in this group, but they were not numerous enough to show up in the stands Pearson selected for analysis. Common habitat descriptions from the literature and personal experience would add to the list these passerines: Gray Jay, Boreal Chickadee, Ruby-crowned Kinglet, Solitary Vireo, Cape May Warbler, Yellow-rumped Warbler, Pine Warbler, and Bay-breasted Warbler. Spruce Grouse also fits here. Most importantly, Pearson's study determined that these highly conifer-dependent species were more likely to occur in a stand if there was extensive conifer forest surrounding the stand.

The key question, then, is how much can conifer-dominated habitats be fragmented by harvests that create patches of early-successional deciduous trees before there is a detrimental effect on the populations of birds that require conifers? This question about habitat fragmentation has yet to be answered. The only way now to determine these thresholds is to understand what the natural landscape contained for coniferous forest types and how contiguous that habitat was. Birds need enough suitable habitat for a population to thrive; small fragments separated by unusable forest are probably not sufficient for short-lived birds.

The issues discussed previously under area effect come into play here. In harvest-schedule plans care must be taken to avoid fragmenting a conifer-dominated landscape to such an extent



Steve Wilson

Tom J. Ulrich

Lynn and Donna Rogers

VIREO/H. Clarke

*The coniferous forests of northern Minnesota contribute to the state's unique avian diversity by supporting populations of conifer-dependent species like the Spruce Grouse (top left), Swainson's Thrush (top right), Magnolia Warbler (middle), and Nashville Warbler.*

that the remaining habitat patches are too small for conifer-dependent birds. If the stand is to be regenerated to conifers and large areas of mature conifer forest remain in the landscape, there should be sufficient area of habitat for conifer-dependent species. But providing suitable coniferous habitat may be a problem in other areas because of the successional nature of the dominant spruce-fir/aspen-birch type. Mature mixed forests with a large conifer component are often succeeded by a young aspen-dominated stand when harvested. Consequently, a patch configuration of conifer forest should be created by the harvest design so that enough suitable habitat remains for conifer-dependent species.

## Contiguous Mature Forest

The best evidence available shows that about 50% of the original forests of Minnesota were old growth (Jaakko Pöyry Consulting 1992a). This figure is an average of all the closed-canopy forest types. Individual communities varied in their proportion of old growth: jack pine, 9%; swamp conifers, river-bottom hardwoods, and boreal conifer-hardwoods, 41% each; red-white pine, 55%; and northern hardwood/maple-basswood, 89%. Only about 4% old growth remains in Minnesota now. The definition of old growth used for this analysis is stands older than 120 years, except for boreal conifer-hardwoods, which is older than 90 years.

In spite of this dramatic change in forest age, no species of forest birds (with the exception of the Passenger Pigeon of the oak forests) has disappeared since European settlement. If one uses the definition of old growth adopted by management agencies (DNR) of white/red pine and northern hardwoods types older than 120 years, there do not seem to be any species in these northern forests that are old-growth obligates (Green 1992; Taylor 1990). This situation contrasts starkly with the situation in the Pacific Northwest, but it is not surprising considering the shorter intervals of disturbance here and the younger age of the ancient trees (white pine longevity is about 350 years; white cedar may be 500 years). Birds have likely adapted to this relatively rapid forest change.

However, late-successional forests, also called mature or "old forests," have attributes important for some species, for example, the vertical, layered structure of a mature to old-growth deciduous forest or the conifer component of a mature boreal hardwood forest. This structural complexity is part of the "understory re-initiation phase of stand development" that follows the "stem exclusion phase" where a dense closed canopy does not allow for a well-developed shrub or sapling understory (Frelich 1995). The increased vegetational layers and gaps of mature forests are important habitat components for bird species richness. Sixty-five species were identified as "mature forest" species in the GEIS technical paper on wildlife (Jaakko Pöyry Consulting 1992b).

The best expression now of a contiguous mature upland forest, predominantly deciduous, is the North Shore Highlands (ECS subsection). Formerly, the maple-basswood forest of the "Big Woods" was also an extensive mature upland forest, but only tiny patches remain after extensive agricultural and suburban development. The northern hardwood forests near Leech Lake and Lake Winnibigoshish (Chippewa Plain subsection) also display these characteristics. An analysis of patch configuration of the northern ecoregions at the subsection level that used 1976 land-use data showed that the North Shore Highlands had the largest mean patch size and the lowest number of patches of any of the subsections (Mladenoff, White, and Polzer 1993). This quantitative result confirms what is experienced observing the hills along the North Shore.

William Penning

VIREO/W. Greene

VIREO/W. Greene

Maslowski Photo

*Several species reach their highest densities in mature deciduous or mixed upland forests, including the Red-eyed Vireo (immature, top left), Black-and-white Warbler (female, top right), Ovenbird (bottom left), and Black-throated Green Warbler.*

The birds in these forests, however, are not as distinctive, although several species reach their highest densities in mature deciduous or mixed upland forests. When both these upland forest types are examined in Minnesota (Hawrot et al. 1994) and elsewhere (DeGraaf 1991; Taylor 1990), a suite of species is highlighted as indicative of mature forests (Table 14).

Only the Black-throated Blue and Cerulean Warblers are rare. This is not a signal, however, that the contiguous nature of these mature forests is unimportant. We just do not know what size thresholds for patch or area might be. The question about area effect posed for habitat fragmentation of conifer forests also applies here. Individuals of a species need to interact to form a breeding population. What the geographical scale of that interaction should be for contiguous mature forests is unknown.

**Table 14.** *Species associated with mature forests*

| |
|---|
| Pileated Woodpecker |
| Least Flycatcher |
| Veery |
| Wood Thrush |
| Solitary Vireo |
| Red-eyed Vireo |
| Black-throated Blue Warbler |
| Black-throated Green Warbler |
| Blackburnian Warbler |
| Cerulean Warbler |
| Black-and-white Warbler |
| Ovenbird |

*Sources:* Hawrot et al. (1994); DeGraaf (1991); Taylor (1990).

## Riparian Zones

Forest management for riparian areas should be addressed at the landscape level because many species require the special habitat types (e.g., floodplain forest, lowland conifers) that occupy the riparian zones. Stand-level considerations, like providing and protecting nest sites, are important, however, and will be discussed in chapter 6.

At the landscape level the important goal is to plan for maintaining riparian habitat especially where it is critical for rare or riparian obligate species or where forests are found mostly along water bodies. The latter situation obviously occurs in the agricultural/prairie ecoregions (SW and W; see Map 2), but it also occurs in the Southeastern and Central ecoregions (see Maps 9 and 10) where development pressure from suburbs, second homes, and agriculture is heaviest. The loss of riparian habitat in these ecoregions, most of which is private land, affects these forest-dependent species: colonial waterbirds (all six species), two

Richard Hamilton Smith

*Riparian habitat should be maintained, especially where it is critical for rare or riparian obligate species or in regions where forests are found mostly along water bodies, such as in the southeastern and central ecoregions where development pressure is heaviest.*

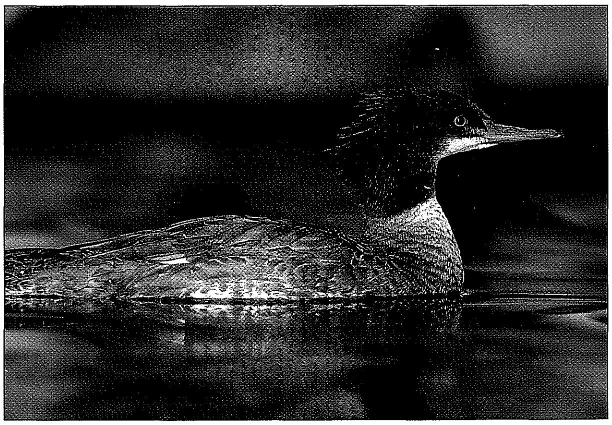
species of ducks (Wood Duck, Hooded Merganser), a few raptors, and some passerines that are habitat specialists in the riparian zone.

Raptors that are affected include both eagle and osprey, which could occur in these regions if adequate habitat existed, and, additionally, the Barred Owl and Red-shouldered Hawk, which use the mesic, mature forests found adjacent to water bodies. The Red-shouldered Hawk is a state species of special concern, as is the Louisiana Waterthrush, a riparian habitat specialist in the Southeastern and southern Central regions. Another obligate riparian species in the southeast is the Prothonotary Warbler, the only hole-nesting warbler. Two other passerines, the Yellow-throated Vireo and Warbling Vireo, are found preferentially in mature bottomland forests in both the prairie and agriculture-transition areas. A study in the central Appalachians also identified the Acadian Flycatcher and Louisiana Waterthrush as two species that were closely associated with riparian habitats (Murray and Stauffer 1995).

Providing adequate habitat for all these species in the ecoregions subjected to acute development pressure on a land base that is mostly privately owned is one of the biggest challenges for landscape-level planning. Meeting the challenge will take firm leadership from public agencies responsible for natural resources as well as many cooperative endeavors with landowners and other units of government. One opportunity is to plant deforested floodplain areas with trees for energy or commodity production using species, rotations, and planting configurations that will provide habitat benefits.

Because of the large forested and publicly owned lands in the northern ecoregions, the loss of riparian forests is not as dire there. In addition to the species already mentioned for the southern regions, three other hole-nesting ducks (Common Goldeneye, Bufflehead [very rare], and Common Merganser) and one riparian obligate passerine (Northern Waterthrush) occur in the north and need good-quality riparian habitat.

To assess the vulnerability of riparian birds to changes in the amount of timber harvest, an analysis was done by Hanowski and Niemi (1994a) that used the forest change model developed for the GEIS in conjunction with an avian habitat model. They reported that "up to 10 riparian bird species were projected to significantly decrease (> 25% change in numbers) in the Lake Superior region with the present level of forest harvest (about 4 million cords/year). Thirteen species were projected to decline if harvest levels were to increase to 4.9 million cords/year. . . However, if no clear-cutting occurred within 100–200 feet of water only one species was projected [to decline] under the present harvest level, and two at the medium and high harvest regimes" (p. 84). These modeled results are not a prediction, but they do highlight the sensitivity of riparian species to the age and composition of forests adjacent to water bodies. One way to preserve these habitat values is to use silvicultural practices to maintain a closed-canopy forest with some old supercanopy trees in a riparian buffer that is tailored to the landscape and habitat condition.

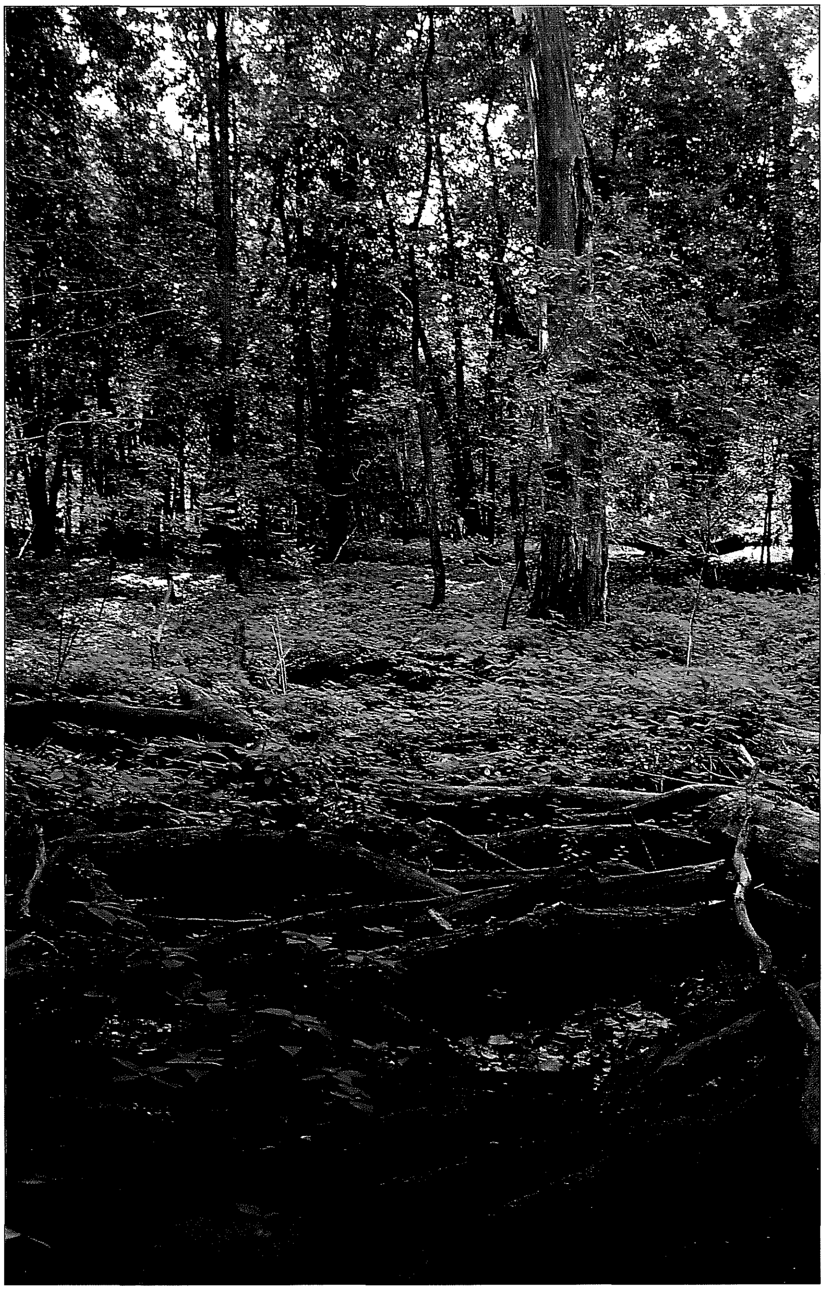

Lynn and Donna Rogers

*Common Merganser (female).*

Stephen J. Maxson

Scott W. Sharkey

*The Common Merganser (facing page), Red-shouldered Hawk (immature, top), and Barred Owl, are riparian species.*



Minnesota DNR/D. Wovcha

*The loss of riparian habitat in the southeastern and central ecoregions affects six species of colonial waterbirds, two species of ducks, a few raptor species, and some passerines that are habitat specialists in the riparian zone.*


*Riparian forests, particularly lowland conifers, provide needed habitat for some conifer-dependent species like the Boreal Chickadee.*

Riparian forests, particularly lowland conifers, also provide needed habitat for some conifer-dependent species (Boreal Chickadee and Bay-breasted Warbler are examples) in areas where upland, nonpine coniferous habitat is rare. It is difficult to define how wide this coniferous riparian habitat strip should be; the only published study in a boreal forest concluded that "there was evidence that 60-m-wide [200-ft-wide] strips are required for forest-dwelling birds" (Darveau et al. 1995, p. 67). Making sure that this habitat, as well as mature lowland deciduous forest, is well distributed across the landscape over the long term is a necessary planning activity.

Because riparian zones are often linear, the concept of corridors and connected landscapes comes into play. There is much debate about the utility of this idea. Its application is dependent on the species of interest and the scale at which it is contemplated. For forest birds, forested corridors seem most useful in agricultural landscapes, linking patches of woods that are surrounded by inhospitable farmland. Providing travel corridors between cut-overs in heavily forested areas does not seem as useful, because forest birds have the ability to fly and find suitable habitat patches in the less-forbidding landscape matrix of a managed forest.

The current thinking about the role of corridors was nicely presented by Morrison et al. (1992, pp. 57–58): "Much has been written on recommending corridors as part of habitat conservation plans, but much empirical data on use of corridors is circumstantial or absent. Intuitively, the notion of connecting patches at various scales with various structures of vegetation and other environmental elements is a good one, but more studies are needed to determine which types of corridors function as assumed for various species, habitats, and landscape contexts."

Managing for riparian zones very much depends on the geographical context. Linear floodplain forests in the west, northwest, southwest, and southeast ecoregions, especially those that traverse an agricultural upland, provide critical habitat for many forest species. Wildlife trees, big trees, and a mature canopy are very important features to maintain. In the contiguous forest of the northeast and north-central ecoregions, the habitat condition surrounding rivers and headwater streams is more varied. No single planning guideline can fit all cases.

## Chapter 6

# Stand-Level Recommendations

As the preceding chapters have emphasized, creating diverse landscapes of different forest-type composition, ages, and patch sizes produces an array of habitat conditions for the diversity of forest birds. The same generalization about diverse forest conditions can be applied at the stand level as well, except here the emphasis is on diversity of vegetation structure, composition, and micro-habitat features. It will also be apparent that it is difficult to draw an exact distinction between diversity at the landscape level and at the stand level. Some specific suggestions follow, many of them familiar, but presented here with forest birds as examples. A more expansive list of recommendations can be found in Crow et al. 1994, Report on the Scientific Roundtable on Biological Diversity Convened by the Chequamegon and Nicolet National Forests.

### Plantations

Plantations differ, ranging from those of a single species and uniform structure to those with compositional and structural variations that are similar to natural stands. Intensively managed conifer plantations typically have no understory or shrub layer. Consequently, the birds that inhabit these stands at the pole-timber or older stage are a small suite of canopy-dwelling conifer-dependent birds plus some ubiquitous generalist species. The typical number of species in a stand is 6 to 15; the following birds are usually present: Blue Jay, Black-capped Chickadee, American Robin, Cedar Waxwing, Brown-headed Cowbird, and Chipping Sparrow (Hoffman and Mossman 1990). This list would be larger if the plantation were imbedded in a more natural forest of stands of mixed deciduous/coniferous composition, where birds in the more varied forest could use the plantation as part of their breeding habitat.

The addition of deciduous shrubs and saplings can increase the species richness to 20 to 35 species. This addition can either be part of


*Intensively managed conifer plantations typically have no understory or shrub layer. Consequently they are used only by a small suite of canopy-dwelling conifer-dependent birds and some ubiquitous generalist species.*


*The addition of deciduous shrubs and saplings can increase the species richness of conifer plantations to 20 to 35 species. This addition can happen either as part of the plantation design or be the result of thinning or neglect in overmature stands.*

the plantation design or the result of thinning or neglect in overmature stands that have started to break apart. There are no quantitative studies in this part of the United States to indicate what the proportion of these deciduous admixtures should be for any species richness or compositional goal. The report by Crow et al. (1994, p. 31) offers the following suggestion:

*Manage pine plantations to maintain greater diversity in composition and structure. Goals include a more open canopy (with a greater diversity of tree sizes and species, at least in red pine stands), natural tree regeneration, and adequate light to support shade-intolerant herbs and shrubs characteristic of jack and red pine stands. Management of established plantations might include thinning substantial fractions of the canopy at long intervals, or prescribed burning. In addition, new plantations might be planted at lower densities, with admixtures of other canopy species.*

The thinning of natural stands can also be designed to leave deciduous trees and gaps for shrubs to provide added vegetational diversity.

A study of 35- to 50-year-old plantations (Bielefeldt and Rosenfield 1994) that had received minimal management in southeastern Wisconsin found 59 species of breeding or summering birds, including 30 regionally uncommon-to-rare and/or area-sensitive species. The benefits of these plantations were at both the stand and landscape level and were related to the following factors: direct provision of large amounts of upland coniferous habitat, consolidation of forest cover, interspersion of coniferous and deciduous habitat, and low-intensity management regimes.

Conifer plantations are most useful as bird habitat in areas where the forest cover has been lost (usually to marginal farming) and where low-intensity management can be practiced that allows for deciduous shrubs and trees to be mixed in the stand and/or interspersed in patches.

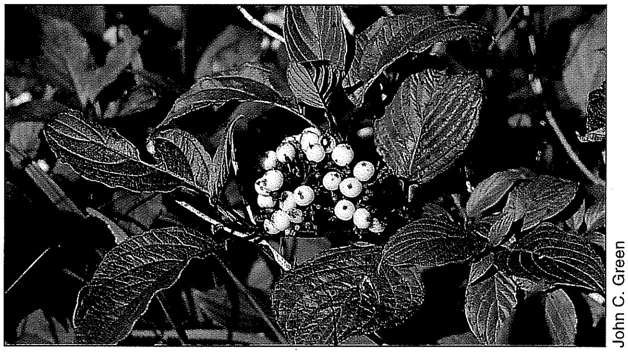
Again, it is important to recognize the landscape context in establishing diversity goals for plantations and to identify which species need habitat enhancement. Generalized "wildlife habitat" has little meaning unless species and habitat type are specified. With that in mind plantations can be managed for a variety of goals. For example, where conifers in the landscape are now scarce as compared to pre–European settlement conditions, some relatively pure conifer or pine stands are desirable as part of landscape diversity.

## Berries and Seeds

Most forest birds, with the exception of raptors and waterbirds, are insectivorous during the breeding season (see appendix B). In appendix B those species that are listed as omnivores consume insects, commonly to feed their young this high-protein food, and also eat summerripening berries and fallen seeds. Even sparrows and finches, whose bills are designed for cracking seeds, have insects as half or more of their diet in the summer (Martin et al. 1951). As the flush of summer insects wanes and as berry bushes ripen, more species turn to this source of food. Thrushes, catbirds and thrashers, waxwings, some vireo species, and many sparrows and blackbirds are observed devouring the common berries. They may depend on them as a premigration food source. The most sought-after berries are often consumed before they have fully ripened.

During late summer and early fall, the most utilized bushes in Minnesota forests are juneberries (*Amelanchier* spp.), dogwoods (*Cornus* spp.), elderberries (*Sambucus* spp.), cherries (*Prunus* spp.) and, of course, blueberries (*Vaccinium* spp.). In one week in mid-August I observed 14 species eating highbush blueberries, including Mallard, Eastern Kingbird, and Yellow-rumped Warbler, species that are not usually thought of as berry-eaters. By mid to late fall these berries are all gone, but highbush cranberry (*Viburnum trilobum*) and mountain ash (*Sorbus americana*) can keep their berries all winter if the crop is good and if the migrant birds do not eat them all. Mountain ash in particular is a choice source of food in winter for northern visitants like Bohemian Waxwing and Pine Grosbeak and, in years when the crop is prolific, for American Robin and Cedar Waxwing as well. Flocks of these latter two nomadic migrants can appear in northern Minnesota in midwinter long after the local nesting birds of these species have left.

These berry-bearing shrubs usually require full sunlight and often occur in the forest where gaps are created from blowdowns, harvest, or poor

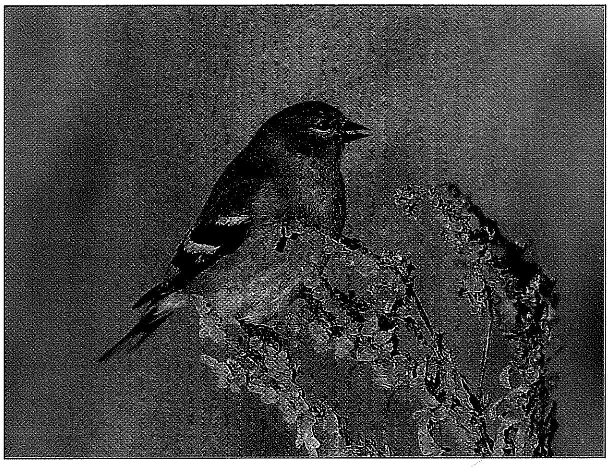






*Juneberries, dogwoods, chokecherries, and blueberries are among the most heavily used fruiting shrubs in Minnesota.*

Lynn and Donna Rogers

*Pine Grosbeaks commonly feed on the seeds of ash trees, ornamentals as well as black ash.*



Bill Marchel

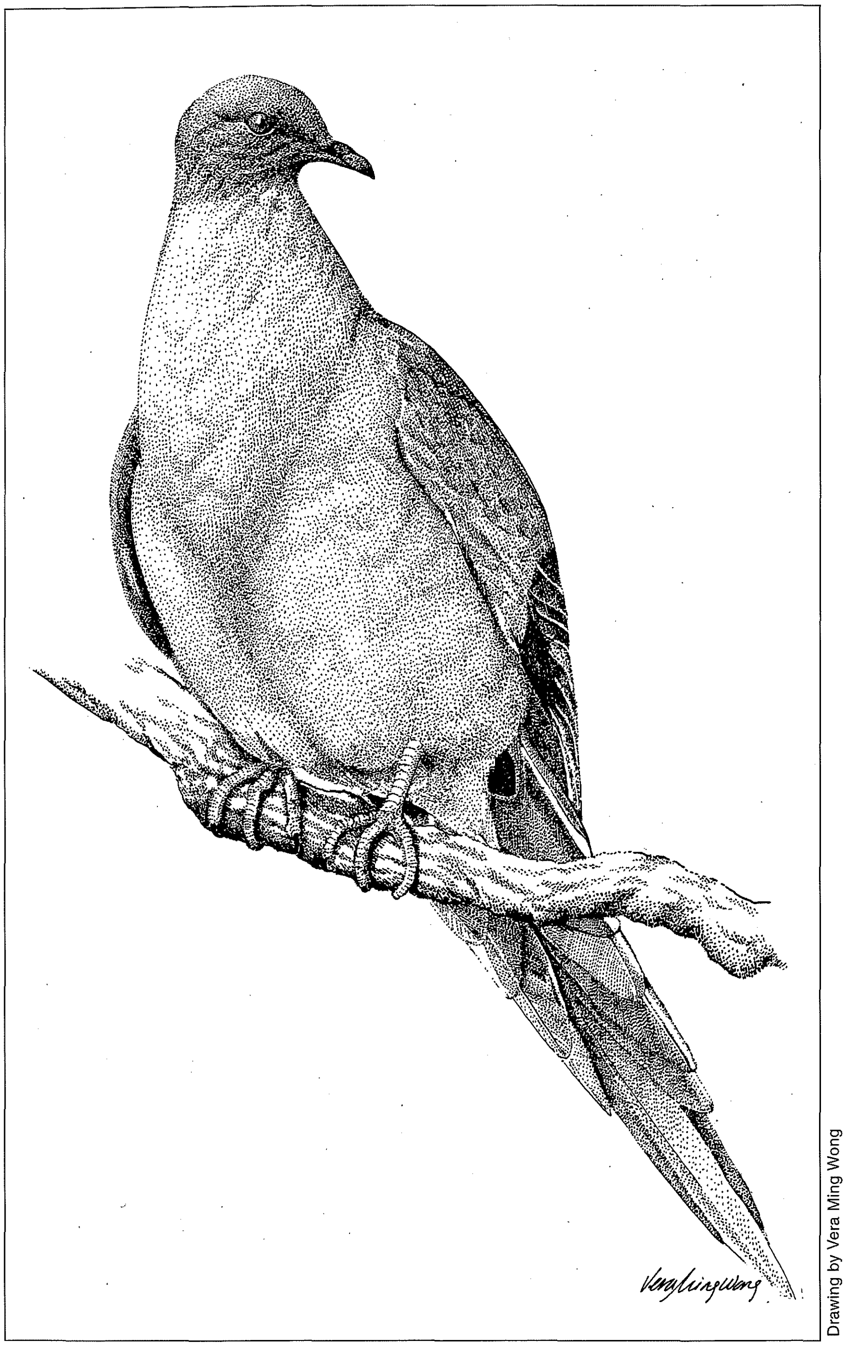
*Small finches like this American Goldfinch feed on alder cones and many weed seeds.*

site conditions. Red osier dogwood (*Cornus stolonifera*) can be abundant in old fields or untreated clear-cuts. On more intensively managed sites all these shrubs should be fostered by more judicious use of herbicides and thinning practices that select for them, not against them.

Mountain ash, which grows to become a small tree, occurs in the three northeastern counties. It is abundant near Lake Superior in northeastern Cook County and common in central Lake County between Isabella and the North Shore Highlands. Elsewhere in its range it is less frequently found. It is a great wildlife resource, especially in mid to late winter, and should not be treated like a weed tree. European mountain ash (*Sorbus aucuparia*) is a planted ornamental in the southeastern part of the state and sometimes becomes naturalized.

The seeds of birches and conifers are another important winter food for residents and irruptive migrants as well as winter visitants. The size of the species' bill determines the preferred food. Some common trees and the birds that most often utilize them follow:

**balsam fir:** Red-breasted Nuthatch
**white birch:** Common Redpoll, Pine Siskin, American Goldfinch
**yellow birch:** Common Redpoll, Pine Siskin, American Goldfinch
**white cedar:** Pine Siskin
**black spruce:** White-winged Crossbill, Red-breasted Nuthatch
**white spruce:** White-winged Crossbill, Pine Siskin
**white pine:** Red Crossbill, Pine Grosbeak
**red pine:** Red Crossbill, Pine Grosbeak
**maple:** Evening Grosbeak, Pine Grosbeak
**ash (ornamentals as well as black ash):** Evening Grosbeak, Pine Grosbeak

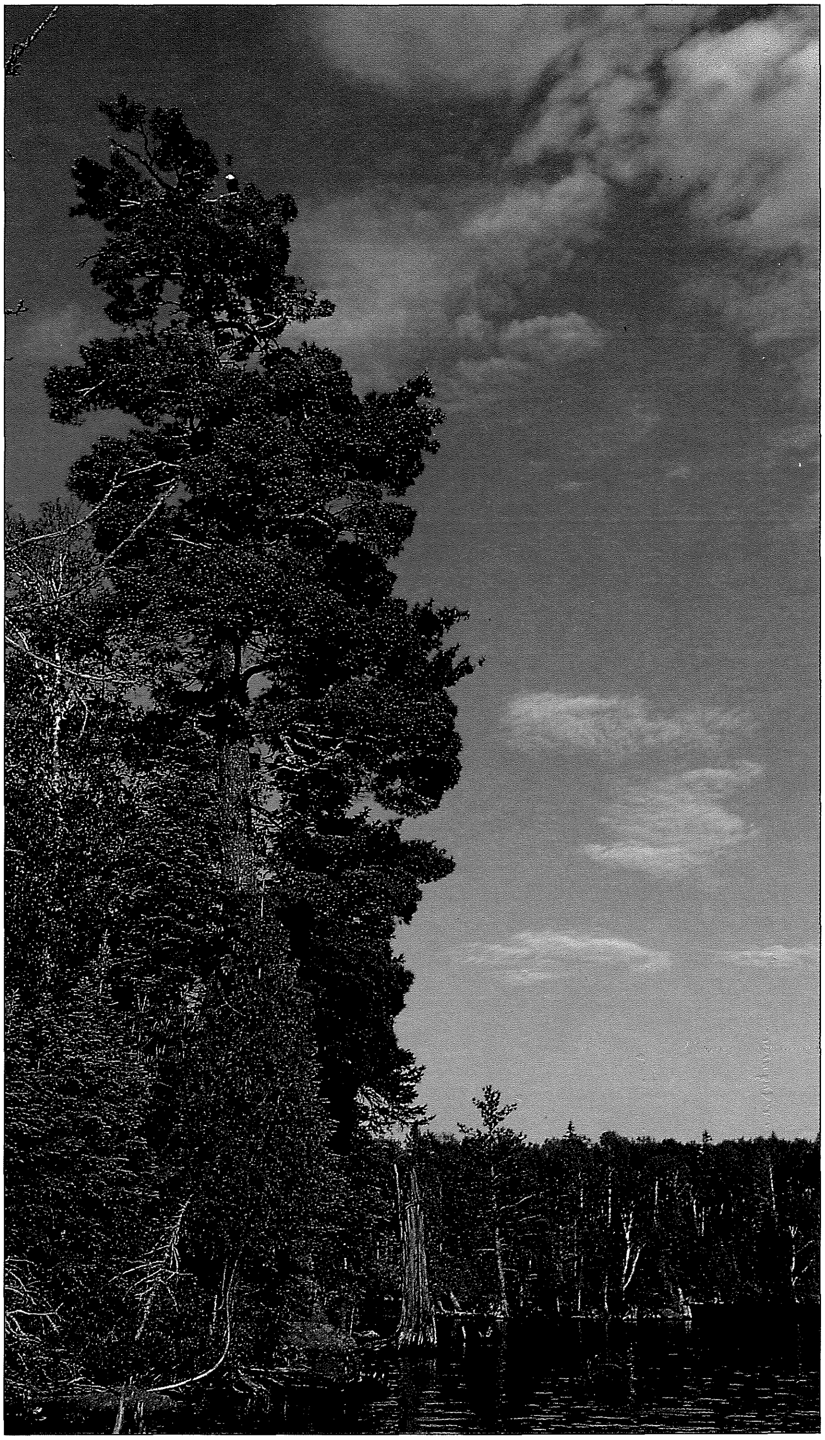


Drawing by Vera Ming Wong

*The Passenger Pigeon became extinct in 1914.*

*The preeminent bird that used oaks was the Passenger Pigeon. Its muscular gizzard allowed it "to grind acorns to a digestible pulp" (Pfannmuller 1991, p. 58). Huge flocks of Passenger Pigeons and the vast oak woods of the eastern deciduous forest once co-existed. The disturbance force that the massive breeding populations of Passenger Pigeons (see Schorger 1955) exerted on the oak forest has not been considered in studies of the ecology of oak communities. For example, the "great nesting" in central Wisconsin in 1871 concentrated an estimated 136 million pigeons in an area of 850 square miles (Schorger 1937); the impact of that huge breeding flock on the forest is hard to picture, but it must have been immense.*

Bill Marchel

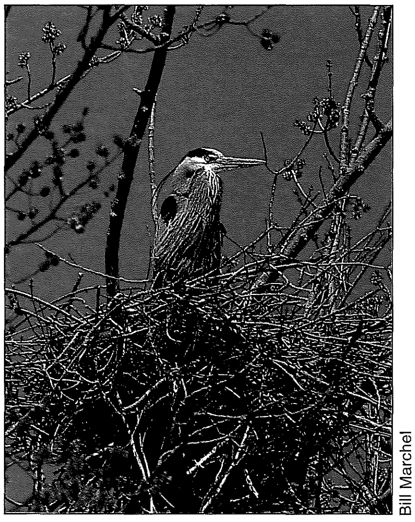


Lynn and Donna Rogers

*Eagles very often use supercanopy trees, commonly white pines, that are strong enough to hold their heavy nests. The nest is placed in a high crotch with the live branches above providing shade.*

The small finches feed also on alder cones and many weed seeds. Seed crops vary greatly from year to year and species to species. These winter birds are erratic for that reason, having evolved in these northern climes to seek out seed crops over a vast geographical area. On a local scale the best insurance for adequate winter food for seed-eaters is the presence of a variety of the native species of trees.

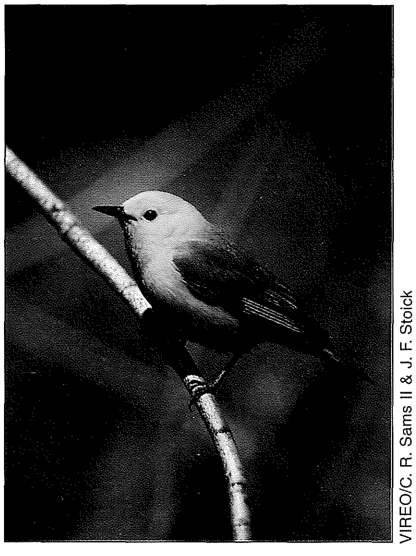
Acorns as a wildlife food have been touted mostly for mammals and for good reason—the tough shell makes it difficult for most birds to get at the kernel. A few birds have adaptations that allow them to crack open acorns, and they use this food for usually 10 to 25% of their diet: Common Grackle, White-breasted Nuthatch, Red-bellied Woodpecker, Red-headed Woodpecker, and Blue Jay. The jay is a special case. Besides the large amount of acorns consumed (25 to 50% of its diet), its caching behavior is responsible for much dispersal (actually planting since they cache the nuts in the ground) of oak, beech, and (formerly) chestnut trees in the eastern deciduous forest. The jay has also been given credit for the rapid spread northward of oak after the glaciers retreated (Johnson and Webb 1989).


Bill Marchel

*Some colonial waterbirds like the Great Blue Heron place their nests in trees or shrubs near or in water that provides protection from predators.*

## Riparian Stands

The features of the riparian zone that are important habitat requirements for birds vary depending on the landscape context. Examples of the difference between floodplain forests on the prairie and headwater streams in the northern forest were given in chapter 5. In all ecoregions big trees, either as nesting platforms or as nest cavities, are important for a number of species that feed in lakes, ponds, and rivers and nest on the adjacent shores. Specifically, eagles and ospreys and hole-nesting ducks (five species; see appendix A) have that requirement. Eagles very often use supercanopy trees, commonly white pine, that are strong enough to hold their heavy nests. These are placed in a high crotch with the live branches above providing shade. Ospreys are not as particular, but they do need a big tree, either dead or with a broken top, where their nest is placed. Although the eagle and osprey once bred throughout the state where lakes occurred, they are now confined to the forested ecoregions because of the lack of nest trees in agricultural areas.


VIREO/C. R. Sams II & J. F. Stoick

*The Prothonotary Warbler is the only cavity-nesting warbler and is a floodplain obligate.*

In addition, some colonial waterbirds place their nests in trees or shrubs near or in water that provides protection from predators;

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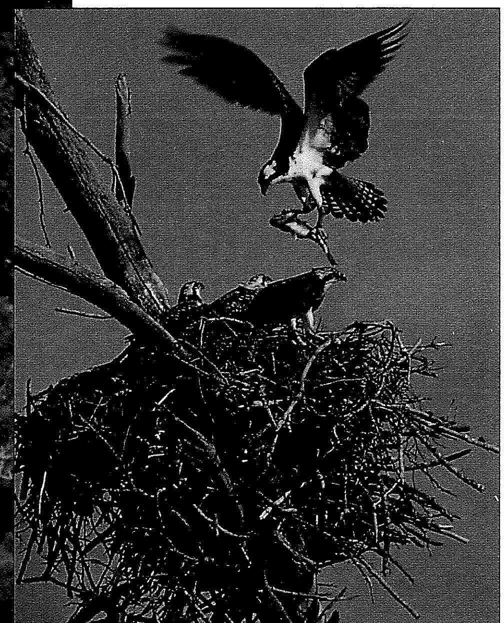


Henry Kartarik

*Ospreys are not as particular as eagles, but they do need a big tree, either dead or with a broken top, where the nest is placed.*

islands or beaver ponds are commonly used. Six species of tree-nesting waterbirds occur in some of the forested ecoregions (see appendix A).

Floodplain forests provide habitat for many deciduous forest birds (Grettenberger 1991). Because these forests usually have large, old trees, they are occupied by many cavity-dependent and bark-utilizing species that are not as common in the surrounding forested uplands (M. Knutson, personal communication). There is one floodplain obligate species, the Prothonotary Warbler. It breeds along rivers predominantly in the southeastern ecoregion. It once nested along the Rum River in Isanti County and the Mississippi River north to Stearns County but is no longer found there, presumably because its riparian habitat has been destroyed or degraded (Green and Janssen 1975). It still breeds along the lower reaches of the St. Croix and Minnesota Rivers as well as along the Mississippi and its tributaries southeast of the Twin Cities (Janssen 1987). Its main habitat requirement is nesting cavities, which these mature floodplain forests still provide.

The management response at the stand level to provide for the needs of these riparian birds is twofold. First, the continuing, long-term provision of a resource of big trees is a necessity for the fish-eating raptors. Bald Eagles, now that their populations have recovered from pesticides, seem to be limited by the availability of nest sites. Management around active nest sites to minimize disturbance should also be implemented; the DNR and the U.S. Forest Service have good guidelines. Second, active colony sites should have buffers to prevent disturbance during the breeding season and to protect the nest trees during the inactive season from blowdowns if harvesting is nearby. Because riparian zones have multiple functions, site-specific management guidelines should integrate avian habitat needs with those of other wildlife species, fisheries, water quality, and aesthetics.

## Wildlife Openings

A discussion of wildlife openings may seem out of place in a guide about birds and forests because openings are a deer management tool and provide grassy habitat for non-forest birds. Lists of the benefits of wildlife openings, however, often include their value for songbirds; thus that value should be assessed. Furthermore, commentators that cite the habitat benefits of forest edges in openings for birds often mistakenly include Ruffed Grouse in the list of birds that benefit. Two quotations illustrate this point: "Ruffed grouse favor the edges of roads, trails, meadows, or clearcuts" (*Sierra*, March–April 1995, p. 51); "Some species would benefit from edge and fragmentation such as the white-tailed deer, ruffed grouse and in severe winters, moose" (North Shore Trail extension draft environmental assessment, U.S. Forest Service, March 1995, p. 26). What these quotations show is that the terms *edge* and *opening* are often used as if they were interchangeable with the term *early-successional habitat*, but they are not. Another reason to discuss openings is that the standards and guidelines in the Superior National Forest plan include small, grassy forest openings as ill-conceived goals for Bobolink and Savannah Sparrow.

Artificial openings in forests that are kept in grass or forbs by burning or mowing are rarely large enough to provide habitat for grassland birds even if they were a desirable addition in forested areas. Most grassland or open-country species need good-sized pastures or meadows for successful breeding and a source population close at hand. A study in coastal Maine, where there is a lot of grassland-barrens habitat, found that 10 grassland species were usually found in areas at least 25 acres in extent (Vickery et al. 1994).

One exception was the Savannah Sparrow, which was found in smaller patches, although its greatest incidence was in areas of 250 acres or

Lynn and Donna Rogers

*Permanent grassy "wildlife openings" in predominantly forested regions may prove to be an evolutionary sink for grassland species like the Savannah Sparrow because they cannot find mates.*

Warren Nelson

*Le Conte's Sparrow is a sedge-fen specialist but is also sometimes found in wet fields.*

NRRI/J. Pastor

*Natural grass-type openings in the northern forested area are provided by sedge meadows on drained beaver ponds or old lake beds.*

Lynn and Donna Rogers

Lynn and Donna Rogers

*In the northeastern and north-central forests, grassy openings only increase habitat for some common shrub-edge species like Common Yellowthroat (left) and Song Sparrow.*

more. In Minnesota singing males of common grassland species, like Savannah Sparrow or Vesper Sparrow, are sometimes found in artificially created, small, grassy openings in the forest (personal observation). But this habitat is probably an evolutionary sink for these individuals because persistent singing indicates the lack of a mate, and no evidence of breeding has ever been reported.

Natural grass-type openings in the northern forested area are provided by sedge meadows on drained beaver ponds or old lake beds. These provide habitat for two species that are specialists for sedge-fens and that are also sometimes found in wet fields: Sedge Wren and Le Conte's Sparrow. At the prairie-forest margin in the northwestern part of the state these wet, brushy meadows, either as natural fens or abandoned farmland, have other typical grassland birds like Bobolink, Savannah Sparrow, and Clay-colored Sparrow because there are larger breeding populations of these species in the region (Niemi and Hanowski 1992). At the prairie-forest margin throughout the central part of the state, fire in pre–European settlement times created a grassland-savannah that also provided habitat for open-country birds.

In the northeastern and north-central forests the grassy openings that are a wildlife-management technique only increase habitat for some common species like Song Sparrow, Indigo Bunting, and Common Yellowthroat that use the shrubby edges of openings. These species are ubiquitous in fragmented forests throughout the state and do not need special attention. Additionally, where timber harvesting is not practiced, early-successional habitat in forest openings, needed for species like Chestnut-sided and Mourning Warblers, is created by beaver activity. For example, a study conducted by researchers at NRRI to quantify the impact of beaver on streams and forests on the Kabetogama Peninsula in Voyageurs National Park showed that

13% of the land area is under water in beaver ponds (Johnston and Naiman 1990). Perhaps an additional 10 to 15% is in upland forest adjacent to ponds where beaver cut large aspen (J. Pastor, personal communication). Beaver ponds create the edge, and beaver logging opens up the adjacent forest for early-successional shrubs.

The other species that is often cited as needing edge habitat or openings is the Ruffed Grouse. This labeling of grouse as an "edge species" is erroneous, the result of poor definition or misunderstanding. It is worthwhile to quote Minnesota's premier grouse researcher, Gordon Gullion (1984, pp. 74–75), on this topic:

*Ruffed grouse have usually been included among the species for whom the development of a great deal of 'edge' is supposedly beneficial.*

*However, when we take a closer look at what happens at the edges where ruffed grouse concentrate, and why the birds are there, the story takes a different slant. Actually, extensive use of forest edges by ruffed grouse provides the best indication of how unsatisfactory a forest habitat has become for these birds. When grouse must depend upon edges to find the resources they need it means that the rest of the forest is deficient in those resources, and the quality of the habitat has deteriorated to such a state that only a small portion remains acceptable.*

## Managing against Cowbirds and Predators

Openings have been criticized because they increase fragmentation with the resulting deleterious effect of creating more edge. For forest birds the adverse result has been increased predation from both mammals and birds and parasitism from Brown-headed Cowbirds. This situation may apply where forest management for harvest or wildlife openings is carried out in forests already fragmented by development like agriculture, settlements, or recreation (see the sections on fragmentation effect and edge effect). Therefore, the degree of concern about management actions that can affect songbird productivity depends on the larger landscape context.

Cowbirds need cows, or at least a substitute for the pastures where they find insects disturbed

Bill Marchel

*A study conducted in Ontario with artificial nests showed that the dominant nest predator in both scrubland and forest was the ubiquitous Blue Jay.*

by grazing cows, horses, and so on. Other short-grass habitats frequented by cowbirds for feeding include mowed recreation areas, campgrounds, lawns, and roadsides. Because cowbirds fly from one to four miles from feeding areas to woodland edges, where they search for nests in which to deposit their eggs, rural wooded landscapes fragmented by agriculture or recreational development provide the right mix of habitat components. There are many areas in Minnesota that fit this picture (see Maps 9 and 10 and the discussion on fragmentation in chapter 5).

Care should be taken when management practices are carried out not to increase feeding opportunities for cowbirds. Road, trail, and other disturbance corridors should be narrow (20 to 25 feet) and the edges or openings kept in brush or long grass over 6 inches tall. Mowed rights-of-way during the cowbird egg-laying period (May and June) provide corridors that penetrate forested areas where host species are more abundant (Rich et al. 1994). Breeding Bird Survey (BBS) routes in Minnesota provide data that show that cowbird numbers per route (24.5 miles) range from 5 to 20 birds in the four northern ecoregions (N, NC, NE, EC). Almost no cowbirds are found in large forested areas like the Superior National Forest (excluding the Iron Range).

The BBS coverage for avian predators gives some sense of their relative abundance. Crows are very common, from 20 to 40 per BBS route, in all these northern ecoregions except the heavily forested parts of the Superior National Forest, and Blue Jays are ubiquitous, though not in high numbers, in all wooded settings. Managing to decrease the numbers of these habitat generalists is difficult to do; the best defense is to maintain forested blocks as large as possible. Crows particularly prosper in landscapes with forest and open country interspersed.

The situation with mammalian predators is


Maslowski Photo

*Many forest mammals, including the red squirrel, prey on birds' eggs.*

far more complex. Most nest predation studies have been carried out in mixed land-use areas where edge and fragmentation are high. Different predators specialize in different habitats as shown by an interesting study in Ontario that used cameras to document predation on artificial nests. Photographs showed that the dominant predator in the marsh was the raccoon (80% of pictures); in the meadow, striped skunk (74%); in the scrubland, Blue Jay (70%); and in the forest, also Blue Jay (71%) (Picman and Schriml 1994).

In heavily forested areas there are many forest mammals that prey on birds' eggs. Species documented in two studies were red squirrel, gray squirrel, eastern chipmunk, red fox, striped skunk, red-backed vole, deer mouse, black bear, raccoon, and, in more boreal forests in Minnesota, fisher and pine marten (in Maine by Rudnicky and Hunter 1993; in the Chippewa National Forest in Minnesota by Fenske, in preparation; and Hanski et al., in preparation).

These studies in large forests managed for timber harvest did not show any edge effect associated with clear-cuts, although depredation rates on open-cup nests were high in the forested habitats taken as a whole. Predations seem to depend on the amount of cover at the nest site and the searching behavior and densities of the actual predators in a forested stand. Both studies showed less predation in the clear-cuts than in the adjacent forest, which partly reflects these predator-specific considerations. Forest birds have coexisted with forest predators for a long time. The key question that remains to be answered is, have the numbers of different forest predators increased in response to large-scale modifications in forest age, patch size, and composition or to other human influences like trapping and hunting pressure?

The lack of a predation effect associated with edges in these heavily forested areas is in contrast to the documented edge effect in agricultural landscapes. The review by Paton (1994, pp. 19, 21) concluded that the "data suggest that nest predation rates are greatest at less than 50 m [164 ft] from an edge." The management implications of this information for fragmented forests relate to the ratio of edge to patch size: the smaller the patch, the greater the amount of edge. By increasing the size of a forested stand the edge effect can be lessened, and predation will be less of a concern. Again, the level of management concern and action depends on the landscape context. Research is needed to determine if there is a threshold or just a continuum between forests fragmented by development and forest habitat fragmented by management activities (see section on area effect). Also, predation rates and their effect on the breeding productivity of songbirds in contiguous forest need much careful investigation.

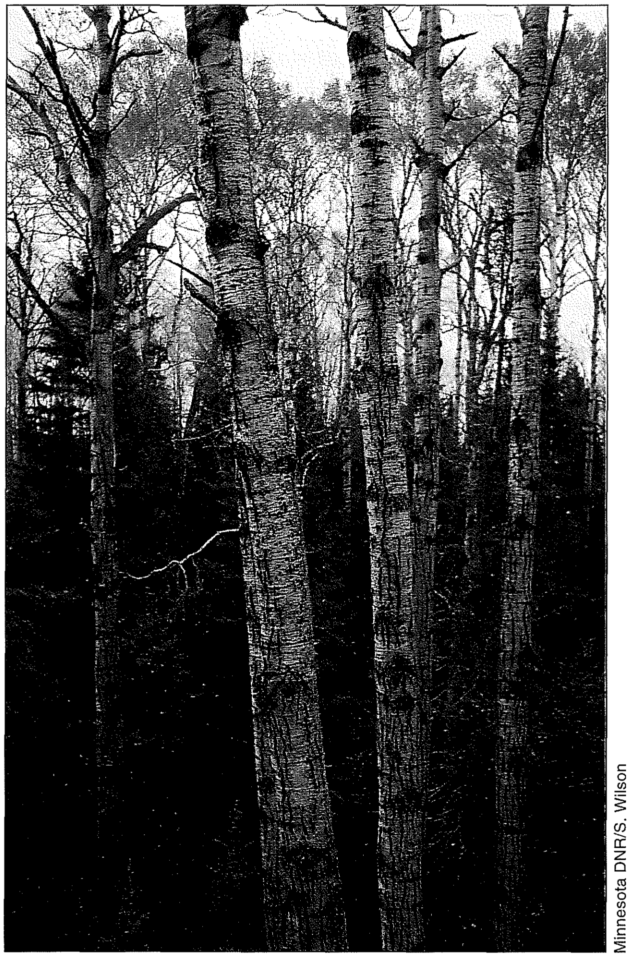
## Conifers

Conifer-dependent species have already been discussed in the section on plantations in this chapter and in the section on conifer-dominated landscapes in chapter 5. This emphasis on conifer-dependent species is natural because Minnesota's national claim to a special suite of forest birds results from its location in the ecotone between the boreal and the deciduous forests, known as the "Great Lakes–St. Lawrence Forest" (Braun 1950) or the "Northern Hardwood and Conifer Forest Region" (Mladenoff and Pastor 1993). Minnesota's distinctive list of northern conifer birds is shared with northern Wisconsin and Michigan, the Adirondacks, and northern New England, but northern Minnesota has a better representation of some species because of the greater boreal component in its forests.

Not all conifer birds are created equal in their use of conifers; some prefer pines, some black spruce, others upland spruce-fir, and some just mixed conifer stands. Exact preferences in Minnesota habitats have not been sorted out species by species with the exception of the Pine Warbler, which requires forests of mature pine, usually red and/or white. Given that uncertainty, the best posture is to maintain a good representation of conifers in these naturally coniferous woods.

There is no question that the amount of conifer forest in Minnesota has decreased substantially since the middle of the last century. Some has been converted to farmland but most has been replaced by the early-successional hardwoods aspen and birch. Left undisturbed these forests would eventually succeed to conifer, but as these second- and third-generation forests are cut, aspen continues to dominate because of the ease of its regeneration either from sprouts or seed. It is more difficult to regenerate conifers because of the expense of planting trees and because the silvicultural techniques needed are finicky and seldom used. As a result, the present landscape supports fewer stands dominated by conifers and more stands dominated by aspen. Given this situation, the conifer understory in mature aspen stands becomes very important because it can provide significant habitat for conifer-dependent species.

The important question is, how will current forest management affect the natural succession from aspen to conifer? Will more intensive management on a shorter rotation significantly reduce or eliminate the conifer component in stands managed for aspen? There is great uncertainty about the tree species composition that will result from the current harvest methods in the transition forest, and also great concern. The study completed for the Generic Environmental Impact Statement (GEIS) titled "Reduction of Conifer Component in Aspen Stands" (Jaakko Pöyry Consulting 1992a) showed that during the period from 1977 to 1990, aspen cover type increased by 12% in harvested, naturally regenerated stands in Minnesota. At the same time, some older undisturbed stands converted from aspen to other types like spruce-fir and maple. Because stands changed in both directions, overall succession was unclear. One problem with this study was its brief duration, 13 years. Succession from aspen to conifers takes longer than 13 years. It remains to be seen whether development of a conifer understory and eventual succession of aspen stands to conifer will occur at a rate sufficient to balance continuing postharvest conversion to aspen. The study concluded (pp. 67–69) that:



Minnesota DNR/S. Wilson

*Combining group selection of aspen and retention of conifers adds structural and habitat diversity usually lacking in aspen stands.*

*Data on the development of the conifer understory by age—not available at this time—would be necessary to really determine at what age it is safe, on average, to harvest aspen stands without causing permanent future loss of the conifer component. . . . At this point, the study group cannot predict whether conifers will be lost in short rotation* *harvest. But the impact on biodiversity would be significant, and directly proportional to level of harvest, if such a reduction in conifer component occurs.*

In the face of uncertainty the best strategy is prudence. Given the situation of aspen dominance and the need for conifers in this conifer/hardwood ecotone, it is worthwhile to look at alternative silvicultural methods designed to encourage the retention of the conifer component in aspen stands. Although the underlying rationale for these prescriptions is not new, they have not often been carried out in the field. The 1977 Manager's Handbook for Aspen in the North Central States (U.S. Forest Service 1977, p. 5) has a section on "Growing Conifers with Aspen," which makes the following recommendations:

*Where mature aspen has an understory of immature spruce-fir, clearcut the aspen at age 30 to 50 to release the conifer understory. Openings in the conifer canopy will be large enough to allow good aspen sucker development in scattered patches. Manage the conifers either by group selection, shelterwood, or diameter limits according to age structure and the proportions of aspen. Make shelterwood and diameter limit cuttings to encourage advance spruce-fir regeneration when the aspen component is minor or scattered. Clearcut mature aspen and conifers to regenerate a fully stocked aspen sucker stand.*

This prescription was developed when most stands were harvested by chain saws, but the newer "cut-to-length" harvesting equipment should make it currently applicable.

More recently Mladenoff and Pastor (1993, pp. 164-65) made these suggestions for achieving ecosystem-management goals that encompass both habitat diversity and long-term productive potential:

*Although aspen stands are often thought of as being single-species stands, natural stands are often of mixed composition, particularly in later stages. . . . Clear-cutting on short rotations (thirty to fifty years) has traditionally had the objective of eliminating these minor associates as well as regenerating another aspen stand through sprouts.*

*However, several objectives related to biodiversity retention and the buffering of long-term productive potential could be accomplished by modifying this strategy to use partial cutting with an extended rotation and two stand entries. . . . The silvicultural technique is a combination of group selection and seed tree silviculture, except that patches of both aspen and conifers are selected at different stand entries.*

Similar ideas, but with an emphasis on white pine, were presented by Kotar (1994, p. 18):

*When white pine saplings in aspen stands are of sufficient height, they are capable of staying ahead of aspen sprouts as mature aspen is removed from the stand. Because stocking of white pine saplings is usually relatively low, another aspen generation can still be established. In fact more than one rotation of aspen can be produced during a single rotation of white pine. If enough white pine is retained on the landscape to maintain the seed source, pine and aspen can be managed together indefinitely. Similar strategies may be possible with red oak and perhaps other species on appropriate sites.*

These examples provide concrete suggestions for promoting the regeneration of conifers through subtle changes in forest practices. Using these nontraditional silvicultural techniques accomplishes the twin objectives of maintaining biodiversity and harvesting forest products, both necessary for ecological and economical sustainability.

Richard Hamilton Smith

*Larger down logs, which last longer than finer leaf and branch litter, are important as moist sites for seedling establishment, especially for yellow birch and some conifers.*

## Wildlife Trees and Residuals

Of all the guidelines for managing nongame avian species, excluding those that are endangered, prescriptions for wildlife trees (also known as snags) have the longest history and largest body of literature. The U.S. Forest Service took the lead in the 1970s and produced a very detailed manual for western forests (U.S. Forest Service 1979) and also summarized habitat characteristics in the Midwest (Hardin and Evans 1977). The concept of snags was more appropriate in the dry western forests, where dead trees remain standing longer. But because they are easy to identify and to count, snags have remained a mainstay of published guidelines. It is readily acknowledged that residuals, dead or alive, standing or down, left after harvest serve many other wildlife functions besides that of an occasional nesting cavity or an ephemeral source of insects for woodpeckers. Hence, the term *wildlife tree* is a better descriptor than *snag*.

Avian uses of standing wildlife trees left in a harvest area include:

- foraging sites for bark probers and gleaners
- cavities for roosting and nesting for primary excavators (woodpeckers)
- cavities for roosting and nesting for secondary users (ducks, owls, some passerines; see Table 9)
- hunting perches for raptors
- song perches for passerines and boreal owls
- shelter (conifers) for passerines

The added structural features increase the species richness and avian density in the early stages of the regenerating stand. One study in the Superior National Forest showed that the "combined densities of 26 breeding species ranged from 3.9 in the least complex habitat to 8.6 territorial males/ha in the most complex" (Niemi

*Table 15. Snag guidelines*

| Agency | Management document | Guideline | Date |
|---|---|---|---|
| DNR | Forest-Wildlife Guidelines to Habitat Management | 1–6/acre; depends on habitat type | 1985 |
| Superior National Forest | Land and Resource Management Plan | 6–12/acre; all management zones | 1986 |
| Chippewa National Forest | Land and Resource Management Plan | 1–4/acre per management zone; depends on tree species | 1986 |
| DNR | Region II Snag Management Guidelines | 7–15/acre; depends on tree size | 1994 |

and Hanowski 1984, p. 438). Although most of the species are common forest songbirds, their presence adds an important biological function (insect predation) to the new stand. Young conifers left in the harvested stand can also provide structural diversity throughout the entire next rotation.

"Dead and down woody material" is the phrase recently coined in connection with the ideas of "New Forestry" (Franklin 1989); these ideas address ecosystem functions more than they address insect control in recommending leaving woody debris after harvesting. The nutrient enrichment provided by slash is well recognized. The way woody debris functions is by providing niches for a host of small species—"invertebrates, fungi, lichens, mosses, vascular plants and microorganisms that exploit this pool of organic matter and nutrients" (Hunter 1990, p. 157). Larger down logs, which last longer than the finer leaf and branch litter, are also important as moist sites for seedling establishment, especially for yellow birch and some conifers. As the forest grows up around big, down trees, they are used as display and drumming sites by Ruffed Grouse. Also the decaying logs provide feeding and nesting places for ground-foraging birds and small mammals that are an important part of the prey base for forest raptors.

The main focus in wildlife guidelines for snags and residuals has been to provide nesting and roosting sites for cavity birds. The model that was developed by the U.S. Forest Service (1979) used life-history attributes of woodpeckers inhabiting the Blue Mountains of the inland Northwest to produce a numerical guideline for snag requirements. These attributes were territory size, density (pairs/100 acres), cavities per pair/year (nesting and roosting), and minimum snag size (dbh). The recommendation from this model has been the basis for most other agency guidelines. Adapting this model, using local judgments about individual species, types of trees, and the risk associated with minimum values, has produced a range of snag guidelines from 3 to 16 per acre (Hunter 1990). No guideline for Minnesota has been published using locally derived field measurements.

A compilation of Minnesota "snag" guidelines, published and proposed, is presented in Table 15. In these guidelines the specifics on the type of tree to leave, the size, and the spacing range all the way from no published guidance to a general purpose to numerical objectives. The DNR guidelines (1994) are very explicit, as these excerpts show:

**Live Snag Distribution**

Leave snags in the following size classes and numbers where possible. The maximum snags/acre represents 10 $ft^2$ of basal area. The goal is to leave 7–15 live trees > 6 in. dbh per acre.

1–2 trees > 18 in. dbh per acre
2–5 trees > 12 in. dbh per acre
4–8 trees > 6 in. dbh per acre

**Cavity Tree Potential**

| Excellent | Good | Fair |
|---|---|---|
| White Pine | Cedar | Birch |
| Aspen | Norway Pine | Balsam |
| Oak | Basswood | Jack Pine |
| Elm | Tamarack | Spruce |
| Ash | | Balm of Gilead |
| Maple | | |
| Yellow Birch | | |

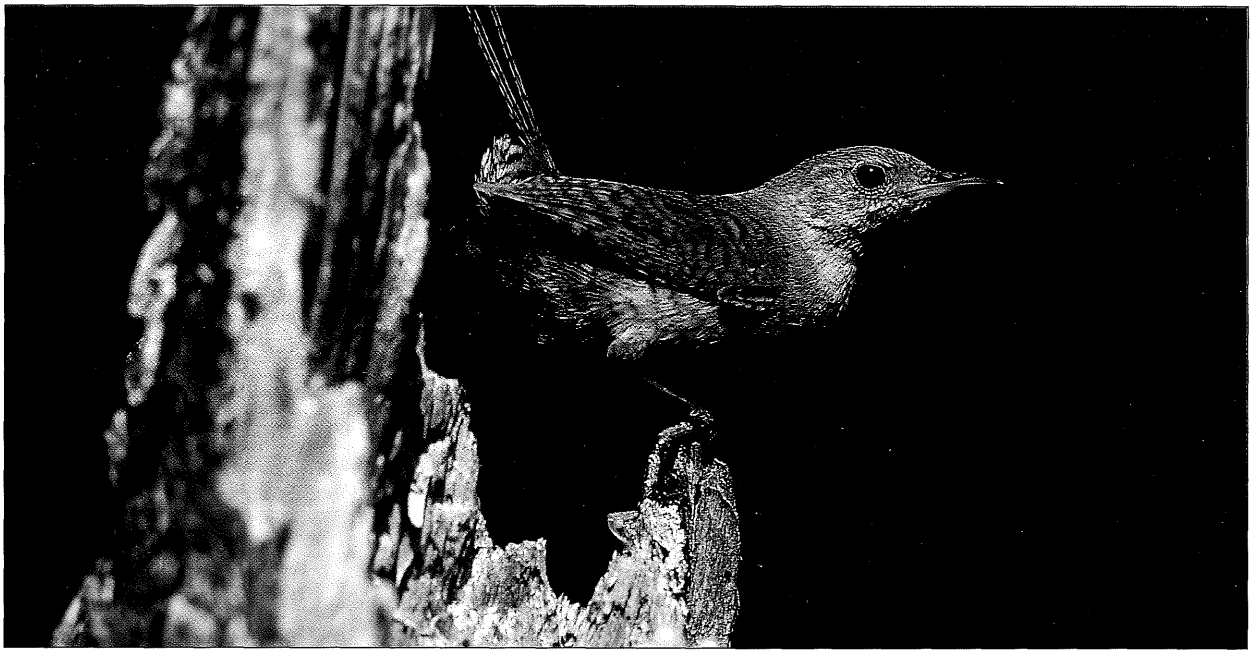
A more generalized approach was taken by the Chippewa National Forest in a recent (U.S. Forest Service 1994, p. iv-15a) amendment to its plan: "To maintain diversity, snag trees and residual trees will be designed to remain in timber sale areas. Highest priority for wildlife purposes are oak, maple and basswood (within essential bald eagle habitat areas, the desired species are white pine and red pine). Species of medium priority are white pine, red pine and ash. Those of low priority are jack pine, balsam fir, aspen and birch."

Both the DNR and the National Forests are using reserved clumps of trees or reserve islands to accomplish the wildlife-tree management objectives. The DNR (1994, p. 2) states its purpose this way: "Snag management objectives can be accomplished by various techniques. Snags can be scattered throughout a timber sale, in "islands" or a combination of both. Clearcuts and plantations larger than 15 acres may necessitate islands, depending on the design of the timber sale. Islands should be variable in size with the total being 1/2 acre for every 10 acres cut. Islands should be planned when [a] sale is designed."

Another example comes from the Chippewa National Forest's recent plan amendment (U.S. Forest Service 1994): "Snag/reserve tree guidelines should be applied to most acres of all cutting units in all cover types. Recognize that even distribution won't always be feasible, and that snag/reserve trees will often occur as reserve areas or clumps; but reserve areas or clumps should be used in addition to, not in lieu of, individual trees and snags."

Because the major goal of guidelines of this type is to provide a continuing supply of suitable cavity trees for the primary excavators, well distributed across the landscape, the shift in emphasis from snags to residuals acknowledges that dead-snag retention is only temporary because of decay and blow-downs. Snags alone are thus a nonrenewable resource over the time frame of most stand rotations. Providing the cavity tree resource through clumps and patches is also a way to avoid conflict with safety considerations and other aesthetic guidelines.

There is also a reason at the landscape level for using residual clumps instead of isolated trees. In areas of the state where the forest is fragmented by agriculture or other developments, predation and parasitism on bird nests are of high concern.


Bill Marchel

*The House Wren is a secondary cavity nester and, unfortunately, also a nest predator.*

Single, dispersed trees provide increased opportunities for cowbirds and avian predators, which are more numerous in these fragmented landscapes, to perch and scan for open-nesting victims. However, several secondary cavity nesters, like kestrels, bluebirds, and swallows, respond best to cavities in trees that are in the open. Judgments must be made using knowledge of the local avian populations to decide what species need habitat enhancements and what the risks are to other species. A necessary piece of information is population numbers of crows, jays, grackles, and cowbirds. Another secondary cavity nester is the House Wren, which, unfortunately, is also a nest predator. All of this background helps to illustrate the trade-off problems inherent in most wildlife-management decisions.

In choosing what guideline to use to provide for a continuous resource of cavity trees, an understanding of the nesting requirements of the large woodpeckers who excavate most of the cavities is necessary. The primary excavators in the northern ecoregions are the Yellow-bellied Sapsucker, Hairy Woodpecker, Northern Flicker, and Pileated Woodpecker. In the southern ecoregions Red-headed Woodpecker and Red-bellied Woodpecker also fit that description. The three-toed woodpeckers in the boreal-type forest are a special case. Not much is known about their habitat requirements except that they are found where there are numerous conifers dying or recently killed from insect infestations, flooding, or fire. Smaller birds that excavate their own cavities, like chickadees and Downy Woodpecker, use soft snags, and their requirements will be discussed separately.

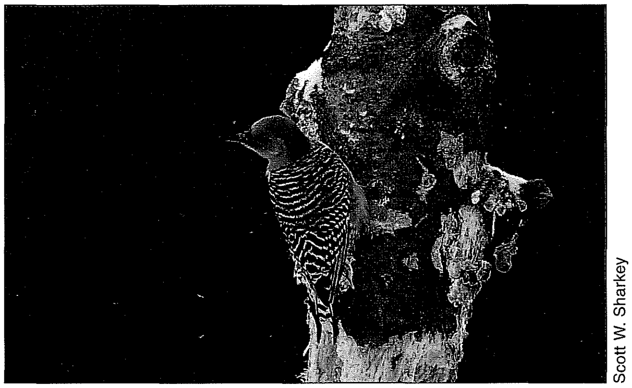
The size of the woodpecker and, therefore, the size of the tree that it needs are the main considerations. Obviously, large species need large trees, but smaller species can also use large trees; thus the focus should be on the larger end of the scale. Many of the secondary cavity users (ducks, owls) are also large bodied and need large holes. A range of tree sizes (dbh) from the literature (Evans and Conner 1979; DeGraaf 1987, 1991; Hamel 1992; Brawn et al. 1984; Runde and Capen 1987) follows:

**Red-headed Woodpecker:** 14–20 in.
**Red-bellied Woodpecker:** 14–19 in.
**Yellow-bellied Sapsucker:** 9–18 in.
**Hairy Woodpecker:** 9–18 in.
**Northern Flicker:** 12–24 in.
**Pileated Woodpecker:** 12–22 in.

Tree height ranged from 30 to 66 feet.

Research in northern forests on the type of tree preferred identified "live deciduous trees with fruiting bodies of heartwood decay fungi, branch stubs, broken tops or previously excavated cavities" (Runde and Capen 1987, p. 217). Aspen was the major choice in that study and in another one in Minnesota that looked at small owls (Boreal and Saw-whet) that occupy such woodpecker cavities (Lane et al. 1993). Old-growth aspen stands easily supply such trees. As that forest type is harvested, provision must be made for older trees because aspen rotations of 40 years are too short to produce trees that these woodpeckers and owls need. Barred Owl is another species at risk if large, wolf trees with broken tops and natural cavities are not part of the forest.

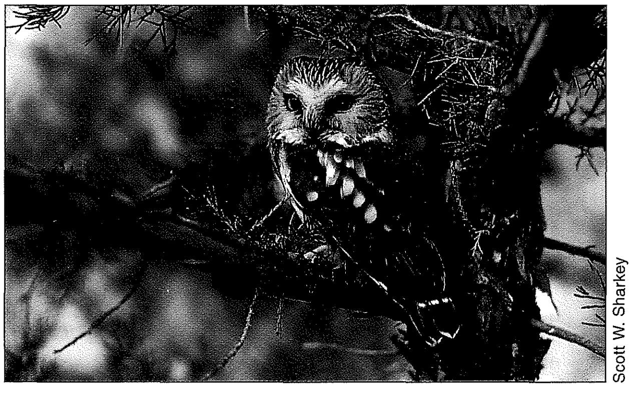
Concern for the smaller birds, like chickadees, Downy Woodpecker, and Red-breasted Nuthatch, that can excavate their own holes is not as acute. They use tree species similar to those used by the woodpeckers but of smaller size (6–9 in./dbh) and far more rotten. These soft snags are usually produced when trees die in the self-thinning process as stands age or from the


Scott W. Sharkey

*The Red-bellied Woodpecker (female shown here) is a primary excavator in the southern ecoregions.*


Bill Marchel

*Smaller birds that excavate their own cavities, like the Black-capped Chickadee, use soft snags.*


Scott W. Sharkey

*Live deciduous trees with heartwood decay are preferred by the larger species of woodpeckers, and their abandoned nest holes are later used by the Northern Saw-Whet Owl.*

periodic dieback of the ubiquitous white birch. Dead balsam firs are also common in northern forests.

The final consideration is the spacing of a continuous supply of big cavity-producing trees (preferably aspen) across the landscape. Using figures on the number of cavities used per year (1 to 4), the territory size, and maximum density per 100 acres, DeGraaf (1987) calculated the cavity trees needed to sustain a population at the hypothetical maximum level for woodpecker species in New England. These are yearly figures because woodpeckers in Minnesota excavate new nesting and roosting sites each season:

**Red-headed Woodpecker:**
20 trees/100 acres/year
**Red-bellied Woodpecker:**
25 trees/100 acres/year
**Yellow-bellied Sapsucker:**
10 trees/100 acres/year
**Downy Woodpecker:**
40 trees/100 acres/year
**Hairy Woodpecker:**
20 trees/100 acres/year
**Northern Flicker:**
5 trees/100 acres/year
**Pileated Woodpecker:**
2.4 trees/100 acres/year

Because these are yearly figures, they would have to be multiplied by the rotation age of the stands to provide for a continuous supply of cavity trees. Similar calculations should be made using territory sizes and population densities for any local area where providing cavities is a concern. Better data on actual woodpecker densities for different forest types are needed for more accurate recommendations.

This emphasis on managing for cavity trees for the 32 species of birds in Minnesota that need them is not just because this aspect of wildlife management has been well studied. Experience in the intensively managed forests of Europe has shown that cavity species disappear if their needs are not satisfied either by wildlife prescriptions or by providing nesting boxes. In the remote forests of Minnesota the latter type of mitigation is not an option. As demand for wood products increases, management activities will intensify. Consequently, wild forests, with their natural component of dead and decaying wood, will not be as available as in the past. Wildlife guidelines that mitigate this prospect will then have to be used and applied at both the stand and landscape levels.

Just because cavity trees have been covered in detail does not mean that the other wildlife benefits of residuals are less important. There are just more explicit guidelines developed for cavity nesters. For other species the availability of shelter, hunting or song perches, or foraging sites on older bark crevices provided by residuals left in the stand may be equally important for mitigation in an intensively managed forest. Any wildlife tree guideline should provide for a range of residual densities to avoid the pitfall of treating all sites the same. The amount and distribution of wildlife trees and residual clumps will also depend on the forest type and the size of the trees available. Because ultimately we do not know how many trees per acre to leave to satisfy all wildlife values, we should fall back on the assumption that mimicking the conditions the species evolved with in a particular forest type will satisfy their needs and provide for associated biological functions and processes.

## Looking to the Future

Managers and planners face a difficult and often bewildering task in moving beyond the traditional stand- and species-level approaches to forest management to embrace a more complex, multilevel, ecosystem-based approach. The transition is further complicated by our lack of knowledge of ecosystem functions and processes that operate at different scales. Managers are also challenged with maintaining the forest's ecological integrity while still accommodating the myriad of growing demands that society places on forest resources. Nevertheless, management prescriptions in this new era of resource management are guided by the tremendous knowledge we have gained over the years about forest-dependent plants and animals, forest communities, and, most recently, forest landscapes. This guide is a compilation of the current base of information on one of the forest's most outstanding resources—its rich diversity of bird life. Understanding what we now know about birds' responses to microhabitat features, different forest communities, and patterns across the forest landscape will bring managers one step closer to integrating the needs of these important forest inhabitants with the other services forests provide, from aesthetics to recreation to timber.

The success of managers in integrating these needs will depend on their ability to try new, innovative management approaches designed to maintain the integrity of forest resources at all scales of diversity. In Minnesota we are fortunate that sufficient forest resources remain to allow us an opportunity to experiment with new management tools not only at the familiar microhabitat and stand levels but also at the landscape level. Applying an experimental approach to ecosystem management is known as adaptive management. Management planning in general consists of several steps: (1) developing information about species and ecosystems, (2) establishing a vision for the future, (3) making management choices to accomplish that vision, (4) developing an action plan, (5) monitoring and evaluating the actions, and (6) modifying management choices based on new information. Adaptive management means taking what we do know, acting prudently, monitoring and analyzing the results rigorously, and changing activities as needed. As the U.S. Forest Service's Monitoring Task Group has stated (U.S. Forest Service 1993a, p. 8):

*Many management actions and policies are essentially "perturbation experiments" that frequently have uncertain outcomes (Walters and Holling 1990). Adaptive management is the process of monitoring and evaluating the results of these "experiments" and using the information to adjust current and future management actions (Holling 1978, Walters 1986). Resource management plans should be dynamic, evolving over time rather than being implemented unchanged over a planning period. Under the adaptive management approach, information from monitoring activities is used continually to evaluate and modify resource management activities.*

Thus, this approach seeks to confront the inevitable complexities and uncertainties of ecosystem science with a flexible management response.

The information presented in the chapters and appendixes to this guide is designed to facilitate an adaptive approach to managing forest birds at the ecosystem level—an approach that addresses each of the critical planning stages, from developing information about species and ecosystems to monitoring and evaluating actions taken. The chapters are designed principally around the theme of improving our understanding of how birds fit into multiscale, ecosystem-based assessments from the microhabitat to landscape scale. The appendixes provide information that managers can use in the inventory, monitoring, and analysis phases of management.

- Appendix A provides distribution, abundance, and migration information for the data-gathering stage of assessment.
- Appendix B gives life-history attributes that can be used in grouping species into guilds for analysis; it also gives figures for body mass which acts as a surrogate for territory size. Actual territory size is dependent on habitat quality and population density and is, consequently, not a fixed number.
- Appendix C displays species-habitat relationships for northern Minnesota; it can be used to delineate which species are more habitat specific than others. Caution is necessary here because broad forest types do not necessarily represent the microhabitat features that are important to birds.
- Appendix D brings together classifications of rarity and vulnerability that can be used in risk analysis.

Taken as a whole these appendixes serve as a compendium of information from sources that are not readily available to managers today. They provide a database for constructing adaptive management strategies.

As ongoing research in Minnesota and throughout the Great Lakes states continues to unravel the intricate relationship between forest birds and the forest ecosystem, new knowledge will improve our understanding of why earlier management actions did not have the results predicted and how future actions might be modified. This new knowledge coupled with the concepts, management approaches, and reference materials in this book will enable forest managers to continually adapt their management plans and actions to ensure that a sustainable future lies ahead for our forest birds.

# Appendix A

## Distribution and Abundance of Breeding Species

This appendix lists forest/tree-dependent species and provides information about their distribution, abundance, and migratory status. In addition to all birds found in both upland forests and forested wetlands, the list of forest birds includes some waterbirds that nest in trees as well as the fish-eating raptors eagle and osprey. Brushland and peatland birds are also included because these habitats are so intrinsically mixed with forests in many ecoregions. To keep the focus on forest birds, species that are primarily found nesting in open agricultural lands, settlements, marshes, or lakes were not included even though these habitats are also interspersed with forests. An exception was made for grassland species that occur in shrubby or grasslike peatlands that are interspersed with forested peatlands in the northwestern area of the state. Three species that have high populations on the prairie (Clay-colored Sparrow, Savannah Sparrow, and Bobolink) occur in these adjacent northwestern peatlands. Note that this list is not exactly the same as the bird list in the Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota, because of the inclusion of edge and shrub wetland species, brushland species, and starling and the elimination of American Black Duck (not dependent on trees), Yellow-breasted Chat (former), and White-winged Crossbill (not confirmed as a breeding species).

Two non-native species (species not present at the time of European settlement and introduced somewhere by human act) are included on this list. These species are Wild Turkey (introduced by the Minnesota Department of Natural Resources; no credible historical observations [Roberts 1932]) and European Starling (introduced purposefully in New York from Europe in 1890–91). For hunted species, the list includes five ducks and five upland game species (three grouse, turkey, and woodcock) and American Crow; Northern Bobwhite is not a game species in Minnesota.

Note that the distributional presence is only for the breeding season because that is the most important time for species productivity in relation to habitat quality. Migratory status is also given for reference. Because migration can encompass the whole state for many species and is variable from season to season, no specific distributional information can be presented.

Presence in the ecoregions is taken from Janssen (1987) and Green and Janssen (1975) with additional recent observations from the Minnesota DNR's County Biological Survey and seasonal reports in *The Loon*. A blank space in the table means that as far as is known, the species does not breed regularly in that ecoregion. Isolated occurrences disjunct from the main range were not included, because most of these are probably displaced individuals and no breeding documentation exists.

### Migratory Status

Breeding bird species can be divided into three groups according to the following standard classification:

- Permanent residents: occur in the state throughout the year although some individuals may migrate within or outside the state,
- Continental (or short-distance) migrants: winter range is primarily north of the Mexican border, and
- Neotropical (or long-distance) migrants: winter range is almost entirely south of the Mexican border.

The list of neotropical migrants was developed by the Research Working Group of the Neotropical Migratory Bird Conservation Program and was published in 1991 as the "Preliminary List of Migrants for Partners in Flight" (*Partners in Flight Newsletter*, winter 1992).

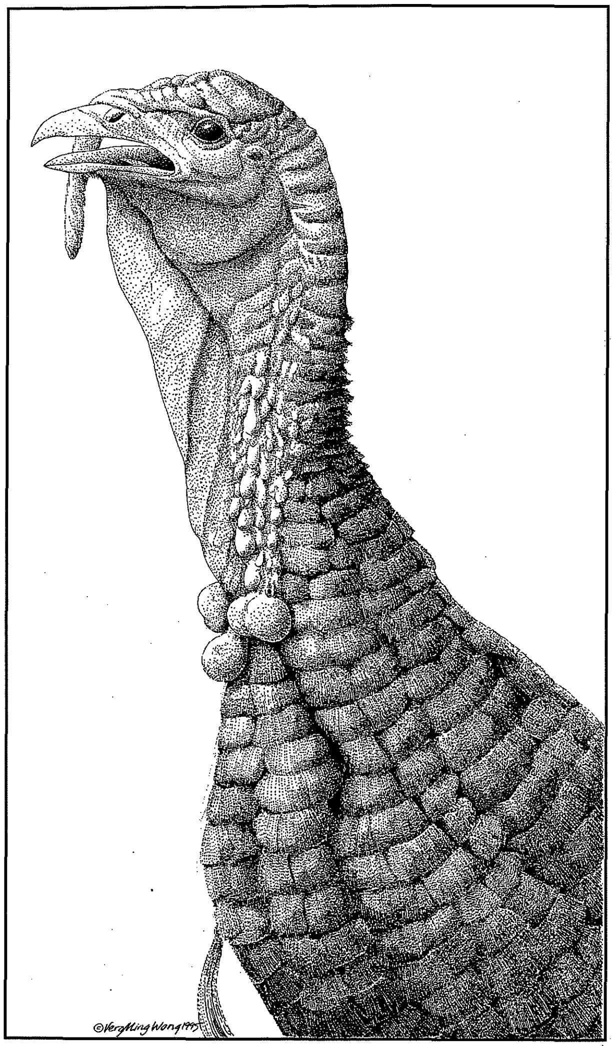
### Abundance

The abundance descriptions are strictly qualitative and are meant to give some idea about how species' populations relate to each other across a broad geographical unit. This means comparing populations of songbirds with small territories to those of raptors with large territories; the latter always come out as much less abundant. This is counter to the impression one forms driving through the forest, where raptors are conspicuously perched and small birds hiding in the dense cover are never seen. Frequency of observation is not the same as frequency of occurrence. Estimating abundance over an area the size of an ecoregion can also be misleading because of the variation in habitat types and patterns that ultimately determine population numbers. The categories are meant as a rough approximation of how often that species would be encountered while actively looking for birds over the entire ecoregion. It is also assumed that the space and time coverages per ecoregion are approximately the same. Keeping in mind these caveats plus the fact that the percentages given are rough estimates, these are the abundance frequencies for observations:

**Abundant** (25% or more)
**Common** (15–25%)
**Uncommon** (5–15%)
**Rare** (1–5%)
**Very Rare** (0–1%)

Although these abundance descriptions are estimates, some quantitative data were used to make judgments for each species by ecoregion. Good data do not exist on an ecoregion scale, but combining what does exist from site surveys and roadside counts gave abundance descriptions based on frequency of occurrence rather than population density. The quantitative data come from three sources:

- **Statewide:** Breeding Bird Survey data for 82 routes (not all covered) for the last three years (National Biological Service)
- **NE, NC, EC:** Point count data from the National Forests and National Wildlife Refuges (Natural Resources Research Institute, University of Minnesota)
- **C, SE, NW:** Point count censuses for selected state parks (Powell 1992) and natural communities (DNR County Biological Survey, 1990–92; Stucker 1992)



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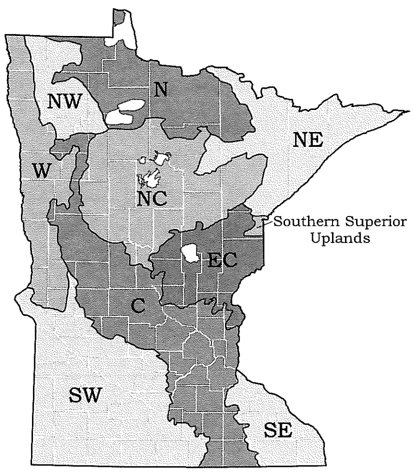
It must be emphasized that none of these data are comprehensive enough to cover populations of all species at an ecoregion scale. Very rare species are often missed. Detection for some groups is also a problem for any of these surveys, which are conducted primarily during June in the early morning hours using the high rate of singing during the height of the breeding season as the main technique of detection. Groups that are definitely underrepresented are nocturnal species, raptors, waterbirds, and permanent residents that nest earlier. There is also no readily available information on the proportion of land use or habitat type for each ecoregion; thus quantitative extrapolations of the point count data are not possible.

*The historical status of the Wild Turkey is equivocal. There is a four-page discussion in Roberts' classic book about why he came to the conclusion that "there is no absolutely positive evidence that the Wild Turkey ever existed in Minnesota" (p. 425). He does cite some hearsay reports from Jackson County and Fillmore County before natural history records were kept, which began in Fillmore County in 1876. Because better historical information is available from Iowa (Dinsmore 1994) that shows that they disappeared from northern Iowa about 1860, turkeys on the fringe of their range in Minnesota could have been gone before any credible observations were made. The present flocks of turkeys are descendants from introduced birds.*

## Key




### Ecoregions (see map)

**NW** = Northwest (Lake Agassiz, Aspen Parklands)
**N** = North (N. Minnesota and Ontario Peatlands)
**NE** = Northeast (Northern Superior Uplands)
**NC** = North-central (N. Minnesota Drift and Lake Plains)
**EC** = East-central (Western Superior Uplands)
**C** = Central (Minnesota and NE Iowa Moraines)
**SE** = Southeast (Driftless and Dissected Plateau)
**SW** = Southwest (North Central Glaciated Plains)
**W** = West (Red River Valley)

The very small portion of the ecoregion called "Southern Superior Uplands Section" that touches Minnesota south of Duluth was not analyzed separately; the birds that occur there are included in the EC region.

### Migratory Status

**Permanent** = Permanent residents - occur in the state throughout the year, although some individuals may migrate within or outside the state
**Continental** = Continental or short-distance migrants - winter range is primarily north of the Mexican border
**Neotropical** = Neotropical or long-distance migrants - winter range is almost entirely south of the Mexican border

### Abundance

**A** = Abundant - recorded on 25% or more of visits to a region
**C** = Common - recorded on 15–25% of visits
**U** = Uncommon - recorded on 5–15% of visits
**R** = Rare - recorded on 1–5% of visits
**VR** = Very Rare - recorded on 0–1% of visits

A blank space in the table means that as far as is known, the species does not breed regularly in that ecoregion. Isolated occurrences disjunct from the main range were not included, because most of these are probably displaced individuals, and no breeding documentation exists. Note that the distributional presence is only for the breeding season.

## Distribution and abundance by ecoregion for forest-dependent breeding birds

| Species | Ecoregion | | | | | | | | | Migratory status |
|---|---|---|---|---|---|---|---|---|---|---|
| | NW | N | NE | NC | EC | C | SE | SW | W | |
| Double-crested Cormorant | VR | VR | VR | VR | VR | R | VR | R | VR | Continental |
| Great Blue Heron | R | R | U | U | R | U | U | R | R | Continental |
| Great Egret | | | | | | U | R | VR | R | Continental |
| Green Heron | VR | | | R | R | R | R | VR | VR | Continental |
| Black-crowned Night-Heron | VR | | | | | VR | | VR | | Continental |
| Yellow-crowned Night-Heron | | | | | | | VR | | | Continental |
| Wood Duck | R | R | VR | R | R | U | R | R | VR | Continental |
| Common Goldeneye | VR | VR | VR | VR | | | | | | Continental |
| Bufflehead | VR | VR | | | | | | | | Continental |
| Hooded Merganser | VR | VR | VR | VR | VR | VR | VR | | VR | Continental |
| Common Merganser | | VR | R | VR | | | | | | Continental |
| Turkey Vulture | | | R | VR | VR | VR | R | | | Continental |
| Osprey | VR | VR | R | R | VR | VR | VR | | | Continental |
| Bald Eagle | VR | VR | R | R | VR | VR | VR | | | Continental |
| Sharp-shinned Hawk | VR | R | R | VR | VR | | | | | Continental |
| Cooper's Hawk | VR | VR | | VR | VR | VR | VR | | | Continental |
| Northern Goshawk | VR | VR | VR | VR | VR | | | | | Continental |
| Red-shouldered Hawk | | | | VR | VR | VR | VR | | | Continental |
| Broad-winged Hawk | VR | R | U | R | R | VR | VR | | | Neotropical |
| Red-tailed Hawk | U | U | R | U | U | U | U | R | U | Continental |
| American Kestrel | R | U | R | U | U | U | R | R | VR | Continental |
| Merlin | VR | VR | R | VR | | | | | | Neotropical |
| Spruce Grouse | VR | R | VR | VR | | | | | | Permanent |
| Ruffed Grouse | R | U | U | U | R | R | R | | | Permanent |
| Sharp-tailed Grouse | R | R | | VR | R | | | | | Permanent |
| Wild Turkey | | | | | | R | U | | | Permanent |
| Northern Bobwhite | | | | | | | VR | | | Permanent |

| Species | Ecoregion | | | | | | | | | Migratory status |
|---|---|---|---|---|---|---|---|---|---|---|
| | NW | N | NE | NC | EC | C | SE | SW | W | |
| American Woodcock | VR | R | U | R | VR | VR | VR | | | Continental |
| Mourning Dove | A | C | VR | C | C | A | C | A | A | Continental |
| Black-billed Cuckoo | U | R | U | U | R | R | R | VR | VR | Neotropical |
| Yellow-billed Cuckoo | VR | | | VR | VR | R | VR | VR | VR | Neotropical |
| Eastern Screech-Owl | | | | | VR | R | VR | VR | | Permanent |
| Great Horned Owl | R | R | R | R | U | U | R | R | R | Permanent |
| Barred Owl | VR | VR | R | R | R | R | R | | | Permanent |
| Great Gray Owl | VR | VR | VR | VR | | | | | | Permanent |
| Long-eared Owl | VR | VR | VR | VR | VR | VR | | | | Continental |
| Boreal Owl | | VR | VR | | | | | | | Permanent |
| Northern Saw-whet Owl | VR | VR | R | VR | VR | | | | | Continental |
| Whip-poor-will | R | VR | VR | VR | VR | VR | VR | | | Neotropical |
| Chimney Swift | R | VR | VR | R | R | U | U | R | VR | Neotropical |
| Ruby-throated Hummingbird | VR | VR | U | U | VR | VR | VR | VR | VR | Neotropical |
| Red-headed Woodpecker | VR | | VR | R | R | U | U | U | VR | Continental |
| Red-bellied Woodpecker | | | | | VR | R | C | VR | | Permanent |
| Yellow-bellied Sapsucker | R | U | C | C | U | R | U | VR | VR | Continental |
| Downy Woodpecker | U | U | U | U | U | U | R | VR | VR | Permanent |
| Hairy Woodpecker | U | U | U | U | U | R | U | VR | VR | Permanent |
| Three-toed Woodpecker | | | VR | | | | | | | Permanent |
| Black-backed Woodpecker | VR | VR | VR | VR | | | | | | Permanent |
| Northern Flicker | U | C | C | U | U | U | U | U | R | Continental |
| Pileated Woodpecker | R | R | R | R | R | R | R | VR | VR | Permanent |
| Olive-sided Flycatcher | VR | VR | U | R | VR | | | | | Neotropical |
| Eastern Wood-Pewee | C | R | U | U | A | C | A | VR | R | Neotropical |
| Yellow-bellied Flycatcher | VR | VR | U | R | VR | | | | | Neotropical |
| Acadian Flycatcher | | | | | | VR | R | | | Neotropical |
| Alder Flycatcher | C | U | C | U | U | R | | | VR | Neotropical |

| Species | Ecoregion | | | | | | | | | Migratory status |
|---|---|---|---|---|---|---|---|---|---|---|
| | NW | N | NE | NC | EC | C | SE | SW | W | |
| Willow Flycatcher | VR | | | | | R | R | VR | VR | Neotropical |
| Least Flycatcher | C | C | C | C | C | U | R | VR | U | Neotropical |
| Eastern Phoebe | R | U | R | U | U | U | U | VR | VR | Continental |
| Great Crested Flycatcher | C | C | R | C | A | C | C | R | R | Neotropical |
| Eastern Kingbird | C | U | R | U | U | U | R | U | C | Neotropical |
| Tree Swallow | C | C | U | U | U | C | U | R | R | Continental |
| Gray Jay | VR | R | R | R | VR | | | | | Permanent |
| Blue Jay | C | C | C | C | C | C | A | U | U | Permanent |
| Black-billed Magpie | R | R | | VR | | | | | VR | Permanent |
| American Crow | C | A | C | A | C | A | A | A | A | Continental |
| Common Raven | R | R | U | R | VR | | | | | Permanent |
| Black-capped Chickadee | U | U | C | C | U | U | C | R | R | Permanent |
| Boreal Chickadee | | VR | VR | VR | | | | | | Permanent |
| Tufted Titmouse | | | | | | VR | VR | | | Permanent |
| Red-breasted Nuthatch | VR | R | U | U | R | VR | | | | Permanent |
| White-breasted Nuthatch | R | R | VR | U | U | U | C | VR | R | Permanent |
| Brown Creeper | VR | VR | R | U | R | VR | VR | | | Continental |
| House Wren | C | U | R | U | U | A | A | C | A | Neotropical |
| Winter Wren | R | R | C | U | R | VR | VR | | | Continental |
| Sedge Wren | C | U | R | U | R | U | R | VR | U | Continental |
| Golden-crowned Kinglet | R | VR | U | R | VR | VR | | | | Continental |
| Ruby-crowned Kinglet | VR | VR | U | R | VR | | | | | Continental |
| Blue-gray Gnatcatcher | | | | | | R | U | | VR | Neotropical |

| Species | Ecoregion | | | | | | | | | Migratory status |
|---|---|---|---|---|---|---|---|---|---|---|
| | NW | N | NE | NC | EC | C | SE | SW | W | |
| Eastern Bluebird | R | R | VR | R | R | U | R | VR | VR | Continental |
| Veery | C | C | A | C | A | U | R | | VR | Neotropical |
| Swainson's Thrush | VR | VR | C | R | | | | | | Neotropical |
| Hermit Thrush | U | U | C | U | U | VR | | | | Continental |
| Wood Thrush | VR | R | VR | R | U | VR | C | VR | VR | Neotropical |
| American Robin | C | A | A | A | C | A | A | A | A | Continental |
| Gray Catbird | C | R | R | U | U | C | C | R | U | Neotropical |
| Brown Thrasher | U | R | VR | R | R | U | U | U | U | Continental |
| Cedar Waxwing | C | U | C | U | U | U | R | VR | VR | Continental |
| Loggerhead Shrike | | | | | VR | VR | VR | VR | VR | Continental |
| European Starling | U | R | R | C | C | C | U | C | U | Continental |
| Bell's Vireo | | | | | | VR | VR | | | Neotropical |
| Solitary Vireo | VR | VR | U | R | VR | | | | | Neotropical |
| Yellow-throated Vireo | U | VR | VR | U | R | U | C | | VR | Neotropical |
| Warbling Vireo | U | R | VR | U | VR | U | U | VR | U | Neotropical |
| Philadelphia Vireo | | VR | VR | | | | | | | Neotropical |
| Red-eyed Vireo | A | A | A | A | A | A | U | VR | R | Neotropical |
| Blue-winged Warbler | | | | | | VR | R | | | Neotropical |
| Golden-winged Warbler | VR | VR | VR | U | U | R | | | | Neotropical |
| Tennessee Warbler | | VR | R | VR | VR | | | | | Neotropical |
| Nashville Warbler | C | U | A | C | A | R | | | | Neotropical |
| Northern Parula | | VR | U | U | VR | | | | | Neotropical |
| Yellow Warbler | A | C | R | C | U | C | U | R | U | Neotropical |
| Chestnut-sided Warbler | U | C | A | C | A | R | | | | Neotropical |
| Magnolia Warbler | VR | VR | C | R | VR | | | | | Neotropical |
| Cape May Warbler | | | R | VR | | | | | | Neotropical |
| Black-throated Blue Warbler | | | R | VR | VR | | | | | Neotropical |
| Yellow-rumped Warbler | U | R | U | U | R | | | | | Continental |

| Species | Ecoregion | | | | | | | | | Migratory status |
|---|---|---|---|---|---|---|---|---|---|---|
| | NW | N | NE | NC | EC | C | SE | SW | W | |
| Black-throated Green Warbler | VR | R | C | U | U | | | | | Neotropical |
| Blackburnian Warbler | VR | VR | C | U | R | | | | | Neotropical |
| Pine Warbler | VR | R | R | U | VR | VR | | | | Continental |
| Palm Warbler | VR | VR | VR | R | VR | | | | | Neotropical |
| Bay-breasted Warbler | | | VR | | | | | | | Neotropical |
| Cerulean Warbler | | | | | | VR | R | | | Neotropical |
| Black-and-white Warbler | R | R | C | U | U | R | | | | Neotropical |
| American Redstart | U | VR | C | U | U | U | C | VR | VR | Neotropical |
| Prothonotary Warbler | | | | | | VR | VR | | | Neotropical |
| Ovenbird | C | C | A | A | A | U | C | | VR | Neotropical |
| Northern Waterthrush | R | VR | U | R | R | VR | | | | Neotropical |
| Louisiana Waterthrush | | | | | VR | VR | VR | | | Neotropical |
| Connecticut Warbler | R | R | R | R | VR | | | | | Neotropical |
| Mourning Warbler | R | R | A | U | C | VR | | | | Neotropical |
| Common Yellowthroat | A | A | C | A | A | A | C | C | A | Neotropical |
| Hooded Warbler | | | | | | VR | | | | Neotropical |
| Wilson's Warbler | | | VR | | | | | | | Neotropical |
| Canada Warbler | | | C | R | VR | | | | | Neotropical |
| Scarlet Tanager | R | R | U | U | U | U | U | VR | VR | Neotropical |
| Northern Cardinal | | | | | VR | C | A | VR | | Permanent |
| Rose-breasted Grosbeak | C | U | C | U | U | U | C | R | VR | Neotropical |
| Blue Grosbeak | | | | | | | | VR | | Neotropical |
| Indigo Bunting | R | R | VR | U | R | C | C | VR | VR | Neotropical |
| Rufous-sided Towhee | R | | | R | VR | VR | U | | | Continental |
| Chipping Sparrow | U | U | C | C | U | C | U | U | U | Neotropical |
| Clay-colored Sparrow | A | C | R | C | R | U | VR | R | C | Neotropical |
| Savannah Sparrow | A | C | R | C | U | U | U | U | A | Neotropical |
| Le Conte's Sparrow | U | VR | VR | R | VR | VR | | | | Continental |
| Song Sparrow | A | A | C | A | C | A | C | C | A | Continental |
| Lincoln's Sparrow | VR | VR | R | VR | VR | | | | | Neotropical |

| Species | Ecoregion NW | N | NE | NC | EC | C | SE | SW | W | Migratory status |
|---|---|---|---|---|---|---|---|---|---|---|
| Swamp Sparrow | U | U | U | U | U | U | U | VR | VR | Continental |
| White-throated Sparrow | U | A | A | C | U | R | | | | Continental |
| Dark-eyed Junco | VR | VR | R | R | | | | | | Continental |
| | | | | | | | | | | |
| Bobolink | C | U | VR | U | U | C | R | U | A | Neotropical |
| Rusty Blackbird | | | VR | | | | | | | Continental |
| Common Grackle | U | U | R | C | C | C | C | A | A | Continental |
| Brown-headed Cowbird | A | C | R | C | C | A | A | C | A | Continental |
| Orchard Oriole | | | | | | VR | VR | VR | VR | Neotropical |
| Northern Oriole | C | R | VR | U | U | C | C | U | U | Neotropical |
| | | | | | | | | | | |
| Purple Finch | VR | R | U | U | VR | | | | | Continental |
| Red Crossbill | | | VR | | | | | | | Permanent |
| Pine Siskin | VR | VR | R | VR | VR | VR | | | | Permanent |
| American Goldfinch | C | U | C | U | U | C | C | U | C | Continental |
| Evening Grosbeak | VR | VR | U | R | | | | | | Permanent |

*Sources:* Green and Janssen (1975); Janssen (1987); seasonal reports in *The Loon;* and Minnesota DNR's County Biological Survey.

# Appendix B

## Selected Life-History Characteristics

This appendix serves as a compendium of life-history attributes from reference sources not available to everyone.

### Key

**Nest Site**

| | |
|---|---|
| ledge | cavity |
| ground | tree |
| shrub | cfr tree = conifer tree |

### Food

**Type**

**C** = carnivore: vertebrates
**Cr** = crustaceovore: crustaceans
**F** = frugivore: fruits
**G** = granivore: nuts, seeds
**I** = insectivore: insects
**O** = omnivore: a variety of foods, both plant and animal
**P** = piscivore: fish
**V** = vermivore: sandworms, earthworms, etc.

**Substrate**

**air:** caught in the air
**bark:** on, in, or under bark of trees
**floral:** on or in flowers
**freshwater shoreline:** shores of freshwater ponds, lakes, rivers, or streams
**ground:** on the ground or on very low, weedy vegetation
**lower canopy:** on leaves, twigs, and branches of shrubs, saplings, and lower crowns of trees
**upper canopy:** on leaves, twigs, and branches of trees in main canopy

**Technique**

**ambusher:** slowly stalks or waits for prey to come within reach
**diver:** dives from surface for underwater food
**excavator:** locates food in bark by drilling holes
**foot plunger:** catches prey by plunging from air to water surface
**forager:** takes almost any food items encountered on the substrate
**gleaner:** selects particular food items from the substrate
**hawker:** flies after prey and captures it either in air or on ground
**hover-gleaner:** hovers in air while selecting prey
**prober:** inserts bill into substrate and locates prey by touch
**sallier:** perches on exposed branch or twig, waits for insect to fly by, and then pursues and catches insect in air
**scaler:** exposes prey under bark by scaling off loose bark
**scavenger:** takes a variety of items, including refuse or carrion
**screener:** flies with bill open and screens prey from air

**Body Mass**

given as a surrogate for territory size

**Sources:**

**Nest site and clutch size:** Ehrlich, Dobkin, and Wheye (1988).
**Food:** Degraff, Tilghman, and Anderson (1985).
**Body mass:** Dunning (1993).

## Selected life-history characteristics

| | | | Breeding season food and foraging habits | | | |
|---|---|---|---|---|---|---|
| Species | Nest site | Clutch size | Type | Substrate | Technique | Body mass (g) |
| Double-crested Cormorant | tree | 3–4 | P | water | diver | 1540.0–1808.0 |
| Great Blue Heron | tree | 3–5 | P | water | ambusher | 2204.0–2576.0 |
| Great Egret | tree | 3 | C | water | ambusher | 812.0–935.0 |
| Green Heron | tree | 2–4 | Cr | water | ambusher | 212.0 |
| Black-crowned Night-Heron | tree | 3–5 | P,Cr | water | ambusher | 727.0–1014.0 |
| Yellow-crowned Night-Heron | tree | 4–5 | Cr | water | ambusher | 649.0–716.0 |
| Wood Duck | cavity | 10–15 | G | ground/water | gleaner | 635.0–908.0 |
| Common Goldeneye | cavity | 7–10 | O | water/bottom | forager | 800.0–1400.0 |
| Bufflehead | cavity | 8–10 | I | water/bottom | gleaner | 297.0–551.0 |
| Hooded Merganser | cavity | 8–11 | P | water | diver | 540.0–910.0 |
| Common Merganser | cavity | 10–12 | P | water | diver | 1050.0–2054.0 |
| Turkey Vulture | ledge | 2 | C | ground | scavenger | 1467.0 |
| Osprey | tree | 3 | P | water | ft-plunger | 1220.0–1900.0 |
| Bald Eagle | tree | 2 | P,C | water/ground | ft-plngr/scavngr | 3631.0–6400.0 |
| Sharp-shinned Hawk | cfr tree | 4–5 | C | air/ground | hawker | 82.0–208.0 |
| Cooper's Hawk | tree | 4–5 | C | air/ground | hawker | 297.0–588.0 |
| Northern Goshawk | cfr tree | 3–4 | C | air/ground | hawker | 735.0–1364.0 |
| Red-shouldered Hawk | tree | 3 | C | ground | hawker | 475.0–643.0 |
| Broad-winged Hawk | tree | 2–3 | C | ground | hawker | 420.0–490.0 |
| Red-tailed Hawk | tree | 2–3 | C | ground | hawker | 1028.0–1224.0 |
| American Kestrel | cavity | 4–5 | I | air | hawker | 111.0–120.0 |
| Merlin | tree | 4–5 | C | air | hawker | 134.0–281.0 |
| Spruce Grouse | ground | 4–7 | O | ground | forager | 370.0–513.0 |
| Ruffed Grouse | ground | 9–12 | O | ground | forager | 532.0–621.0 |
| Sharp-tailed Grouse | ground | 10–14 | O | ground | forager | 817.0–1090.0 |
| Wild Turkey | ground | 10–12 | O | ground | forager | 4222–10,800 |
| Northern Bobwhite | ground | 12–16 | O | ground | forager | 178.0 |
| American Woodcock | ground | 4 | V | ground | prober | 176.0–278.0 |

| Species | Nest site | Clutch size | Type | Substrate | Technique | Body mass (g) |
|---|---|---|---|---|---|---|
| | | | Breeding season food and foraging habits | | | |
| Mourning Dove | tree | 2 | G | ground | gleaner | 115.0–123.0 |
| Black-billed Cuckoo | tree | 2–3 | I | lower canopy | gleaner | 39.6–65.0 |
| Yellow-billed Cuckoo | tree | 4 | I | lower canopy | gleaner | 50.0–84.6 |
| Eastern Screech-Owl | cavity | 4–5 | I | ground | hawker | 140.0–235.0 |
| Great Horned Owl | tree | 2–3 | C | ground | hawker | 985.0–2503.0 |
| Barred Owl | cavity | 2–3 | C | ground | hawker | 468.0–1051.0 |
| Great Gray Owl | tree | 2–4 | C | ground | hawker | 568.0–1900.0 |
| Long-eared Owl | tree | 4–5 | C | ground | hawker | 178.0–342.0 |
| Boreal Owl | cavity | 4–6 | C | ground | hawker | 90.0–194.0 |
| Northern Saw-whet Owl | cavity | 5–6 | C | ground | hawker | 54.0–124.0 |
| Whip-poor-will | ground | 2 | I | air | screener | 43.0–63.7 |
| Chimney Swift | cavity | 4–5 | I | air | screener | 17.0–29.8 |
| Ruby-throated Hummingbird | tree | 2 | O | floral | hover-gleaner | 2.4–4.8 |
| Red-headed Woodpecker | cavity | 4–5 | I | air | sallier | 56.1–90.5 |
| Red-bellied Woodpecker | cavity | 4–5 | I | bark | gleaner | 56.2–67.2 |
| Yellow–bellied Sapsucker | cavity | 5–6 | O | bark | excavator | 40.7–62.2 |
| Downy Woodpecker | cavity | 4–5 | I | bark | gleaner | 20.7–32.2 |
| Hairy Woodpecker | cavity | 4 | I | bark | gleaner | 59.3–79.6 |
| Three-toed Woodpecker | cavity | 4 | I | bark | scaler | 57.0–74.0 |
| Black-backed Woodpecker | cavity | 4 | I | bark | scaler | 61.3–88.1 |
| Northern Flicker | cavity | 5–8 | I | ground | gleaner | 106.0–164.0 |
| Pileated Woodpecker | cavity | 4 | I | bark | excavator | 250.0–309.0 |
| Olive-sided Flycatcher | tree | 3 | I | air | sallier | 26.7–42.2 |
| Eastern Wood-Pewee | tree | 3 | I | air | sallier | 10.4–18.2 |
| Yellow-bellied Flycatcher | ground | 3–4 | I | air | sallier | 9.2–15.5 |
| Acadian Flycatcher | tree | 3 | I | air | sallier | 9.9–16.1 |
| Alder Flycatcher | shrub | 3–4 | I | air | sallier | 10.0–15.6 |
| Willow Flycatcher | shrub | 3–4 | I | air | sallier | 11.3–16.4 |

| Species | Nest site | Clutch size | Type | Substrate | Technique | Body mass (g) |
|---|---|---|---|---|---|---|
| | | | Breeding season food and foraging habits | | | |
| Least Flycatcher | tree | 4 | I | air | sallier | 8.2–14.9 |
| Eastern Phoebe | ledge | 4–5 | I | air | sallier | 11.4–24.4 |
| Great Crested Flycatcher | cavity | 5 | I | air | sallier | 27.2–39.6 |
| Eastern Kingbird | tree | 3–4 | I | air | sallier | 43.6 |
| Tree Swallow | cavity | 4–6 | I | air | screener | 15.6–25.4 |
| Gray Jay | cfr tree | 3–4 | O | grnd/uppr can | forager | 62.0–73.0 |
| Blue Jay | cfr tree | 4–5 | O | upper canopy | forager | 64.1–109.0 |
| Black-billed Magpie | tree | 5–8 | I | ground | gleaner | 135.0–209.0 |
| American Crow | tree | 4–6 | O | ground | forager | 438.0–458.0 |
| Common Raven | ledge | 4–6 | O | ground | scavenger | 1050.0–1400.0 |
| Black-capped Chickadee | cavity | 6–8 | I | lower canopy | gleaner | 8.2–13.6 |
| Boreal Chickadee | cavity | 5–8 | I | lower canopy | gleaner | 7.0–12.4 |
| Tufted Titmouse | cavity | 5–7 | I | lower canopy | gleaner | 17.5–26.1 |
| Red-breasted Nuthatch | cavity | 5–6 | I | bark | gleaner | 8.0–12.7 |
| White-breasted Nuthatch | cavity | 5–8 | I | bark | gleaner | 18.5–26.7 |
| Brown Creeper | cavity | 5–6 | I | bark | gleaner | 7.2–9.9 |
| House Wren | cavity | 6–8 | I | lower canopy | gleaner | 8.9–14.2 |
| Winter Wren | ground | 5–6 | I | ground | gleaner | 7.5–10.5 |
| Sedge Wren | ground | 7 | I | ground | gleaner | 7.2–10.3 |
| Golden-crowned Kinglet | cfr tree | 8–9 | I | lower canopy | gleaner | 4.5–7.8 |
| Ruby-crowned Kinglet | cfr tree | 7–9 | I | lower canopy | gleaner | 5.0–9.7 |
| Blue-gray Gnatcatcher | tree | 4–5 | I | lower canopy | gleaner | 4.8–8.9 |
| Eastern Bluebird | cavity | 4–5 | I | ground | gleaner | 31.6 |
| Veery | ground | 4 | O | grnd/lowr can | forager | 26.2–41.7 |
| Swainson's Thrush | shrub | 3–4 | O | grnd/lowr can | forager | 21.9–50.7 |
| Hermit Thrush | ground | 4 | I | ground | gleaner | 26.6–37.4 |

| Species | Nest site | Clutch size | Breeding season food and foraging habits: Type | Substrate | Technique | Body mass (g) |
|---|---|---|---|---|---|---|
| Wood Thrush | tree | 3–4 | O | ground | forager | 39.2–57.7 |
| American Robin | tree | 4 | V | ground | gleaner | 63.5–103.0 |
| Gray Catbird | shrub | 4 | O | grnd/lowr can | forager | 26.6–56.5 |
| Brown Thrasher | shrub | 4–5 | O | grnd/lowr can | forager | 57.6–89.0 |
| Cedar Waxwing | tree | 3–5 | I,F | air/upper canopy | sallier/gleaner | 25.5–40.2 |
| Loggerhead Shrike | shrub | 5–6 | C | ground | hawker | 40.5–54.1 |
| European Starling | cavity | 4–6 | O | ground | forager | 79.9–84.7 |
| Bell's Vireo | shrub | 4 | I | lower canopy | gleaner | 7.4–9.8 |
| Solitary Vireo | cfr tree | 4 | I | lower canopy | gleaner | 14.1–19.3 |
| Yellow-throated Vireo | tree | 4 | I | upper canopy | gleaner | 15.6–21.4 |
| Warbling Vireo | tree | 4 | I | upper canopy | gleaner | 14.8 |
| Philadelphia Vireo | tree | 4 | I | upper canopy | gleaner | 10.3–16.1 |
| Red-eyed Vireo | shrub | 4 | I | upper canopy | gleaner | 12.0–25.1 |
| Blue-winged Warbler | ground | 5 | I | lower canopy | gleaner | 7.2–11.0 |
| Golden-winged Warbler | ground | 4–5 | I | lower canopy | gleaner | 7.2–11.8 |
| Tennessee Warbler | ground | 5–6 | I | lower canopy | gleaner | 7.3–18.4 |
| Nashville Warbler | ground | 4–5 | I | lower canopy | gleaner | 6.7–13.4 |
| Northern Parula | tree | 4–5 | I | upper canopy | gleaner | 7.1–10.2 |
| Yellow Warbler | shrub | 4–5 | I | lower canopy | gleaner | 7.4–16.0 |
| Chestnut-sided Warbler | shrub | 4 | I | lower canopy | gleaner | 7.5–13.1 |
| Magnolia Warbler | cfr tree | 4 | I | lower canopy | gleaner | 6.6–12.9 |
| Cape May Warbler | cfr tree | 4 | I | upper canopy | gleaner | 9.3–17.3 |
| Black-throated Blue Warbler | shrub | 4 | I | lower canopy | gleaner | 8.4–12.4 |
| Yellow-rumped Warbler | cfr tree | 4 | I | lower canopy | gleaner | 9.9–16.7 |
| Black-thrtd Green Warbler | cfr tree | 4–5 | I | upper canopy | gleaner | 7.7–11.3 |
| Blackburnian Warbler | cfr tree | 4 | I | upper canopy | gleaner | 9.5–10.0 |
| Pine Warbler | cfr tree | 4 | I | bark | gleaner | 9.4–15.1 |
| Palm Warbler | ground | 4–5 | I | ground | gleaner | 7.0–12.9 |
| Bay-breasted Warbler | cfr tree | 4–5 | I | upper canopy | gleaner | 10.7–15.1 |

| Species | Nest site | Clutch size | Breeding season food and foraging habits | | | Body mass (g) |
|---|---|---|---|---|---|---|
| | | | Type | Substrate | Technique | |
| Cerulean Warbler | tree | 4 | I | upper canopy | gleaner | 8.4–10.3 |
| Black-and-white Warbler | ground | 5 | I | bark | gleaner | 8.8–15.2 |
| American Redstart | tree | 4 | I | air/lower canopy | sallier/gleaner | 6.7–12.0 |
| Prothonotary Warbler | cavity | 4–6 | I | bark/lowr can | gleaner | 13.6–20.0 |
| Ovenbird | ground | 4–5 | I | ground | gleaner | 14.0–28.8 |
| Northern Waterthrush | ground | 4–5 | I | shoreline | gleaner | 13.8–24.4 |
| Louisiana Waterthrush | ground | 5 | I | shoreline | gleaner | 17.4–26.0 |
| Connecticut Warbler | ground | 4–5 | I | ground | gleaner | 10.7–26.8 |
| Mourning Warbler | ground | 3–4 | I | ground | gleaner | 9.6–17.9 |
| Common Yellowthroat | shrub | 3–5 | I | lower canopy | gleaner | 7.6–15.5 |
| Hooded Warbler | shrub | 3–4 | I | air/lower canopy | sallier/gleaner | 8.1–13.9 |
| Wilson's Warbler | ground | 4–6 | I | air/lower canopy | sallier/gleaner | 6.3–10.5 |
| Canada Warbler | ground | 4 | I | lower canopy | gleaner | 8.7–13.5 |
| Scarlet Tanager | tree | 4 | I | upper canopy | gleaner | 17.5–35.2 |
| Northern Cardinal | shrub | 3–4 | O | ground | forager | 33.6–64.9 |
| Rose-breasted Grosbeak | tree | 4 | O | upper canopy | forager | 35.4–65.0 |
| Blue Grosbeak | tree | 4 | O | ground | forager | 26.1–31.4 |
| Indigo Bunting | shrub | 3–4 | O | lower canopy | gleaner | 11.2–18.6 |
| Rufous-sided Towhee | ground | 3–4 | O | ground | forager | 32.1–52.3 |
| Chipping Sparrow | cfr tree | 4 | O | ground | forager | 9.8–18.8 |
| Clay-colored Sparrow | shrub | 3–4 | O | lower canopy | forager | 9.8–14.5 |
| Savannah Sparrow | ground | 3–5 | O | ground | forager | 15.1–17.8 |
| Le Conte's Sparrow | ground | 4 | O | ground | forager | 12.4–15.2 |
| Song Sparrow | ground | 3–4 | O | grnd/lowr can | forager | 11.9–29.8 |
| Lincoln's Sparrow | ground | 4–5 | O | ground | forager | 10.4–24.0 |
| Swamp Sparrow | shrub | 4–5 | O | ground | forager | 10.9–22.2 |
| White-throated Sparrow | ground | 4–6 | O | ground | forager | 19.0–35.4 |
| Dark-eyed Junco | ground | 3–5 | O | ground | forager | 14.3–26.7 |

| | | | Breeding season food and foraging habits | | | |
|---|---|---|---|---|---|---|
| **Species** | **Nest site** | **Clutch size** | **Type** | **Substrate** | **Technique** | **Body mass (g)** |
| Bobolink | ground | 5–6 | O | ground | forager | 26.5–56.3 |
| Rusty Blackbird | cfr tree | 4–5 | I | ground | gleaner | 45.9–80.4 |
| Common Grackle | tree | 4–5 | O | ground | forager | 100.0–127.0 |
| Brown-headed Cowbird | parasite | 4–5 | O | ground | forager | 30.5–58.0 |
| Orchard Oriole | tree | 3–5 | I | upper canopy | gleaner | 16.0–25.1 |
| Northern Oriole | tree | 4–5 | O | upper canopy | forager | 22.3–41.5 |
| Purple Finch | cfr tree | 4–5 | G,F | upper canopy | gleaner | 18.1–35.3 |
| Red Crossbill | cfr tree | 3–4 | O | upper canopy | forager | 29.2–48.0 |
| Pine Siskin | cfr tree | 3–4 | O | upper canopy | forager | 10.8–20.1 |
| American Goldfinch | shrub | 4–6 | O | lower canopy | forager | 8.6–20.7 |
| Evening Grosbeak | cfr tree | 4–5 | O | upper canopy | forager | 38.7–86.1 |

## Appendix C

## Relative Abundance of Birds in Twelve Habitat Types in the Chequamegon, Chippewa, and Superior National Forests

### Key

### Habitat Types

The habitat types are based on U.S. Forest Service forest types and in most cases the categories are a combination of several similar types. A blank in a column indicates that the habitat type was not sampled on that forest.

**Lowland Open** = sedge, alder, nonforested bog (Chequamegon only)
**Upland Open** = upland brush (Chequamegon only)
**Regen** = Regenerating = sapling size class of all forest types (sapling size = less than 5 in. dbh)
**Lowland Conifer** = pole- and saw-sized black spruce, cedar, tamarack, and mixed swamp conifer (pole-sized = 5–9 in. dbh; saw-sized = greater than 9 in. dbh)
**Lowland Decid** = Lowland deciduous = pole- and saw-sized black ash (Chequamegon and Chippewa only)
**Mature Hemlock** = pole- and saw-sized hemlock (Chequamegon only)
**Young Pines** = pole-sized jack, red, and white pine
**Mature Pines** = saw-sized jack, red, and white pine
**Young Decid** = Young deciduous = pole-sized oak, aspen, birch, and maple
**Mature Decid** = mature deciduous = saw-sized oak, aspen, birch, and maple
**Young Mixed** = pole-sized fir/aspen/birch and aspen/white spruce
**Mature Mixed** = saw-sized fir/aspen/birch and aspen/white spruce

**Source:** Adapted from Hawrot et al. (1994).

### Mean Number Birds/Stand:

— = 0

• = > 0 - .09

● = > .09 - .5

⬤ = > .5 - 2.0

⬤ = > 2.0 (max = 7.9)

The mean number of birds is based on three 10 minute point counts per stand.

Species that are rare (detected on less than 10% of stands) on all three National Forests are not included in this table, for example, Gray Catbird, Boreal Chickadee, and Northern Waterthrush.

## Relative abundance of birds in twelve habitat types in the Chequamegon, Chippewa, and Superior National Forests

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ruffed Grouse | Chequamegon | — | — | • | — | — | — | • | • | • | • | | |
| | Chippewa | | | • | • | — | | • | — | • | • | | |
| | Superior | | | • | ● | | | • | • | • | • | ● | ● |
| Yellow-bellied Sapsucker | Chequamegon | • | ● | ● | ● | ● | ● | ● | ● | ● | ⬤ | | |
| | Chippewa | | | • | ● | ⬤ | | • | ● | ● | ⬤ | | |
| | Superior | | | ● | ● | | | • | ● | ● | ● | ● | ● |
| Downy Woodpecker | Chequamegon | — | — | — | — | — | • | • | — | • | • | | |
| | Chippewa | | | • | • | ● | | • | • | • | • | | |
| | Superior | | | — | • | | | — | — | • | • | • | — |
| Hairy Woodpecker | Chequamegon | — | — | — | • | ● | ● | • | • | • | • | | |
| | Chippewa | | | • | • | ● | | • | — | • | • | | |
| | Superior | | | • | — | | | • | • | • | • | • | — |
| Northern Flicker | Chequamegon | • | ● | — | • | • | • | • | — | • | • | | |
| | Chippewa | | | ● | ● | ● | | • | • | • | ● | | |
| | Superior | | | ● | • | | | • | • | ● | • | • | • |
| Pileated Woodpecker | Chequamegon | — | — | — | • | • | — | — | — | • | • | | |
| | Chippewa | | | • | • | • | | — | • | • | • | | |
| | Superior | | | • | — | | | • | • | • | • | • | • |

— = 0 • = > 0 - .09 ● = > .09 - .5 ⬤ = > .5 - 2.0 ⚫ = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Olive-sided Flycatcher | Chequamegon | — | — | — | • | — | — | — | — | — | — | | |
| | Chippewa | | | • | ● | — | | — | — | — | — | | |
| | Superior | | | • | • | | | — | • | • | • | — | — |
| Eastern Wood-Pewee | Chequamegon | ● | ● | • | • | ● | ● | ⬤ | ⬤ | ⬤ | ⬤ | | |
| | Chippewa | | | ● | • | ● | | ⬤ | ⬤ | ⬤ | ● | | |
| | Superior | | | — | • | | | • | ⬤ | ● | ● | — | — |
| Yellow-bellied Flycatcher | Chequamegon | ● | — | ● | ⬤ | ● | — | • | — | — | • | | |
| | Chippewa | | | ● | ● | • | | • | • | • | — | | |
| | Superior | | | ● | ⬤ | | | ● | ● | • | • | ● | ● |
| Alder Flycatcher | Chequamegon | ⬤ | ● | • | ● | • | • | • | — | • | — | | |
| | Chippewa | | | ● | ● | • | | • | • | • | • | | |
| | Superior | | | ● | ● | | | • | • | • | • | • | • |
| Least Flycatcher | Chequamegon | ● | ● | ⬤ | ⬤ | ⬤ | ⬤ | ⬤ | ● | ⬤ | ⬤ | | |
| | Chippewa | | | ● | ● | ⬤ | | ⬤ | ⬤ | ⬤ | ⬤ | | |
| | Superior | | | ● | ● | | | ● | ⬤ | ⬤ | ⬤ | ⬤ | ● |
| Great Crested Flycatcher | Chequamegon | — | — | • | ● | ⬤ | ⬤ | • | • | • | • | | |
| | Chippewa | | | ● | ● | ● | | — | • | ● | ● | | |
| | Superior | | | • | • | | | — | — | • | • | — | — |

— = 0   • = > 0 - .09   ● = > .09 - .5   ⬤ = > .5 - 2.0   ⚫ = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gray Jay | Chequamegon | · | — | — | · | · | · | — | — | · | — | | |
| | Chippewa | | | • | • | · | | — | — | · | — | | |
| | Superior | | | — | • | | | — | · | · | — | — | — |
| Blue Jay | Chequamegon | • | — | ● | • | • | ● | • | ● | • | • | | |
| | Chippewa | | | • | ● | • | | • | • | • | • | | |
| | Superior | | | • | • | | | • | • | • | • | • | • |
| American Crow | Chequamegon | · | — | — | — | · | · | — | · | · | · | | |
| | Chippewa | | | · | · | • | | · | · | • | • | | |
| | Superior | | | · | — | | | · | · | · | · | — | — |
| Black-capped Chickadee | Chequamegon | • | • | ● | ● | ● | ● | • | ● | • | • | | |
| | Chippewa | | | • | • | • | | • | • | • | · | | |
| | Superior | | | · | • | | | · | · | • | • | • | · |
| Red-breasted Nuthatch | Chequamegon | • | — | • | • | · | • | • | • | · | • | | |
| | Chippewa | | | · | • | · | | • | • | • | · | | |
| | Superior | | | · | • | | | · | • | • | · | • | • |
| White-breasted Nuthatch | Chequamegon | — | · | • | • | • | • | • | • | • | • | | |
| | Chippewa | | | · | · | • | | • | • | · | • | | |
| | Superior | | | · | — | | | · | · | · | · | — | — |

— = 0 · = > 0 - .09 • = > .09 - .5 ● = > .5 - 2.0 ⬤ = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brown Creeper | Chequamegon | · | · | · | • | • | • | · | · | • | • | | |
| | Chippewa | | | · | • | ● | | • | • | · | • | | |
| | Superior | | | — | • | | | · | • | • | • | · | • |
| Winter Wren | Chequamegon | • | · | · | ● | ● | ● | · | · | • | • | | |
| | Chippewa | | | • | ● | • | | — | · | • | • | | |
| | Superior | | | • | ● | | | · | • | • | • | ● | ● |
| Golden-crowned Kinglet | Chequamegon | — | — | • | • | · | · | — | · | · | · | | |
| | Chippewa | | | • | • | — | | · | • | · | — | | |
| | Superior | | | · | ● | | | • | • | • | · | • | • |
| Ruby-crowned Kinglet | Chequamegon | — | — | — | · | · | — | — | — | · | · | | |
| | Chippewa | | | · | · | — | | — | — | — | — | | |
| | Superior | | | · | • | | | · | • | · | · | · | · |
| Veery | Chequamegon | ● | • | • | • | ● | • | • | • | ● | • | | |
| | Chippewa | | | ● | • | ⬤ | | ● | ● | ● | ● | | |
| | Superior | | | ● | • | | | • | ● | ● | ● | ● | ● |
| Swainson's Thrush | Chequamegon | — | — | · | — | — | — | · | · | · | — | | |
| | Chippewa | | | — | · | · | | · | — | · | · | | |
| | Superior | | | · | • | | | · | • | · | • | • | ● |

— = 0 · = > 0 - .09 • = > .09 - .5 ● = > .5 - 2.0 ⬤ = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hermit Thrush | Chequamegon | ● | ● | ⬤ | ⬤ | ● | ⬤ | ⬤ | ⬤ | ⬤ | ⬤ | | |
| | Chippewa | | | ● | ⬤ | • | | ⬤ | ⬤ | ● | ● | | |
| | Superior | | | ⬤ | ● | | | ⬤ | ⬤ | ● | ● | ● | ● |
| Wood Thrush | Chequamegon | • | — | — | — | • | • | — | • | ● | ● | | |
| | Chippewa | | | • | • | • | | — | — | • | • | | |
| | Superior | | | • | • | | | — | — | — | • | — | — |
| American Robin | Chequamegon | ● | ● | ⬤ | ● | ● | ⬤ | ⬤ | ⬤ | ⬤ | ● | | |
| | Chippewa | | | ● | ● | ● | | ● | ● | • | • | | |
| | Superior | | | ⬤ | ● | | | ● | ● | ● | ● | ● | ● |
| Brown Thrasher | Chequamegon | — | ⬤ | ● | — | — | — | • | • | — | — | | |
| | Chippewa | | | • | — | — | | — | — | • | — | | |
| | Superior | | | • | — | | | — | — | — | • | — | — |
| Cedar Waxwing | Chequamegon | • | • | • | — | • | — | • | • | • | • | | |
| | Chippewa | | | ● | • | • | | ● | • | ● | ● | | |
| | Superior | | | ● | • | | | • | ● | • | ● | ● | • |
| Solitary Vireo | Chequamegon | • | — | — | ● | ● | ● | ● | • | • | ● | | |
| | Chippewa | | | • | ● | • | | • | • | • | — | | |
| | Superior | | | • | ● | | | ● | ● | • | • | • | • |

— = 0   • = > 0 - .09   ● = > .09 - .5   ⬤ = > .5 - 2.0   ⬤ (largest) = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellow-throated Vireo | Chequamegon | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > .09 - .5 | | |
| | Chippewa | | | > 0 - .09 | — | > 0 - .09 | | > .09 - .5 | > 0 - .09 | > .09 - .5 | > .09 - .5 | | |
| | Superior | | | > 0 - .09 | — | | | — | > 0 - .09 | > 0 - .09 | — | — | — |
| Red-eyed Vero | Chequamegon | > .09 - .5 | > .09 - .5 | > .09 - .5 | > .5 - 2.0 | > 2.0 | > 2.0 | > .5 - 2.0 | > .5 - 2.0 | > 2.0 | > 2.0 | | |
| | Chippewa | | | > .5 - 2.0 | > .5 - 2.0 | > 2.0 | | > 2.0 | > 2.0 | > 2.0 | > 2.0 | | |
| | Superior | | | > .5 - 2.0 | > .5 - 2.0 | | | > .5 - 2.0 | > .5 - 2.0 | > 2.0 | > 2.0 | > .5 - 2.0 | > .5 - 2.0 |
| Golden-winged Warbler | Chequamegon | > .09 - .5 | — | > 0 - .09 | > 0 - .09 | — | — | — | > 0 - .09 | > 0 - .09 | — | | |
| | Chippewa | | | > .5 - 2.0 | > 0 - .09 | > 0 - .09 | | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | | |
| | Superior | | | > .09 - .5 | — | | | — | > 0 - .09 | > 0 - .09 | — | > 0 - .09 | — |
| Nashville Warbler | Chequamegon | > .5 - 2.0 | — | > 2.0 | > .5 - 2.0 | > .5 - 2.0 | > .5 - 2.0 | > 2.0 | > .5 - 2.0 | > .09 - .5 | > .09 - .5 | | |
| | Chippewa | | | > .5 - 2.0 | > 2.0 | > .09 - .5 | | > .09 - .5 | > .5 - 2.0 | > .09 - .5 | > .09 - .5 | | |
| | Superior | | | > 2.0 | > 2.0 | | | > 2.0 | > .5 - 2.0 | > .5 - 2.0 | > .5 - 2.0 | > 2.0 | > .5 - 2.0 |
| Northern Parula | Chequamegon | > 0 - .09 | — | — | > .5 - 2.0 | > .09 - .5 | > .09 - .5 | — | — | > 0 - .09 | > .09 - .5 | | |
| | Chippewa | | | > 0 - .09 | > .09 - .5 | > 0 - .09 | | > .09 - .5 | > .09 - .5 | > 0 - .09 | > .09 - .5 | | |
| | Superior | | | > 0 - .09 | > .09 - .5 | | | > 0 - .09 | > 0 - .09 | > .09 - .5 | > .09 - .5 | > .09 - .5 | > .5 - 2.0 |
| Yellow Warbler | Chequamegon | > 0 - .09 | > 0 - .09 | — | > 0 - .09 | > 0 - .09 | — | — | — | — | — | | |
| | Chippewa | | | > .09 - .5 | > 0 - .09 | > .09 - .5 | | > .09 - .5 | > .09 - .5 | > .09 - .5 | > .09 - .5 | | |
| | Superior | | | > 0 - .09 | — | | | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > 0 - .09 | — |

— = 0 • = > 0 - .09 ● = > .09 - .5 ● = > .5 - 2.0 ● = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chestnut-sided Warbler | Chequamegon | ⬤ | ⬤ | — | ● | ● | • | ⬤ | ⬤ | ● | ● | | |
| | Chippewa | | | ⬤ | ● | ⬤ | | ⬤ | ⬤ | ⬤ | ⬤ | | |
| | Superior | | | ⬤⬤ | ● | | | ⬤ | ⬤ | ⬤ | ⬤ | ⬤ | ● |
| Magnolia Warbler | Chequamegon | — | — | — | • | • | • | — | • | • | • | | |
| | Chippewa | | | • | • | • | | • | ● | • | • | | |
| | Superior | | | ● | ● | | | ● | ● | ● | ● | ● | ⬤ |
| Cape May Warbler | Chequamegon | — | — | — | • | — | • | • | • | — | • | | |
| | Chippewa | | | • | • | — | | — | • | — | — | | |
| | Superior | | | • | • | | | ● | • | • | • | • | ● |
| Black-throated Blue Warbler | Chequamegon | • | — | — | — | • | • | — | — | • | • | | |
| | Chippewa | | | — | • | — | | — | — | — | • | | |
| | Superior | | | — | • | | | — | • | • | • | • | ● |
| Yellow-rumped Warbler | Chequamegon | ● | ● | ⬤ | ⬤ | ● | ● | ● | ● | ● | • | | |
| | Chippewa | | | ● | ● | — | | ● | ● | • | — | | |
| | Superior | | | ● | ⬤ | | | ● | ● | ● | ● | ● | ⬤ |
| Black-throated Green Warbler | Chequamegon | • | ● | • | ⬤ | ⬤ | ⬤⬤ | ● | ⬤ | ⬤ | ⬤ | | |
| | Chippewa | | | — | ● | ● | | • | ⬤ | ⬤ | ● | | |
| | Superior | | | • | ⬤ | | | ● | ● | ● | ⬤ | ⬤ | ⬤ |

— = 0 • = > 0 - .09 ● = > .09 - .5 ⬤ = > .5 - 2.0 ⬤⬤ = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blackburnian Warbler | Chequamegon | · | · | · | ● | • | ● | • | • | • | • | | |
| | Chippewa | | | · | • | • | | ● | ● | · | • | | |
| | Superior | | | — | • | | | ● | ● | ● | • | ● | ● |
| Pine Warbler | Chequamegon | · | • | • | · | · | · | ● | ● | · | · | | |
| | Chippewa | | | · | · | · | | ● | ● | · | · | | |
| | Superior | | | · | — | | | · | • | — | · | · | — |
| Black-and-white Warbler | Chequamegon | ● | — | • | ● | ● | • | • | • | • | • | | |
| | Chippewa | | | • | • | · | | • | · | • | • | | |
| | Superior | | | ● | • | | | · | • | • | ● | ● | ● |
| American Redstart | Chequamegon | · | • | — | · | · | · | • | · | • | • | | |
| | Chippewa | | | • | · | ● | | ⬤ | • | ● | ● | | |
| | Superior | | | • | • | | | • | • | • | • | • | • |
| Ovenbird | Chequamegon | • | • | ⬤ | ● | ⬤ | ⬤ | ⬤ | ⬤ | ⬤ | ⬤ | | |
| | Chippewa | | | • | ● | ⬤ | | ⬤ | ⬤ | ⬤ | ⬤ | | |
| | Superior | | | ● | ● | | | ⬤ | ⬤ | ⬤ | ⬤ | ⬤ | ⬤ |
| Connecticut Warbler | Chequamegon | · | — | · | — | · | — | · | · | — | — | | |
| | Chippewa | | | • | ● | · | | — | · | · | — | | |
| | Superior | | | • | • | | | • | • | • | • | • | • |

— = 0 · = > 0 - .09 • = > .09 - .5 ● = > .5 - 2.0 ⬤ = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mourning Warbler | Chequamegon | ● | ● | • | ● | ● | ● | ● | ● | ● | ● | | |
| | Chippewa | | | ⬤ | ● | ⬤ | | ● | ● | ● | ● | | |
| | Superior | | | ⬤ | ● | | | ⬤ | ● | ⬤ | ⬤ | ● | ● |
| Common Yellowthroat | Chequamegon | ⬤ | ⬤ | ● | ● | ⬤ | ● | • | ● | ● | ● | | |
| | Chippewa | | | ⬤ | ⬤ | ⬤ | | • | • | ● | ● | | |
| | Superior | | | ⬤ | • | | | ● | ● | • | ● | • | ● |
| Canada Warbler | Chequamegon | ● | • | • | ● | ● | • | • | ● | ● | ● | | |
| | Chippewa | | | • | • | • | | — | • | — | • | | |
| | Superior | | | ● | ● | | | • | ● | ● | ⬤ | ⬤ | ⬤ |
| Scarlet Tanager | Chequamegon | • | ● | ⬤ | ● | ● | ● | • | ● | ● | ● | | |
| | Chippewa | | | ● | ● | ● | | ⬤ | ● | ⬤ | ● | | |
| | Superior | | | • | • | | | ● | • | ● | ● | ● | ● |
| Rose-breasted Grosbeak | Chequamegon | ● | • | ● | ● | ⬤ | ● | ⬤ | ⬤ | ● | ● | | |
| | Chippewa | | | ● | • | ● | | ● | • | • | • | | |
| | Superior | | | ⬤ | ● | | | ● | ● | ● | ⬤ | ● | ● |
| Indigo Bunting | Chequamegon | • | ● | • | • | • | • | ● | ● | • | ● | | |
| | Chippewa | | | ● | • | • | | • | • | • | • | | |
| | Superior | | | • | — | | | — | • | • | • | — | — |

— = 0    • = > 0 - .09    ● = > .09 - .5    ⬤ = > .5 - 2.0    **⬤** = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rufous-sided Towhee | Chequamegon | — | > .5 - 2.0 | > .09 - .5 | — | — | — | > 0 - .09 | > 0 - .09 | — | — | | |
| | Chippewa | | | > 0 - .09 | — | — | | > 0 - .09 | > 0 - .09 | — | — | | |
| | Superior | | | — | — | | | — | — | — | — | — | — |
| Chipping Sparrow | Chequamegon | > 0 - .09 | > .09 - .5 | > .5 - 2.0 | > 0 - .09 | > 0 - .09 | > 0 - .09 | > .09 - .5 | > .09 - .5 | > 0 - .09 | > 0 - .09 | | |
| | Chippewa | | | > .09 - .5 | > .09 - .5 | > 0 - .09 | | > .5 - 2.0 | > .5 - 2.0 | > .09 - .5 | > .09 - .5 | | |
| | Superior | | | > .09 - .5 | > .09 - .5 | | | > .09 - .5 | > .09 - .5 | > .09 - .5 | > 0 - .09 | > .09 - .5 | > .09 - .5 |
| Clay-colored Sparrow | Chequamegon | > .09 - .5 | > .5 - 2.0 | > .5 - 2.0 | — | — | — | > 0 - .09 | — | — | — | | |
| | Chippewa | | | > 0 - .09 | — | — | | — | — | — | — | | |
| | Superior | | | — | > 0 - .09 | | | — | — | > 0 - .09 | — | — | — |
| Vesper Sparrow | Chequamegon | > 0 - .09 | > .5 - 2.0 | > 0 - .09 | — | > 0 - .09 | — | > 0 - .09 | — | — | — | | |
| | Chippewa | | | > 0 - .09 | — | — | | — | — | — | — | | |
| | Superior | | | > 0 - .09 | — | | | — | — | — | — | — | — |
| Song Sparrow | Chequamegon | > .5 - 2.0 | > .5 - 2.0 | > .09 - .5 | > .09 - .5 | > 0 - .09 | — | — | — | > 0 - .09 | > 0 - .09 | | |
| | Chippewa | | | > .5 - 2.0 | > .09 - .5 | > .5 - 2.0 | | > 0 - .09 | > 0 - .09 | > .09 - .5 | > .09 - .5 | | |
| | Superior | | | > .09 - .5 | > 0 - .09 | | | > 0 - .09 | > 0 - .09 | > .09 - .5 | > .09 - .5 | — | > 0 - .09 |
| Swamp Sparrow | Chequamegon | > .5 - 2.0 | — | — | > .09 - .5 | > .09 - .5 | — | — | > 0 - .09 | — | — | | |
| | Chippewa | | | > .09 - .5 | > .09 - .5 | > .09 - .5 | | — | — | > 0 - .09 | > 0 - .09 | | |
| | Superior | | | > 0 - .09 | > 0 - .09 | | | > 0 - .09 | > 0 - .09 | > 0 - .09 | — | > 0 - .09 | > 0 - .09 |

— = 0 • = > 0 - .09 ● = > .09 - .5 ⬤ = > .5 - 2.0 ⬤ = > 2.0 (max = 7.9)

| Species | Forest | Lowland Open | Upland Open | Regen | Lowland Conifer | Lowland Decid | Mature Hemlock | Young Pines | Mature Pines | Young Decid | Mature Decid | Young Mixed | Mature Mixed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| White-throated Sparrow | Chequamegon | ⬤ | • | • | ● | ● | • | · | • | • | • | | |
| | Chippewa | | | ● | ⬤ | ● | | · | • | • | • | | |
| | Superior | | | ⬤ | ● | | | ● | ● | ● | ● | ● | ● |
| Red-winged Blackbird | Chequamegon | • | • | — | • | • | · | · | · | · | · | | |
| | Chippewa | | | · | · | • | | — | — | • | · | | |
| | Superior | | | · | — | | | · | · | · | · | — | — |
| Brown-headed Cowbird | Chequamegon | • | • | ● | · | · | · | ● | • | · | · | | |
| | Chippewa | | | • | · | • | | • | • | • | • | | |
| | Superior | | | · | — | | | — | — | · | · | — | — |
| Purple Finch | Chequamegon | · | — | — | · | · | · | · | — | · | · | | |
| | Chippewa | | | · | · | — | | · | · | · | — | | |
| | Superior | | | · | · | | | · | · | · | — | · | — |
| American Goldfinch | Chequamegon | · | ● | · | · | · | · | · | · | · | · | | |
| | Chippewa | | | • | — | — | | · | · | · | · | | |
| | Superior | | | · | · | | | — | — | — | · | — | — |
| Evening Grosbeak | Chequamegon | · | — | · | · | · | · | • | • | · | · | | |
| | Chippewa | | | · | · | — | | · | · | · | — | | |
| | Superior | | | — | • | | | · | • | · | · | • | · |

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## Appendix D

## Species of Management Concern

### Federal Threatened and Endangered Species

The purpose of the endangered species lists is to compile what is known about species on the brink of extinction. The federal list is developed pursuant to the requirements of the Endangered Species Act (48 FR 34182, July 27, 1983) and is periodically updated. It is titled "Endangered and Threatened Wildlife and Plants" (50 CFR 17.11 & 17.12), and the latest list is dated August 23, 1993. Because the listing process is so data- and labor-intensive, the Fish and Wildlife Service is far behind in listing species that meet the requirements. To fill the gap they have developed a list of candidate species that is also periodically updated through publication in the Federal Register (50 CFR Part 17). These candidate species have *not* been evaluated as to their actual status of endangerment. The candidate forest bird species are Cerulean Warbler, Loggerhead Shrike, and Northern Goshawk.

### State "Listed" Species

The state list also is established by law (Minn. Statutes 84.0895). The authority and definitions are contained in the law, and the actual species lists are established by rule (Minn. Rules, parts 6134.0100-0400). The first list was published in 1984 and is presently being updated, which will result in a new rule, probably in 1995. Several publications give a more user-friendly presentation than the rules or statutes:

- Coffin and Pfannmuller (editors). 1988. *Minnesota's Endangered Flora and Fauna.* University of Minnesota Press.
- Pfannmuller and Coffin. 1989. The Uncommon Ones. Minnesota Department of Natural Resources.
- Minnesota DNR. 1986. Checklist of Endangered and Threatened Animal and Plant Species of Minnesota. Section of Wildlife, Minn. DNR.

The key difference between the federal and state lists is the inclusion of a "species of special concern" category at the state level. Because there is often confusion about what that designation means, the full definition follows:

***Subd. 3. Designation.***
***(a)*** *The commissioner shall . . . designate species of wild animal or plant as: . . .*

*(3) species of special concern, if although the species is not endangered or threatened, is extremely uncommon in this state, or has unique or highly specific habitat requirements and deserves careful monitoring of its status. Species on the periphery of their range that are not listed as threatened may be included in this category along with those species that were once threatened or endangered but now have increasing or*

*protected, stable populations.*
***(b)** The range of the species in the state is a factor in determining its status as endangered, threatened, or of special concern. (Minn. Statutes 84.0895)*

The Minnesota statute does not protect habitat but does prohibit the physical taking or selling of an endangered species with some exceptions that are enumerated in the law. It also states that the Department of Natural Resources may undertake management programs that include habitat maintenance and habitat acquisition.

## Management Concern Species

This category is used by the U.S. Fish and Wildlife Service to fulfill the mandate of the Fish and Wildlife Conservation Act of 1980, when the agency was instructed by Congress to "identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973." The list is revised periodically and used on a regional basis. Minnesota is in Region 3, which includes the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. The species in this appendix are from the list that is currently being revised and is expected to be published in July 1995 (S. Lewis, personal communication). Only six forest birds are on the national list, and five of these are of concern in Region 3 (indicated by *): Red-shouldered Hawk*, Olive-sided Flycatcher, Loggerhead Shrike*, Bell's Vireo*, Golden-winged Warbler*, Cerulean Warbler*.

## Sensitive Species

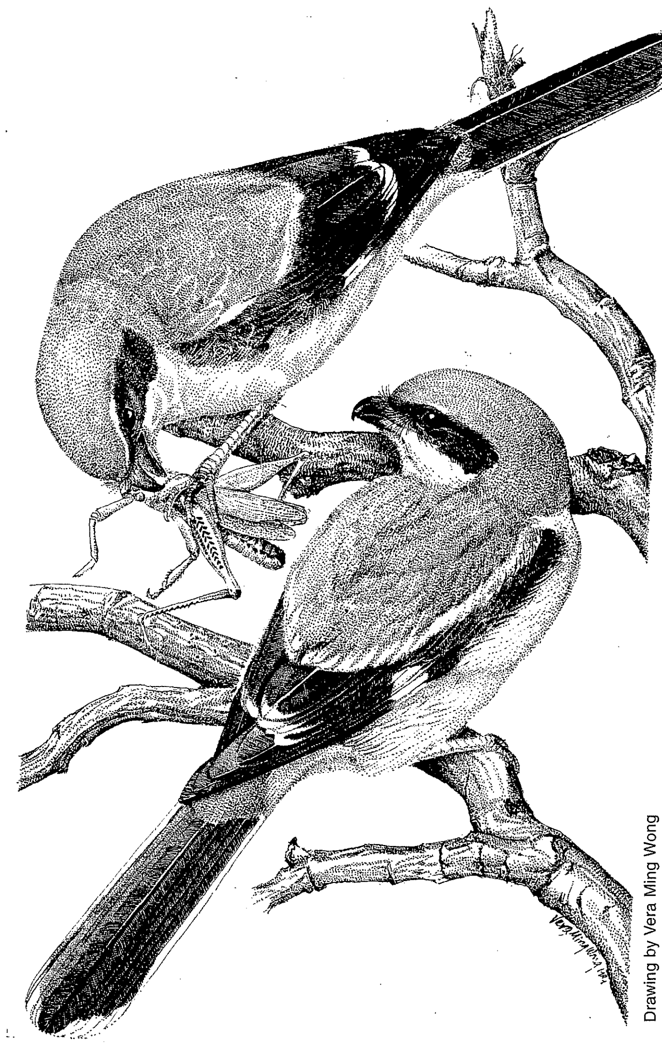
In addition to the management species discussed under monitoring, the U.S. Forest Service has another category, called "sensitive species," which are listed at both the Regional and National Forest levels. For the Eastern Region (R9) sensitive species are defined as "those plant and animal species identified by a Regional Forester for which population viability is a concern as evidenced by significant current or predicted downward trends in population numbers or density, or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution" (U.S. Forest Service 1991, p. 13).

The criteria adopted by the Regional Forester (Milwaukee) to establish the list were twofold: (1) is considered globally imperiled by The Nature Conservancy (Gl - G5), and (2) appears on the Federal Register list of "candidate" species. The Regional Forester's memo of March 8, 1994, describes the purpose of the regional list and differentiates it from the national forests' lists: "The significance of the policy is that conservation actions are planned for sensitive species and their habitats, and effects analyses [usually biological evaluations] are done for agency actions that potentially could affect sensitive species. . . . Taxa for which states have expressed concern for local biodiversity and viability concerns are addressed by individual Forest Units during the forest planning process."

Only two forest birds appear on the Regional Forester's list: Northern Goshawk and Cerulean Warbler.

The Regional Forester's policy was not finalized when the Forest Plans were adopted (1986); thus both the Chippewa and the Superior developed lists that are called "candidate sensitive species." The Chippewa subsequently amended its plan to establish a "forest sensitive species" list (incorporating the state's "listed species"), but the Superior has not yet done that. However, biological evaluations, at least for plants, are conducted for the candidate sensitive species.

Both categories of sensitive species appear in this appendix.




*The Loggerhead Shrike is a candidate species on the Federal List and a threatened species on the State List.*

### Breeding Season Vulnerability

As part of the Forest Wildlife Technical Paper for the Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota (GEIS), a vulnerability analysis was done, using measurable definitions for the Rabinowitz criteria described earlier, for the three harvest scenarios analyzed for the GEIS. For each harvest scenario (base year, 4 million cords; medium, 4.9 million cords; high, 7 million cords) the species that were negatively affected by increased forest harvesting and were identified as vulnerable are identified in this appendix. This model has the same data and definitional problems of all such analyses, but it is a good beginning. For a discussion of the technique and the results, see Jaakko Pöyry, 1992, Forest Wildlife, GEIS Technical Paper, pp. 152–59.

### Breeding Bird Survey Species Trends

The source of these data has been discussed in detail in chapter 2. The important point to note about the data in this appendix is how many forest-dependent species have insufficient data to determine a trend. Just because a trend cannot be measured does not mean that nothing is happening to that species. In Minnesota 41% of the species are too uncommon to be analyzed for trends by the Breeding Bird Survey. This is another reason why special attention needs to be paid to rare species.

### Tropical Winter Vulnerability

None of the categories just described cover the risk that migrants face due to winter habitat conditions. We know that the destruction of tropical forests is a problem yet we know little about exact ranges, densities, and habitat preferences of migrant species in tropical habitats. Another problem that has received very little attention is the use of pesticides on the wintering grounds of neotropical migrants, which may be a problem for continental migrants as well

Given the lack of precise information, all that is indicated in the table is a list of which neotropical migrants are threatened with habitat loss on their wintering grounds. The information is meant to serve as an early warning. The species that are included were identified in analyses done by Diamond (1991), Petit et al. (1993), and Terborgh (1989). Similar information about winter habitat is also provided by Reed (1992) in a classification of rarity for neotropical migrant warblers and vireos. In these analyses several species stand out as being especially at risk: Olive-sided Flycatcher, Yellow-bellied Flycatcher, Great Crested Flycatcher, Chestnut-sided Warbler, and Cerulean Warbler.

## Key

**Fed/State Listed Species =** Federal and State Listed Species
**E =** Endangered
**T =** Threatened
**SC =** Special Concern
**Cand. =** Candidate

**USFWS Mgmt. Concern =** U.S. Fish and Wildlife Service - Management Concern Species
**SNF Sensitive Species =** Superior National Forest - Sensitive Species
**CNF Sensitive Species =** Chippewa National Forest - Sensitive Species

**Tropical Winter Vuln. =** Vulnerable due to habitat destruction on the wintering ground in the tropics
**X =** the species is included on the indicated list

**GEIS Vuln. =** Vulnerable to population declines according to the GEIS study - indicates high vulnerability to decline and the harvest scenario under which declines were projected
**1 =** Base harvest scenario - 4 million cords yearly
**2 =** Medium harvest scenario - 4.9 million cords yearly
**3 =** High harvest scenario - 7 million cords yearly

**BBS Trends =** Breeding Bird Survey trends - only significant changes in population size shown
↓ = decline
↑ = increase
* = $p < .10$
** = $p < .05$
*** = $p < .01$
S = steady, i.e., no significant change
— = insufficient data to determine a trend

**Sources:** Federal and State Threatened and Endangered Species lists; Diamond (1991); Jaakko Pöyry Consulting (1992b); Petit et al. (1993); Reed (1992); Terborgh (1989); U.S. Fish and Wildlife Service (1995); and U.S. Forest Service (1986a, b).

# Species of management concern

| Species | Fed/State Listed Species | USFWS Mgmt. Concern | SNF Sensitive Species | CNF Sensitive Species | Tropical Winter Vuln. | GEIS Vuln. | BBS 82–91 | BBS 66–91 |
|---|---|---|---|---|---|---|---|---|
| Double-crested Cormorant | | | | | | | ↑ ** | ↑ ** |
| Great Blue Heron | | | | | | | S | S |
| Great Egret | | | | | | | ↑ * | ↑ ** |
| Green Heron | | | | | | | S | S |
| Black-crowned Night-Heron | | | | | | | — | — |
| Yellow-crowned Night-Heron | | | | | | | — | — |
| Wood Duck | | | | | | | S | S |
| Common Goldeneye | | | | | | | — | — |
| Bufflehead | | | | | | | — | — |
| Hooded Merganser | | | | | | | — | — |
| Common Merganser | | | | | | | — | — |
| Turkey Vulture | | | | | | | — | — |
| Osprey | State-SC | | | X | | | — | — |
| Bald Eagle | Fed/St-T | | | | | | — | — |
| Sharp-shinned Hawk | | | | | | | S | S |
| Cooper's Hawk | | | | | | | — | — |
| Northern Goshawk | Fed-Cand. | | X | X | | 3 | — | — |
| Red-shouldered Hawk | State-SC | X | | X | | 1-2-3 | — | — |
| Broad-winged Hawk | | | | | | | ↓ *** | S |
| Red-tailed Hawk | | | X | | | | S | ↑ ** |
| American Kestrel | | | | | | | S | S |
| Merlin | | | | | | 3 | — | — |
| Spruce Grouse | | | | | | | — | — |
| Ruffed Grouse | | | | | | | S | ↓ ** |
| Sharp-tailed Grouse | | | X | | | | — | — |
| Wild Turkey | | | | | | | — | — |

| Species | Fed/State Listed Species | USFWS Mgmt. Concern | SNF Sensitive Species | CNF Sensitive Species | Tropical Winter Vuln. | GEIS Vuln. | BBS 82–91 | BBS 66–91 |
|---|---|---|---|---|---|---|---|---|
| Northern Bobwhite | | | | | | | – | – |
| American Woodcock | | | | | | | – | ↓ ** |
| Mourning Dove | | | | | | | S | S |
| Black-billed Cuckoo | | | | | X | | S | S |
| Yellow-billed Cuckoo | | | | | X | | ↑ ** | S |
| Eastern Screech-Owl | | | | | | | – | – |
| Great Horned Owl | | | | | | | ↓ * | S |
| Barred Owl | | | | | | | S | S |
| Great Gray Owl | | | | | | | – | – |
| Long-eared Owl | | | | | | | – | – |
| Boreal Owl | | | X | | | 3 | – | – |
| Northern Saw-whet Owl | | | | | | 3 | – | – |
| Whip-poor-will | | | | | X | | – | – |
| Chimney Swift | | | | | | | S | S |
| Ruby-throated Hummingbird | | | | | X | | S | S |
| Red-headed Woodpecker | | | | | | | ↓ *** | ↓ * |
| Red-bellied Woodpecker | | | | | | | – | – |
| Yellow-bellied Sapsucker | | | | | X | | S | S |
| Downy Woodpecker | | | | | | | S | ↑ * |
| Hairy Woodpecker | | | | | | | S | ↑ * |
| Three-toed Woodpecker | | | X | | | | – | – |
| Black-backed Woodpecker | | | | | | | – | – |
| Northern Flicker | | | | | | | ↓ ** | ↓ * |
| Pileated Woodpecker | | | | | | | ↑ *** | ↑ * |
| Olive-sided Flycatcher | | X | | | X | | S | S |
| Eastern Wood-Pewee | | | | | X | | ↓ * | ↓ ** |

| Species | Fed/State Listed Species | USFWS Mgmt. Concern | SNF Sensitive Species | CNF Sensitive Species | Tropical Winter Vuln. | GEIS Vuln. | BBS 82–91 | BBS 66–91 |
|---|---|---|---|---|---|---|---|---|
| Yellow-bellied Flycatcher | | | | | X | | — | — |
| Acadian Flycatcher | | | | | X | 3 | — | — |
| Alder Flycatcher | | | | | | | ↓ * | ↑ *** |
| Willow Flycatcher | | | | | X | | S | S |
| Least Flycatcher | | | | | X | | S | ↓ ** |
| Eastern Phoebe | | | | | | | S | ↑ ** |
| Great Crested Flycatcher | | | | | X | | S | S |
| Eastern Kingbird | | | | | | | S | S |
| Tree Swallow | | | | | | | S | ↑ * |
| Gray Jay | | | | | | | — | — |
| Blue Jay | | | | | | | ↑ * | ↑ *** |
| Black-billed Magpie | | | | | | | — | — |
| American Crow | | | | | | | S | ↑ ** |
| Common Raven | | | | | | | S | ↑ * |
| Black-capped Chickadee | | | | | | | S | ↑ ** |
| Boreal Chickadee | | | | | | | — | — |
| Tufted Titmouse | | | | | | | — | — |
| Red-breasted Nuthatch | | | | | | | S | S |
| White-breasted Nuthatch | | | | | | | S | ↑ ** |
| Brown Creeper | | | | | | | — | — |
| House Wren | | | | | | | ↓ ** | S |
| Winter Wren | | | | | | | S | S |
| Sedge Wren | | | | | | | ↓ * | ↑ ** |
| Golden-crowned Kinglet | | | | | | 3 | — | — |
| Ruby-crowned Kinglet | | | | | | | ↓ *** | ↓ *** |
| Blue-gray Gnatcatcher | | | | | X | 3 | — | S |

| Species | Fed/State Listed Species | USFWS Mgmt. Concern | SNF Sensitive Species | CNF Sensitive Species | Tropical Winter Vuln. | GEIS Vuln. | BBS 82–91 | BBS 66–91 |
|---|---|---|---|---|---|---|---|---|
| Eastern Bluebird | | | X | | | | ↑ *** | ↑ ** |
| Veery | | | | | X | | S | S |
| Swainson's Thrush | | | | | X | | — | S |
| Hermit Thrush | | | | | | | S | S |
| Wood Thrush | | | | | X | 2-3 | ↑ *** | S |
| American Robin | | | | | | | S | ↑ * |
| Gray Catbird | | | | | | | S | S |
| Brown Thrasher | | | | | | | ↓ *** | S |
| Cedar Waxwing | | | | | | | ↓ * | S |
| Loggerhead Shrike | Fed-Cand.<br>State-T | | | X | | | — | — |
| European Starling | | | | | | | S | S |
| Bell's Vireo | | | | | X | | — | — |
| Solitary Vireo | | | | | X | 3 | S | ↑ * |
| Yellow-throated Vireo | | | | | X | 1-2-3 | S | S |
| Warbling Vireo | | | | | X | | S | S |
| Philadelphia Vireo | | | | | X | | — | — |
| Red-eyed Vireo | | | | | | | ↑ * | S |
| Blue-winged Warbler | | | | | X | | — | — |
| Golden-winged Warbler | | X | | | X | | S | S |
| Tennessee Warbler | | | | | X | | — | S |
| Nashville Warbler | | | | | | | S | S |
| Northern Parula | | | | | X | | — | S |
| Yellow Warbler | | | | | | | S | S |
| Chestnut-sided Warbler | | | | | X | | S | S |
| Magnolia Warbler | | | | | X | | ↑ *** | S |
| Cape May Warbler | | | | | | | — | — |

| Species | Fed/State Listed Species | USFWS Mgmt. Concern | SNF Sensitive Species | CNF Sensitive Species | Tropical Winter Vuln. | GEIS Vuln. | BBS 82–91 | BBS 66–91 |
|---|---|---|---|---|---|---|---|---|
| Black-throated Blue Warbler | | | | | X | 3 | — | — |
| Yellow-rumped Warbler | | | | | X | | S | S |
| Black-throated Green Warbler | | | | | X | | — | S |
| Blackburnian Warbler | | | | | X | | ↑ ** | S |
| Pine Warbler | | | X | | | 3 | — | ↑ *** |
| Palm Warbler | | | | | X | | — | — |
| Bay-breasted Warbler | | | | | X | | — | — |
| Cerulean Warbler | Fed-Cand. | X | | | X | 2-3 | — | — |
| Black-and-white Warbler | | | | | X | | S | S |
| American Redstart | | | | | X | | S | ↓ *** |
| Prothonotary Warbler | | | | | X | | — | — |
| Ovenbird | | | | | X | | S | S |
| Northern Waterthrush | | | | | X | | S | ↑ *** |
| Louisiana Waterthrush | State-SC | | | | X | | — | — |
| Connecticut Warbler | | | | | X | | S | S |
| Mourning Warbler | | | | | | | S | S |
| Common Yellowthroat | | | | | | | ↓ *** | S |
| Hooded Warbler | | | | | X | 1-2-3 | — | — |
| Wilson's Warbler | | | | | X | 1-2 | — | — |
| Canada Warbler | | | | | X | | — | S |
| Scarlet Tanager | | | X | | X | | S | S |
| Northern Cardinal | | | | | | | ↑ *** | ↑ *** |
| Rose-breasted Grosbeak | | | | | X | | S | S |
| Blue Grosbeak | | | | | | | — | — |
| Indigo Bunting | | | | | | | ↓ *** | S |
| Rufous-sided Towhee | | | | | | | — | S |

| Species | Fed/State Listed Species | USFWS Mgmt. Concern | SNF Sensitive Species | CNF Sensitive Species | Tropical Winter Vuln. | GEIS Vuln. | BBS 82–91 | BBS 66–91 |
|---|---|---|---|---|---|---|---|---|
| Chipping Sparrow | | | | | | | S | S |
| Clay-colored Sparrow | | | | | | | S | S |
| Savannah Sparrow | | | | | | | S | S |
| Le Conte's Sparrow | | | | | | | S | ↑ ** |
| Song Sparrow | | | | | | | S | S |
| Lincoln's Sparrow | | | | | | 1-2-3 | — | — |
| Swamp Sparrow | | | | | | | ↑ * | ↑ * |
| White-throated Sparrow | | | | | | | ↑ *** | S |
| Dark-eyed Junco | | | | | | | — | S |
| Bobolink | | | X | | | | ↓ *** | S |
| Rusty Blackbird | | | | | | | — | — |
| Common Grackle | | | | | | | ↓ ** | S |
| Brown-headed Cowbird | | | | | | | ↓ ** | ↓ *** |
| Orchard Oriole | | | | | | | S | ↑ ** |
| Northern Oriole | | | | | X | | ↓ * | S |
| Purple Finch | | | | | | | S | S |
| Red Crossbill | | | | | | | — | — |
| Pine Siskin | | | | | | 3 | — | ↓ ** |
| American Goldfinch | | | | | | | ↓ * | S |
| Evening Grosbeak | | | | | | 3 | — | S |

## Appendix E

### Scientific Names of Birds Mentioned in the Guide in Taxonomic Order

Double-crested Cormorant
*Phalacrocorax auritus*

Great Blue Heron
*Ardea herodias*

Great Egret
*Casmerodius albus*

Green Heron
*Butorides striatus*

Black-crowned Night-Heron
*Nycticorax nycticorax*

Yellow-crowned Night-Heron
*N. violaceus*

Wood Duck
*Aix sponsa*

American Black Duck
*Anas rubripes*

Mallard
*Anas platyrhynchos*

Common Goldeneye
*Bucephala clangula*

Bufflehead
*B. albeola*

Hooded Merganser
*Lophodytes cucullatus*

Common Merganser
*Mergus merganser*

Turkey Vulture
*Cathartes aura*

Osprey
*Pandion haliaetus*

Bald Eagle
*Haliaeetus leucocephalus*

Sharp-shinned Hawk
*Accipiter striatus*

Cooper's Hawk
*A. cooperii*

Northern Goshawk
*A. gentilis*

Red-shouldered Hawk
*Buteo lineatus*

Broad-winged Hawk
*B. platypterus*

Red-tailed Hawk
*B. jamaicensis*

American Kestrel
*Falco sparverius*

Merlin
*F. columbarius*

Spruce Grouse
*Dendragapus canadensis*

Ruffed Grouse
*Bonasa umbellus*

Sharp-tailed Grouse
*Tympanuchus phasianellus*

Wild Turkey
*Meleagris gallopavo*

Northern Bobwhite
*Colinus virginianus*

American Woodcock
*Scolopax minor*

Mourning Dove
*Zenaida macroura*

Passenger Pigeon (extinct)
*Ectopistes migratorius*

Black-billed Cuckoo
*Coccyzus erythropthalmus*

Yellow-billed Cuckoo
*C. americanus*

Eastern Screech-Owl
*Otus asio*

Great Horned Owl
*Bubo virginianus*

Northern Hawk Owl
*Surnia ulula*

Barred Owl
*Strix varia*

Great Gray Owl
*S. nebulosa*

Long-eared Owl
*Asio otus*

Boreal Owl
*Aegolius funereus*

Northern Saw-whet Owl
*A. acadicus*

Whip-poor-will
*Caprimulgus vociferus*

Chimney Swift
*Chaetura pelagica*

Ruby-throated Hummingbird
*Archilochus colubris*

Red-headed Woodpecker
*Melanerpes erythrocephalus*

Red-bellied Woodpecker
*M. carolinus*

Yellow-bellied Sapsucker
*Sphyrapicus varius*

Downy Woodpecker
*Picoides pubescens*

Hairy Woodpecker
*P. villosus*

Three-toed Woodpecker
*P. tridactylus*

Black-backed Woodpecker
*P. arcticus*

Northern Flicker
*Colaptes auratus*

Pileated Woodpecker
*Dryocopus pileatus*

Olive-sided Flycatcher
*Contopus borealis*

Eastern Wood-Pewee
*C. virens*

Yellow-bellied Flycatcher
*Empidonax flaviventris*

Acadian Flycatcher
*E. virescens*

Alder Flycatcher
*E. alnorum*

Willow Flycatcher
*E. traillii*

Least Flycatcher
*E. minimus*

Eastern Phoebe
*Sayornis phoebe*

Great Crested Flycatcher
*Myiarchus crinitus*

Eastern Kingbird
*Tyrannus tyrannus*

Tree Swallow
*Tachycineta bicolor*

Gray Jay
*Perisoreus canadensis*

Blue Jay
*Cyanocitta cristata*

Black-billed Magpie
*Pica pica*

American Crow
*Corvus brachyrhynchos*

Common Raven
*C. corax*

Black-capped Chickadee
*Parus atricapillus*

Boreal Chickadee
*P. hudsonicus*

Tufted Titmouse
*P. bicolor*

Red-breasted Nuthatch
*Sitta canadensis*

White-breasted Nuthatch
*S. carolinensis*

Brown Creeper
*Certhia americana*

Carolina Wren
*Thryothorus ludovicianus*

Bewick's Wren
*Thryomanes bewickii*

House Wren
*Troglodytes aedon*

Winter Wren
*T. troglodytes*

Sedge Wren
*Cistothorus platensis*

Golden-crowned Kinglet
*Regulus satrapa*

Ruby-crowned Kinglet
*R. calendula*

Blue-gray Gnatcatcher
*Polioptila caerulea*

Eastern Bluebird
*Sialia sialis*

Veery
*Catharus fuscescens*

Swainson's Thrush
*C. ustulatus*

Hermit Thrush
*C. guttatus*

Wood Thrush
*Hylocichla mustelina*

American Robin
*Turdus migratorius*

Gray Catbird
*Dumetella carolinensis*

Northern Mockingbird
*Mimus polyglottos*

Brown Thrasher
*Toxostoma rufum*

Bohemian Waxwing
*Bombycilla garrulus*

Cedar Waxwing
*B. cedrorum*

Northern Shrike
*Lanius excubitor*

Loggerhead Shrike
*L. ludovicianus*

European Starling
*Sturnus vulgaris*

Bell's Vireo
*Vireo bellii*

Solitary Vireo
*V. solitarius*

Yellow-throated Vireo
*V. flavifrons*

Warbling Vireo
*V. gilvus*

Philadelphia Vireo
*V. philadelphicus*

Red-eyed Vireo
*V. olivaceus*

Blue-winged Warbler
*Vermivora pinus*

Golden-winged Warbler
*V. chrysoptera*

Tennessee Warbler
*V. peregrina*

Nashville Warbler
*V. ruficapilla*

Northern Parula
*Parula americana*

Yellow Warbler
*Dendroica petechia*

Chestnut-sided Warbler
*D. pensylvanica*

Magnolia Warbler
*D. magnolia*

Cape May Warbler
*D. tigrina*

Black-throated Blue Warbler
*D. caerulescens*

Yellow-rumped Warbler
*D. coronata*

Black-throated Green Warbler
*D. virens*

Blackburnian Warbler
*D. fusca*

Pine Warbler
*D. pinus*

Kirtland's Warbler
*Dendroica pinus*

Palm Warbler
*D. palmarum*

Bay-breasted Warbler
*D. castanea*

Cerulean Warbler
*D. cerulea*

Black-and-white Warbler
*Mniotilta varia*

American Redstart
*Setophaga ruticilla*

Prothonotary Warbler
*Protonotaria citrea*

Worm-eating Warbler
*Helmitheros vermivorus*

Ovenbird
*Seiurus aurocapillus*

Northern Waterthrush
*S. noveboracensis*

Louisiana Waterthrush
*S. motacilla*

Connecticut Warbler
*Oporornis agilis*

Mourning Warbler
*O. philadelphia*

Common Yellowthroat
*Geothlypis trichas*

Hooded Warbler
*Wilsonia citrina*

Wilson's Warbler
*W. pusilla*

Canada Warbler
*W. canadensis*

Yellow-breasted Chat
*Icteria virens*

Scarlet Tanager
*Piranga olivacea*

Northern Cardinal
*Cardinalis cardinalis*

Rose-breasted Grosbeak
*Pheucticus ludovicianus*

Blue Grosbeak
*Guiraca caerulea*

Indigo Bunting
*Passerina cyanea*

Rufous-sided Towhee
*Pipilo erythrophthalmus*

Chipping Sparrow
*Spizella passerina*

Clay-colored Sparrow
*S. pallida*

Vesper Sparrow
*Pooecetes gramineus*

Savannah Sparrow
*Passerculus sandwichensis*

Le Conte's Sparrow
*Ammodramus leconteii*

Song Sparrow
*Melospiza melodia*

Lincoln's Sparrow
*M. lincolnii*

Swamp Sparrow
*M. georgiana*

White-throated Sparrow
*Zonotrichia albicollis*

Dark-eyed Junco
*Junco hyemalis*

Bobolink
*Dolichonyx oryzivorus*

Red-winged Blackbird
*Agelaius phoeniceus*

Rusty Blackbird
*Euphagus carolinus*

Common Grackle
*Quiscalus quiscula*

Brown-headed Cowbird
*Molothrus ater*

Orchard Oriole
*Icterus spurius*

Northern Oriole
*I. galbula*

Pine Grosbeak
*Pinicola enucleator*

Purple Finch
*Carpodacus purpureus*

Red Crossbill
*Loxia curvirostra*

White-winged Crossbill
*L. leucoptera*

Common Redpoll
*Carduelis flammea*

Hoary Redpoll
*C. hornemanni*

Pine Siskin
*C. pinus*

American Goldfinch
*C. tristis*

Evening Grosbeak
*Coccothraustes vespertinus*

***Source:*** Minnesota Ornithological Records Committee (1993).

# Appendix F

## Compilation of Local and Regional Bird Studies


### General - Statewide

Green, J. C. 1991. A landscape classification for breeding birds in Minnesota: An approach to describing regional biodiversity. The Loon 63 (2):80–91.

Janssen, R. B. 1987. Birds in Minnesota. University of Minnesota Press, Minneapolis.

Johnson, D. H. 1982. Raptors of Minnesota — Nesting distribution and population status. The Loon 54(2):73–104.

Minnesota Ornithological Records Committee. 1993. Checklist of the birds of Minnesota. Minnesota Ornithologists' Union.

### NW - Northwest - Lake Agassiz, Aspen Parklands Section

Birds of Agassiz National Wildlife Refuge. Dept. of Interior, USFWS, Agassiz NWR, Middle River, MN 56737. Phone: (218) 449–4115.

Powell, A. N. 1992. The breeding birds of Minnesota's northwestern state parks. 1992 Minnesota state park bird surveys. Minnesota Dept. of Natural Resources.

———. 1993. Bird surveys in Minnesota's northwestern state parks. The Loon 65 (1):4–11.

Steve, S. 1981. Bird list of the Thief River Falls sewage lagoons. The Loon (1):8–10.

Stucker, S. P. 1992. 1991 bird surveys in Kittson and Roseau Counties. The Loon 64 (2):107–13.

### N - North - Northern Minnesota and Ontario Peatlands Section

A checklist of birds. Birds of the Lake States, Voyageurs National Park, Chippewa National Forest, Nicolet National Forest, Superior National Forest. Lake States Interpretive Association, International Falls, MN 56649. Phone: (218) 283–2103.

Powell, A. N. 1992. The breeding birds of Minnesota's northwestern state parks. 1992 Minnesota state park bird surveys. Minnesota Department of Natural Resources.

———. 1993. Bird surveys in Minnesota's northwestern state parks. The Loon 65 (1):4–11.

Stucker, S. P. 1992. 1991 bird surveys in Kittson and Roseau Counties. The Loon 64 (2):107–13.

Wiens, T. P. 1984. Birds of Pine and Curry Island, Lake of the Woods County, Minnesota. The Loon 56 (2):82–88.

### NE - Northeast - Northern Superior Uplands Section

Doran, P., and J. Todd. 1976. Breeding birds on a copper-nickel exploration site. The Loon 48 (1):29–33.

Green, J. C., and G. J. Niemi. 1980. Birds of the Superior National Forest. Superior National Forest, Forest Service, U.S. Dept. of Agriculture.

Hanowski, J. M., and G. J. Niemi. 1994. Breeding bird abundance patterns in the Chippewa and Superior National Forests from 1991 to 1993. The Loon 66 (2):64–70.

Niemi, G. J. 1987. Breeding birds at Hovland Woods, Cook County, Minnesota, 1983. The Loon 59 (1):36–41.

**NC - North-Central - Northern Minnesota Drift and Lake Plains Section**

Blockstein, D. E. 1991. A quantitative assessment of four breeding bird communities in Itasca State Park. The Loon 63 (1):18–26.

Hanowski, J. M., and G. J. Niemi. 1994. Breeding bird abundance patterns in the Chippewa and Superior National Forests from 1991 to 1993. The Loon 66 (2):64–70.

Lokemoen, J. T. 1994. Nesting waterfowl and other water birds on islands in western Minnesota. The Loon 66 (1):38–40.

Parmelee, D. F. 1977. Annotated checklist of the birds of Itasca State Park and surrounding areas. The Loon 49 (2): 81–95.

**EC - East-Central - Western Superior Uplands Section**

Dorf, C. J., and G. E. Nordquist. 1993. Animal surveys at the Minnesota Army National Guard Camp Ripley training site. 1991–1992. Final Report. Minnesota County Biological Survey, Nongame Wildlife and Natural Heritage Programs, Section of Wildlife, Division of Fish and Wildlife. Minnesota Department of Natural Resources, Biological Report No. 40.

Esler, D. 1985. A May 1985 survey of birds in selected Pine County water areas. The Loon 57 (2):79–86.

Hanowski, J. M., and G. J. Niemi. 1993. Birds of the Sandstone Unit, Rice Lake N. W. R. The Loon 65(2):84–90.

———. 1993. Breeding birds of Rice Lake NWR, Aitkin County. The Loon 65 (3):139–46.

Merrill, S. E. 1994. Birds of Camp Ripley, Morrison County. The Loon 66 (3):117–26.

Minnesota Department of Natural Resources. 1993. Animal surveys at the Minnesota Army National Guard Camp Ripley training site. 1993. Minnesota Department of Natural Resources, Biological Report No. 51.

———. 1995. Animal surveys at the Minnesota Army National Guard Camp Ripley training site. 1994 annual report and selected other reports. Minnesota Department of Natural Resources, Biological Report No. 52.

**C - Central - Minnesota and NE Iowa Moraines Section**

Eliason, B. C., and B. A. Fall. 1989. Louisiana Waterthrush in Washington County: Results of the 1988 Minnesota County Biological Survey work. The Loon 61 (1):34–37.

Hennepin Parks. 1994. Birds of Hennepin Parks: Checklist and observation guide.

Howitz, J. L. 1983. Noteworthy breeding birds of the Cedar Creek Natural History Area. The Loon 55 (3):99–100.

La Fond, K. J. 1978. An annotated list of Anoka County birds. The Loon 50 (2):84–99.

Lokemoen, J. T. 1994. Nesting waterfowl and other water birds on islands in western Minnesota. The Loon 66 (1):38–40.

Longley, W. H. 1990. Birds of the Boot Lake Scientific and Natural Area, Anoka County, Minnesota. The Loon 62 (1):46–50.

———. 1991. Birds of the Boot Lake Scientific and Natural Area, Anoka County, part two: 1990. The Loon 63 (1):37–41.

———. 1991. Birds of the Lost Valley Prairie Scientific and Natural Area, Washington County—1990. The Loon 63 (1):34–37.

———. 1992. Birds of the Lost Valley Prairie Scientific and Natural Area, Washington County, Minnesota part two: 1991. The Loon 64 (1):36–39.
———. 1992. Birds of the Falls Creek Scientific and Natural Area, Washington County, Minnesota, 1991. The Loon 64 (1):40–43.
———. 1993. Birds of the Falls Creek Scientific and Natural Area, Washington County, Part Two: 1992. The Loon 65 (1):11–13.
———. 1993. Birds of the St. Croix Savannah Scientific and Natural Area, Washington County, 1992. The Loon 65 (2):61–63.
———. 1994. Birds of the Lamprey Pass Wildlife Management Area, Anoka County, 1993. The Loon 66 (1):34–37.
Rustad, O. 1977. Birds of Rice County, Minnesota (part I). The Loon 48 (4):136–49.
———. 1977. Birds of Rice County (part II). The Loon 49 (1):9–25.

### SE - Southeast - Driftless and Dissected Plateau Section

Fowler, J. 1980. The birds of Olmsted County. The Loon 52 (1):23–35.
Plunkett, A. M. 1990. Birds of the flood control reservoirs of Rochester. The Loon 62 (4):188–95.

### SW - Southwest - North Central Glaciated Plains Section

Buer, M. 1981. Birds of Big Stone National Wildlife Refuge. The Loon 53 (2):67–81.

### W - West - Red River Valley Section

Lokemoen, J. T. 1994. Nesting waterfowl and other water birds on islands in western Minnesota. The Loon 66 (1):38–40.
Powell, A. N. 1992. The breeding birds of Minnesota's northwestern state parks. 1992 Minnesota state park bird surveys. Minnesota Department of Natural Resources.
———. 1993. Bird surveys in Minnesota's northwestern state parks. The Loon 65 (1):4–11.
Stucker, S. P. 1992. 1991 bird surveys in Kittson and Roseau Counties. The Loon 64 (2):107–13.
Svedarsky, W. D., T. A. Feiro, and D. Sandstrom. 1983. Breeding birds of an abandoned gravel pit in northwest Minnesota. The Loon 55 (3):100–107.

## Glossary of Terms

**avifauna:** The birds or kinds of birds of a region, period, or environment.

**biodiversity, biological diversity:** The variety and abundance of species, their genetic composition, and the communities, ecosystems, and landscapes in which they occur. These terms also refer to ecological structures, functions, and processes at all these levels. Biological diversity occurs at spatial scales that range from local through regional to global.

**biogeography:** A science that deals with the geographical distribution of animals and plants.

**biome:** A major ecological community type such as tropical rain forest, grassland, or desert.

**boreal:** Of or relating to the northern biotic area characterized especially by dominance of coniferous forests.

**community:** An assemblage of species at a particular time and place.

**corvids:** Birds belonging to the family Corvidae, which includes jays, crows, ravens and magpies.

**demographics:** The statistical characteristics of a population, for example, sex, age, and so on.

**ecoregion:** A region, hundreds to thousands of square miles in area, that is defined by its macroclimate, glacial geology, bedrock geology, and presettlement vegetation.

**ecosystem:** All the interconnected populations of plants, animals, and microorganisms occupying an area and interacting with their physical and chemical environment. An ecosystem is multiscale and can be defined on any spatial scale from cubic yards to the entire biosphere.

**ecotone:** A transitional area between two adjacent ecological communities.

**empirical:** Originating in or based on observation or experience.

**endemic:** Characteristic of or prevalent in a particular area or environment; restricted or peculiar to a locality or region.

**ericaceous:** Being a heath or a member of the heath family of low, much-branched evergreen shrubs.

**extirpated:** A species that is no longer present in a given locality but is not extinct because it still exists in other regions.

**floristics:** The actual plant species found in a given area as opposed to the physiognomy or structure of the vegetation.

**fragmentation:** Breaking up of a large and contiguous ecosystem into patches separated from each other by different ecosystem types.

**habitat scale**

- **microhabitat:** The condition within an area usually smaller than a forest stand; a site where an individual organism performs a single activity such as nesting or foraging.
- **stand:** Plant communities, particularly of trees, sufficiently uniform in composition, age, structure, and/or topography to be distinguishable from adjacent communities; may also delineate a silvicultural or management entity.
- **landscape:** The landforms and associated ecosystems and habitats at scales of hundreds to thousands of acres; *regional landscape* is at the larger scale of hundreds to thousands of square miles.

**herpetofauna:** The reptiles or kinds of reptiles of a region, period, or environment.

**indicator species:** Individual species that suggest the effects of management practices on a broad set of species. Assumptions implicit in the use of indicators are that they provide a reliable assessment of habitat quality and that if the habitat is maintained for the indicator, conditions will be suitable for other species.

**lepidopteran:** Any of a large order of insects including the butterflies and moths that as adults have four broad or lanceolate wings and as larvae are caterpillars.

**microclimate:** The essentially uniform local climate of a small site or habitat.

**microhabitat:** The microenvironment in which an organism lives; for example, decaying wood creates a microhabitat for insects.

**microspatial heterogeneity:** Dissimilarity or diversity at a small spatial scale.

**Nearctic:** Pertaining to the nontropical portions of North America, roughly the region north of the northern border of Mexico. The boundary between the Nearctic and Neotropical regions is not sharp because of the gradual changes in vegetation and climate. For convenience in classifying migrants, the border of Mexico was chosen as the best approximation of the faunal boundary although some species have winter ranges that straddle the border.

**Neotropical:** Pertaining to the New World tropics, including all of tropical North, Central, and South America, the nontropical parts of South America, the West Indies, and other islands near South America.

**pandemic:** Occurring over a wide geographic area.

**patch:** A nonlinear surface area differing in appearance from its surroundings.

**physiognomy:** The physical structure of vegetation as opposed to the floristics or actual species.

**physiography:** Physical geography.

**population:** A group of individuals of the same species that is located in a particular time and place and that regularly exchanges genes through reproduction.

**seral stages:** Successional stages.

**species diversity**

- **within-habitat:** Diversity within a relatively homogeneous habitat; often measured by the number of species.
- **between-habitat:** Diversity measured by the change in species composition between habitats; or the number of species that are added when additional habitats are sampled across a forest gradient.
- **regional:** Diversity measured by the number of species in a large area containing many different kinds of habitats.

**stratum (*plural* strata):** One of a series of layers, levels, or gradations.

**taxon (*plural* taxa):** A taxonomic group or entity.

**wild animal (technical):** All nonhuman living creatures, wild by nature and endowed with sensation and power of voluntary motion, including mammals, birds, fish, amphibians, reptiles, crustaceans, and mollusks.

**wildlife:** In this book, wildlife is defined as all forms of animal life that are neither human nor domesticated.

## Literature Cited


Ambuel, B., and S. A. Temple. 1983. Area-dependent changes in bird communities and vegetation of southern Wisconsin forests. Ecology 64:1057–68.

Andren, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: A review. Oikos 71:355–66.

Angermeier, P. L., and J. R. Karr. 1994. Biological integrity versus biological diversity as policy directives. BioScience 44 (10): 690–97.

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. Biological Conservation 39:129–52.

Askins, R. A., J. F. Lynch, and R. Greenberg. 1991. Population declines in migratory birds in eastern North America. Current Ornithology 7:1–57.

Bielefeldt, J., and R. N. Rosenfield. 1994. Summer birds of conifer plantations in southeastern Wisconsin. Passenger Pigeon 56 (2):123–35.

Blake, J. G. 1983. Trophic structure of bird communities in forest patches in east-central Illinois. Wilson Bulletin 95:416–30.

Blake, J. G., and J. R. Karr. 1984. Species composition of bird communities and the conservation benefit of large versus small forests. Biological Conservation 30:173–87.

———. 1987. Breeding birds of isolated woodlots: Area and habitat relationships. Ecology 68:1724–34.

Blake, J. G., G. J. Niemi, and J. M. Hanowski. 1992. Drought and annual variation in bird populations. Pages 419–30 in J. M. Hagan III and D. W. Johnston, eds., Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C. and London.

Braun, E. L. 1950. Deciduous forests of eastern North America. Blakiston, Philadelphia.

Brawn, J. D., B. Tannenbaum, and K. E. Evans. 1984. Nest site characteristics of cavity nesting birds in central Missouri. Research Note. North-Central Forest Experiment Station, U.S. Forest Service, U.S. Dept. of Ag.

Brittingham, M. C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31–35.

Coffin, B., and L. Pfannmuller, eds. 1988. Minnesota's endangered flora and fauna. University of Minnesota Press, Minneapolis.

Collins, H. L., D. P. Christian, and L. L. Holmstrand. 1981. Mammals of the Superior National Forest in Minnesota. Superior National Forest, Forest Service, U.S. Dept. of Ag.

Collins, S. L., F. C. James, and P. G. Risser. 1982. Habitat relationships of wood warblers (Parulidae) in north-central Minnesota. Oikos 39:50–58.

Crawford, H. S., and D. T. Jennings. 1989. Predation by birds on spruce budworm *Choristoneura fumiferana*: Functional, numerical, and total responses. Ecology 70 (1):152–63.

Crow, T. R., A. Haney, and D. M. Waller. 1994. Report on the scientific roundtable on biological diversity convened by the Chequamegon and Nicolet National Forests. U.S. Dept. Ag., Forest Service, North-Central

Forest Experiment Station, General Technical Report NC-166.

Curson, J., D. Quinn, and D. Beadle. 1994. Warblers of the Americas. An identification guide. Houghton Mifflin Company, Boston.

Darveau, M., P. Beauchesne, L. Belanger, J. Huot, and P. Larue. 1995. Riparian forest strips as habitat for breeding birds in boreal forest. Journal of Wildlife Management 59 (1):67–78.

DeGraaf, R. M. 1987. Managing northern hardwoods for breeding birds. Pages 348–62 in R. D. Nyland, ed., Managing northern hardwoods. Society of American Foresters Pub. No. 87-03.

———. 1991. Breeding bird assemblages in managed northern hardwood forests in New England. Pages 153–71 in J. E. Rodiek and E. G. Bolen, eds., Wildlife and habitats in managed landscapes. Island Press, Washington, D.C.

DeGraaf, R. M., N. G. Tilghman, and S. H. Anderson. 1985. Foraging guilds of North American birds. Environmental Management 9:493–536.

Diamond, A. W. 1991. Assessment of the risks from tropical deforestation to Canadian songbirds. Pages 177–94 in Transactions of the 56th North American Wildlife & Natural Resources Conference, March 17–22, 1991, Edmonton, Alberta.

Diamond, J. 1992. The third chimpanzee: The evolution and the future of the human animal. HarperCollins, New York.

Dinsmore, J. J. 1994. A country so full of game. The story of wildlife in Iowa. University of Iowa Press, Iowa City.

Droege, S., and B. Peterjohn. 1991. Priority species for Partners in Flight. Pages 40–48 in Needs assessment: Monitoring neotropical migratory birds. Prepared by participants at Monitoring Working Group of Partners in Flight, the Neotropical Migratory Bird Conservation Program, Sept. 4–5, 1991, Arlington, Va.

Dunning, J. B. Jr. 1993. CRC handbook of avian body masses. CRC Press, Boca Raton, Fla.

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, New York.

Elliott, C. A. 1987. Songbird species diversity and habitat use in relation to vegetation structure and size of forest stands and forest-clearcut edges in north-central Maine. Ph.D. diss., University of Maine, Orono.

Evans, K. E., and R. N. Conner. 1979. Snag management. Pages 214–25 in Proceedings of workshop on management of north central and northeastern forests for nongame birds. U.S. Dept. of Ag., Forest Service, General Technical Report NC-51.

Fenske, T. In preparation. Predation of artificial ground nests: The influence of different types of edges. Master's thesis, University of Minnesota, Duluth.

Forman, R. T. T., and M. Godron. 1986. Landscape ecology. John Wiley & Sons, New York.

Franklin, J. 1989. Toward a new forestry. American Forests 95 (11, 12): 37–44.

Freemark, K., and B. Collins. 1992. Landscape ecology of birds breeding in temperate forest fragments. Pages 443–54 in J. M. Hagan III and D. W. Johnston, eds., Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C. and London.

Frelich, L. E. 1992. The relationship of natural disturbances to white pine stand development. Pages 27–37 in R. A. Stine and M. J. Baughman, eds., Proceedings of white pine symposium: History, ecology, policy and management, Duluth, Minn., Sept. 16–18, 1992.

———. 1995. Old forest in the Lake States today and before European settlement. Natural Areas Journal 15 (2): 157–67.

Frost, E. J. 1993. Conservation biology and national forest management in the inland Northwest: A handbook for activists. Greater Ecosystem Alliance, Bellingham, Wash.

Gauthreaux, S. A. 1992. The use of weather radar to monitor long-term patterns of trans-Gulf migration in spring. Pages 96–100 in J. M. Hagan III and D. W. Johnston, eds., Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C. and London.

Gibbs, J. P., and J. Faaborg. 1990. Estimating the viability of Ovenbird and Kentucky Warbler populations in forest fragments. Conservation Biology 4 (2):193–96.

Green, J. C. 1991. A landscape classification for breeding birds in Minnesota: An approach to describing regional biodiversity. The Loon 63:80–91.

———. 1992. Ecological features of white pine stands for wildlife. Pages 44–53 in R. A. Stine and M. J. Baughman, eds., Proceedings of white pine symposium: History, ecology, policy and management, Duluth, Minn., Sept. 16–18, 1992.

Green, J. C., and R. B. Janssen. 1975. Minnesota birds: Where, when, and how many. University of Minnesota Press, Minneapolis.

Green, J. C., and G. J. Niemi. 1980. Birds of the Superior National Forest. Superior National Forest, Forest Service, U.S. Dept. of Ag.

Grettenberger, J. 1991. Habitat fragmentation and forested wetlands on the upper Mississippi River: Potential impacts on forest-interior birds. Passenger Pigeon 53 (3):227–41.

Gullion, G. G. 1984. Grouse of the north shore. Willow Creek Press, Oshkosh, Wis.

Hamel, P. B. 1992. Land manager's guide to the birds of the south. The Nature Conservancy, Chapel Hill, N.C. and the U.S. Forest Service, Southern Region, Atlanta.

Hanowski, J. M., and G. J. Niemi. 1991a. Monitoring bird populations on National Forest lands: Chippewa National Forest, 1991. CNF Report No. 1, NRRI/TR-91/20. Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.

———. 1991b. Monitoring bird populations on National Forest lands: Superior National Forest, 1991. SNF Report No. 1, NRRI/TR-91/21. Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.

———. 1992. Monitoring bird populations on National Forest lands: Chippewa National Forest, 1992. CNF Report No. 2, NRRI/TR-92/21. Center for Water and the Environment,

Natural Resources Research Institute, University of Minnesota, Duluth.
———. 1993. Monitoring bird populations on National Forest lands: Superior National Forest, 1992. SNF Report No. 2, NRRI/TR-93/1. Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.
———. 1994a. Importance of riparian habitat to Minnesota's forest birds. Poster presentation at Ecosystem Management Strategies for the Lake Superior Region Conference, Duluth, Minn., May 16–18, 1994.
———. 1994b. Breeding bird abundance patterns in the Chippewa and Superior National Forests from 1991 to 1993. The Loon 66: 64–70.
Hanski, I. K., T. Fenske, and G.J. Niemi. In preparation. Nest success of breeding birds in forested landscapes of northern Minnesota.
Hardin, K. I., and K. E. Evans. 1977. Cavity nesting bird habitat in the oak-hickory forest: A review. North-Central Forest Experiment Station, Forest Service, U.S. Dept. of Ag. General Technical Report NC-30.
Hargrave, B. 1993. The upper levels of an ecological classification system for Minnesota. Minnesota Department of Natural Resources, St. Paul.
Hawrot, R. Y., J. M. Hanowski, A. R. Lima, and G. J. Niemi. 1993. Monitoring bird populations on National Forest lands: Chequamegon National Forest, 1993. CQNF Report No. 2, NRRI/TR-93/49. Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.
———. 1994. 1994 annual report: Bird monitoring in Great Lakes National Forests: the Chequamegon, Chippewa and Superior. SNF Report No. 4, NRRI/TR-94/34. Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.
Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Journal of Quaternary Research 3 (3):329–82.
———. 1974. Interpretation of Francis J. Marschner's map of the original vegetation of Minnesota. U.S. Forest Service, North-Central Forest Experiment Station, St. Paul, Minnesota.
———. 1981. Fire and succession in the conifer forest of northern North America. Pages 374–405 in D. C. West, H. H. Shugart, and D. B. Botkin, eds., Forest succession: Concepts and applications. Springer-Verlag, New York.
Hoffman, R. M., and M. J. Mossman. 1990. Birds of northern Wisconsin pine forests. Passenger Pigeon 52:339–55.
Holling, C. S., ed. 1978. Adaptive environmental assessment and management. John Wiley and Sons, London.
———. 1988. Temperate forest insect outbreaks, tropical deforestation and migratory birds. Memoirs of the Entomological Society of Canada 146:21–32.
Holmes, R. T. 1990a. Ecological and evolutionary impacts of bird predation on forest insects: An overview. Studies in Avian Biology 13:6–13.

———. 1990b. The structure of a temperate deciduous forest bird community: Variability in time and space. Pages 121–39 in A. Keast, ed., Biogeography and ecology of forest bird communities. SPB Academic Publishing, The Hague, The Netherlands.

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

Howe, R. W., S. A. Temple, and M. J. Mossman. 1992. Forest management and birds in northern Wisconsin. Passenger Pigeon 54:297–305.

Huggard, D. J. 1994. Habitat dilution: A neglected effect of fragmentation? Pages 108–9 in Conserving forest biodiversity: Abstracts of papers and posters presented at the International Forest Biodiversity Conference, December 4–9, 1994, Canberra, Australia.

Hunter, M. L., Jr. 1990. Wildlife, forests, and forestry: Principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, N.J.

Hunter, M. L., Jr., and A. Hutchinson. 1994. The virtues and shortcomings of parochialism: Conserving species that are locally rare, but globally common. Conservation Biology 8:1163–65.

Jaakko Pöyry Consulting, Inc. 1992a. Biodiversity. A technical paper for a generic environmental impact statement on timber harvesting and forest management in Minnesota. Report for Environmental Quality Board.

———. 1992b. Forest wildlife. A technical paper for a generic environmental impact statement on timber harvesting and forest management in Minnesota. Report for Environmental Quality Board.

Janssen, R. B. 1987. Birds in Minnesota. University of Minnesota Press, Minneapolis.

Johnson, W. C., and T. Webb III. 1989. The role of Blue Jays (*Cyanocitta cristata* L.) in the postglacial dispersal of fagaceous trees in eastern North America. Journal of Biogeography 16:561–71.

Johnston, C. A., and R. J. Naiman. 1990. The use of a geographic information system to analyze long-term landscape alteration by beaver. Landscape Ecology 4 (1):5–19.

Kaufmann, M. R., R. T. Graham, D. A. Boyce Jr., W. H. Moir, L. Perry, R. T. Reynolds, R. L. Bassett, P. Mehlhop, C. B. Edminster, W. M. Block, and P. S. Corn. 1994. An ecological basis for ecosystem management. Rocky Mountain Forest and Range Experiment Station and Southwestern Region, Forest Service, U.S. Department of Agriculture, General Technical Report RM-246.

Kotar, J. 1994. Implications of ecosystem management concepts for the practice of silviculture in the Lake States. Prepared for the Lake States Forestry Alliance. Forestry Department, University of Wisconsin, Madison.

Landres, P. B., J. Verner, and J. W. Thomas. 1988. Ecological uses of vertebrate indicator species: A critique. Conservation Biology 2:316–28.

Lane, W. H., T. H. Nicholls, and D. E. Andersen. 1993. Boreal Owl and Northern Saw-whet Owl cavity and nest-site characteristics in northeastern Minnesota. Abstracts of papers presented at 55th Midwest Fish and Wildlife Conference, St. Louis.

Lawton, J. H., S. Nee, A. J. Letcher, and P. H. Harvey. 1993. Animal distributions: Patterns and processes. Pages 41–58 in P. J. Edwards, R. M. May, and N. R. Webb, eds., Large-scale ecology and conservation biology. The 35th Symposium of the British Ecological Society with the Society for Conservation Biology, University of Southampton. Blackwell Scientific Publications, Oxford.

Leopold, A. 1966. A Sand County almanac. Oxford University Press, New York.

Lorimer, C. G., and L. E. Frelich. 1994. Natural disturbance regimes in old-growth northern hardwoods: Implications for restoration efforts. Journal of Forestry 92:33–38.

Lynch, J. F., and R. F. Whitcomb. 1978. Effects of insularization of the eastern deciduous forest on avifaunal diversity and turnover. Pages 461–89 in A. Marmelstein, ed., Classification, inventory and analysis of fish and wildlife habitat: Proceedings of a symposium, U.S. Fish and Wildlife Service OBS-78/76, Washington, D.C.

Marquis, R. J., and C. J. Whelan. 1994. Insectivorous birds increase growth of white oak through consumption of leaf-chewing insects. Ecology 75 (7):2007–14.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife and plants. A guide to wildlife food habits: The use of trees, shrubs, weeds, and herbs by birds and mammals of the United States. Dover Publications, New York.

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. Wildlife Monographs No. 111.

Minnesota Department of Natural Resources. 1986. Checklist of endangered and threatened animal and plant species of Minnesota. Section of Wildlife, Minnesota Department of Natural Resources, St. Paul.

———. 1994. Region II snag guidelines. Minnesota Department of Natural Resources, Division of Forestry and Division of Fish and Wildlife, St. Paul.

Minnesota Environmental Indicators Task Force. 1994. Fact sheet: Minnesota Environmental Indicators Initiative. Minnesota Department of Natural Resources and Minnesota Pollution Control Agency, St. Paul.

Minnesota Ornithological Records Committee. 1993. Checklist of the birds of Minnesota. Minnesota Ornithologists' Union.

Mladenoff, D. J., and J. Pastor. 1993. Sustainable forest ecosystems in the northern hardwood and conifer forest region: Concepts and management. Pages 145–80 in G. H. Aplet, N. Johnson, J. T. Olson, and V. A. Sample, eds., Defining sustainable forestry. Island Press, Washington, D.C.

Mladenoff, D. J., M. A. White, and J. Pastor. 1993. Comparing spatial pattern in unaltered old-growth and disturbed forest landscapes. Ecological Applications 3 (2):294–306.

Mladenoff, D. J., M. A. White, and P. Polzer. 1993. GIS characterization of forest landscape pattern of Minnesota ecoregions using land use/land cover data. Pages 49–65 in Pfannmuller, L. A., G. J. Niemi, D. Mladenoff, J. M. Hanowski, P. Helle, A. Lima, P. Polzer, M. White, and J. C. Green, Effects of change in the forest ecosystem on the biodiversity of Minnesota's northern forest birds. Tech. Report prepared for the Legislative Commission for Minnesota Resources for the FY92-93 Biennium.

Mladenoff, D. J., T. R. Crow, and J. Pastor. 1994. Applying principles of landscape design and management to integrate old-growth forest enhancement and commodity use. Conservation Biology 8 (3):752–62.

Mönkkönen, M. 1994. Diversity patterns in Palaearctic and Nearctic forest bird assemblages. Journal of Biogeography 21:183–95.

Montgomery, K., J. M. Hanowski, A. Lima, and G. J. Niemi. 1993. Monitoring bird populations on National Forest lands: Chippewa National Forest, 1993. CNF Report No. 3, NRRI/TR-93/50. Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.

Morrison, M. L., B. G. Marcot, and R. W. Mannan. 1992. Wildlife-habitat relationships: Concepts and applications. University of Wisconsin Press, Madison.

Morse, D. H. 1993. Black-throated Green Warbler (*Dendroica virens*). In A. Poole and F. Gill, eds., The Birds of North America, No. 55. The Academy of Natural Sciences, Philadelphia; The American Ornithologists' Union, Washington, D.C.

Murcia, C. 1995. Edge effects in fragmented forests: Implications for conservation. Tree 10 (2):58–62.

Murray, N. L., and D. F. Stauffer. 1995. Nongame bird use of habitat in central Appalachian riparian forests. Journal of Wildlife Management 59 (1):78–88.

Niemi, G. J. 1982. Determining priorities in nongame management. The Loon 54:28–36.

Niemi, G. J., and J. M. Hanowski. 1984. Relationships of breeding birds to habitat characteristics in logged areas. Journal of Wildlife Management 48 (2):438–43.

———. 1992. Bird populations. Pages 111–29 in H. E. Wright Jr., B. A. Coffin, and N. E. Aaseng, eds., The patterned peatlands of Minnesota. University of Minnesota Press, Minneapolis.

Niemi, G. J., and J. R. Probst. 1990. Wildlife and fire in the Upper Midwest. Pages 31–46 in J. M. Sweeney, ed., Management of dynamic ecosystems. Proceedings of a symposium held at the 51st Midwest Fish and Wildlife Conference, Springfield, Ill. sponsored by the North Central Section of The Wildlife Society, West Lafayette, Ind.

Niemi, G. J., J. M. Hanowski, A. Lima, T. Nicholls, and N. Weiland. 1994. Management indicator bird species in the Chequamegon National Forest: Uses and limitations. Report to the North Central Forest Experiment Station, U.S. Dept. of Ag. Forest Service, St. Paul, Minn.

Niemi, G. J., J. M. Hanowski, A. Lima, R. Hawrot, K. Montgomery, C. Pearson, and T. Nicholls.

In preparation. Detecting annual changes of breeding birds through habitat-specific monitoring in the western Great Lakes region.

Noss, R. F. 1991. From endangered species to biodiversity. Pages 227–46 in K. A. Kohm, ed., Balancing on the brink of extinction: The endangered species act and lessons for the future. Island Press, Washington, D.C.

Partners in Flight. 1992. Migrant birds: A troubled future? Slide show prepared by the Information and Education Working Group of Partners in Flight. Cornell Laboratory of Ornithology, Ithaca, N.Y.

Paton, P. W. C. 1994. The effect of edge on avian nest success: How strong is the evidence? Conservation Biology 8:17–26.

Pearson, C. W. 1994. The effects of habitat and landscape patterns on avian distribution and abundance in northeastern Minnesota. Master's thesis, University of Minnesota, Duluth.

Pearson, C. W., J. M. Hanowski, A. R. Lima, and G. J. Niemi. 1993. Monitoring bird populations on National Forest lands: Superior National Forest, 1993. SNF Report No. 3, NRRI/TR-93/51. Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth.

Peck, K. M. 1989. Tree species preferences shown by foraging birds in forest plantations in northern England. Biological Conservation 48:41–57.

Peterjohn, B. C., and J. R. Sauer. 1994. Population trends of woodland birds from the North American breeding bird survey. Wildlife Society Bulletin 22:155–64.

Peterson, R. T. 1980. A field guide to the birds east of the Rockies. Houghton Mifflin Company, Boston.

———. 1990. A field guide to western birds. 3d ed. Houghton Mifflin Company, Boston.

Petit, D. R., J. F. Lynch, R. L. Hutto, J. G. Blake, and R. B. Waide. 1993. Management and conservation of migratory landbirds overwintering in the neotropics. Pages 70–92 in D. M. Finch and P. W. Stangel, eds., Status and management of neotropical migratory landbirds. U.S. Dept. of Ag. Forest Service General Technical Report RM-229.

Pfannmuller, L. A. 1991. Significance of oaks and oak forest communities for nongame wildlife. Pages 56–64 in S. B. Laursen and J. F. DeBoe, eds., Conference proceedings of The Oak Resource in the Upper Midwest: Implications for management, St. Mary's College, Winona, Minn. Publication No. NR-BU-5663 S, Minnesota Extension Service, University of Minnesota, St. Paul.

———. 1992. The great north woods medley. Minnesota Volunteer Sept/Oct:8–19.

Pfannmuller, L. A., and B. A. Coffin. 1989. The uncommon ones: Minnesota's endangered plants and animals. Nongame Wildlife and Natural Heritage Programs of the Section of Wildlife, Minnesota Department of Natural Resources, St. Paul.

Pfannmuller, L. A., G. J. Niemi, D. Mladenoff, J. M. Hanowski, P. Helle, A. Lima, P. Polzer, M. White, and J. C. Green. 1993. Effects of change in the forest ecosystem on the biodiversity of Minnesota's northern forest birds. Tech. Report prepared for the

Legislative Commission for Minnesota Resources for the FY92-93 Biennium.

Picman, J., and L. M. Schriml. 1994. A camera study of temporal patterns of nest predation in different habitats. Wilson Bulletin 106 (3):456–65.

Porneluzi, P., J. C. Bednarz, L. J. Goodrich, N. Zawada, and J. Hoover. 1993. Reproductive performance of terrestrial Ovenbirds occupying forest fragments and a contiguous forest in Pennsylvania. Conservation Biology 7 (3):618–22.

Powell, A. N. 1992. The breeding birds of Minnesota's northwestern state parks. 1992 Minnesota state park bird surveys. Minnesota Department of Natural Resources, St. Paul.

Powell, D. S., J. L. Faulkner, D. R. Darr, Z. Zhu, and D. W. MacCleery. 1993. Forest resources of the United States, 1992. U.S. Dept. of Ag. Forest Service, General Technical Report RM-234.

Rabinowitz, D., S. Cairns, and T. Dillon. 1986. Seven forms of rarity and their frequency in the flora of the British Isles. In M. E. Soulé, ed., Conservation biology: The science of scarcity and diversity. Sinauer Associates, Publishers, Sunderland, Mass.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. U.S. Dept. of Ag. Forest Service, Albany, Calif., Pacific Southwest Research Station, General Technical Report PSW-GTR-144.

Reed, J. M. 1992. A system of ranking conservation priorities for Neotropical migrant birds based on relative susceptibility to extinction. In J. M. Hagan III and D. W. Johnston, eds., Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C. and London.

Rich, A. S., D. S. Dobkin, and L. J. Niles. 1994. Defining forest fragmentation by corridor width: The influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conservation Biology 8 (4):1109–21.

Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. The Breeding Bird Survey: Its first fifteen years, 1965–1979. Resource Publication 157, U.S. Fish and Wildlife Service, 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, No. 103.

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 (19):7658–62.

Roberts, T. S. 1932. The birds of Minnesota. 2 vols. University of Minnesota Press, Minneapolis.

Robinson, S. K., and R. T. Holmes. 1984. Effects of plant species and foliage structure on the foraging behavior of forest birds. The Auk 101:672–84.

Robinson, S. K., J. A. Grzybowski, S. I. Rothstein, M. C. Brittingham, L. J. Petit, and F. R. Thompson. 1993. Management implications of cowbird parasitism on neotropical migrant songbirds. In D. M. Finch and P. W. Stangel,

eds., Status and management of neotropical migratory landbirds. U.S. Dept. of Ag. Forest Service General Technical Report RM-229.
Robinson, S. K., F. R. Thompson III, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987–90.
Rudnicky, T. C., and M. L. Hunter Jr. 1993. Avian nest predation in clearcuts, forests, and edges in a forest-dominated landscape. Journal of Wildlife Management 57 (2):358–64.
Ruggiero, L. F., G. D. Hayward, and J. R. Squires. 1994. Viability analysis in biological evaluations: Concepts of population viability analysis, biological population, and ecological scale. Conservation Biology 8 (2):364–72.
Runde, D. E., and D. E. Capen. 1987. Characters of northern hardwood trees used by cavity-nesting birds. Journal of Wildlife Management 51:217–23.
Sauer, J. R., and S. Droege, eds. 1990. Survey designs and statistical methods for the estimation of avian population trends. Biological Report 90 (1) U.S. Dept. of Interior, Fish and Wildlife Service, Washington, D.C.
Schoener, T. W. 1968. Sizes of feeding territories among birds. Ecology 42:123–41.
Schorger, A. W. 1937. The great Wisconsin Passenger Pigeon nesting of 1871. Proceedings of the Linnaean Society, New York 48:1–26.
———. 1955. Passenger Pigeon: Its natural history and extinction. University of Wisconsin Press, Madison.
Schroeder, R. L. 1985. Habitat suitability index models: Pine warbler. 1st rev., U.S. Fish and Wildlife Service FWS/OBS-82/10.28.
Society of American Foresters. 1991. Task force report on biological diversity in forest ecosystems. Society of American Foresters, Bethesda, Md.
Southwick Associates. 1991. Wildlife-associated nonconsumptive recreation in Minnesota: 1985 participation levels and economic impacts. A study prepared for a technical paper for the Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. Southwick Associates, Arlington, Va.
Stauffer, D. F., and L. B. Best. 1980. Habitat selection by birds of riparian communities: Evaluating effects of habitat alterations. Journal of Wildlife Management 44 (1):1–15.
Stearns, F. 1990. Forest history and management in the northern Midwest. Pages 107–22 in J. M. Sweeney, ed., Management of dynamic ecosystems. Proceedings of a symposium held at the 51st Midwest Fish and Wildlife Conference, Springfield, Ill. sponsored by the North Central Section of The Wildlife Society, West Lafayette, Ind.
Stucker, S. P. 1992. 1991 bird surveys in Kittson and Roseau Counties. The Loon 64:107–13.
Takekawa, J. Y., and E. O. Garton. 1984. How much is an Evening Grosbeak worth? Journal of Forestry 82:426–28.
Taylor, R. L. 1990. Avian indicators in the Chequamegon National Forest. Passenger Pigeon 52:225–31.
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, N.J.
———. 1992. Why American songbirds are vanishing. Scientific American 266 (5):98–103.
Thompson, F. R., S. J. Lewis, J. Green, and D. Ewert. 1993. Status of neotropical migrant landbirds in the Midwest: Identifying species of management concern. In D. M. Finch and P. W. Stangel, eds., Status and management of neotropical migratory landbirds. U.S. Dept. of Ag., Forest Service General Technical Report RM-229.
U.S. Fish and Wildlife Service. 1993. 1991 National survey of fishing, hunting, and wildlife-associated recreation. U.S. Dept. of Interior, Fish and Wildlife Service and U.S. Dept. of Commerce, Bureau of the Census. U.S. Government Printing Office, Washington, D.C.
———. 1995. Migratory nongame birds of management concern in the United States: The 1995 list. Prepared by the Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Washington, D.C. (in preparation).
U.S. Forest Service. 1977. The 1977 manager's handbook for aspen in the north central states. U.S. Forest Service, General Technical Report NC-36.
———. 1979. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. U.S. Dept. of Ag. Forest Service Agriculture Handbook No. 553.
———. 1986a. Land and resource management plan: Chippewa National Forest. U.S. Dept. of Ag. Forest Service, Washington, D.C.
———. 1986b. Land and resource management plan: Superior National Forest. U.S. Dept. of Ag. Forest Service, Washington, D.C.
———. 1991. Threatened, endangered, and sensitive plants and animals. Chapter 2670.5 in the Wildlife, fish, sensitive plant habitat management manual. U.S. Dept. of Ag. Forest Service, Washington, D.C.
———. 1993a. Guidelines for monitoring populations of neotropical migratory birds on national forests system lands. Monitoring Task Group Report. U.S. Dept. of Ag. Forest Service, Wildlife and Fisheries.
———. 1993b. National hierarchical framework of ecological units. ECOMAP, U.S. Dept. of Ag. Forest Service, Washington, D.C.
———. 1994. Chippewa National Forest Plan amendment no. 27. Chippewa National Forest, U.S. Dept. of Ag. Forest Service, Washington, D.C.
U.S. Geological Survey. 1976. Land use and land cover digital data from 1:250,000 scale maps: Brainerd Quadrangle (source dates 1977, 78), Duluth Quadrangle (source dates 1978, 79), St. Cloud Quadrangle (source date 1977) and Stillwater Quadrangle (source date 1976). U.S. Geological Survey, Reston, Va.
———. 1977. Land use and land cover digital data from 1:250,000 scale maps: Eau Claire Quadrangle (source dates 1980-81), LaCrosse Quadrangle (source date 1982), Mason City Quadrangle (source dates 1978, 80, 82) and St. Paul Quadrangle (source dates 1974-77). U.S. Geological Survey, Reston, Va.
Veit, R. R., and W. R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon

Society, Lincoln, Mass.

Vickery, P. D., M. L. Hunter Jr., and S. M. Melvin. 1994. Effects of habitat area on the distribution of grassland birds in Maine. Conservation Biology 8 (4):1087–97.

Villard, M., P. R. Martin, and C. G. Drummond. 1993. Habitat fragmentation and pairing success in the Ovenbird (*Seiurus aurocapillus*). The Auk 110 (4):759–68.

Walkinshaw, L. H. 1983. Territorial establishment and behavior. In Kirtland's Warbler: The natural history of an endangered species. Cranbrook Institute of Science, Bloomfield Hills, Mich.

Walters, C. J. 1986. Adaptive management of renewable resources. MacMillan Publishing Co., New York.

Walters, C. J., and C. S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71 (6):2060–68.

Whitcomb, R. F. 1977. Island biogeography and "habitat islands" of eastern forest. I. Introduction. American Birds 31:3–5.

Wilcove, D. S. 1993. Turning conservation goals into tangible results: The case of the Spotted Owl and old-growth forests. Pages 313–30 in P. J. Edwards, R. M. May, and N. R. Webb, eds., Large-scale ecology and conservation biology. The 35th Symposium of the British Ecological Society with the Society for Conservation Biology, University of Southampton. Blackwell Scientific Publications, Oxford.

Wilcove, D. S., and S. K. Robinson. 1990. The impact of forest fragmentation on bird communities in eastern North America. Pages 319–31 in A. Keast, ed., Biogeography and ecology of forest bird communities. SPB Academic Publishing bv, The Hague, The Netherlands.

Zumeta, D. C., and R. T. Holmes. 1978. Habitat shift and roadside mortality of Scarlet Tanagers during a cold wet New England spring. Wilson Bulletin 90 (4):575–86.

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