MANAGEMENT OF WESTERN GREAT LAKES FORESTS FOR THE CONSERVATION OF NEOTROPICAL MIGRATORY BIRDS

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ABSTRACT.—Forests and associated wetlands in the Great Lakes region support some of North America's most diverse assemblages of breeding birds. The majority of species in the western Lake States (as in most ecological communities) are uncommon and localized in occurrence. Many of the region's bird species show clear associations with habitat, but landscape characteristics and geographic factors also affect species' distributions and abundances. Local field surveys provide a mechanism for establishing species priorities for individual management units. Effective conservation plans for most species must be empirically based; in other words, managers need to know where priority species occur and where they are most productive. Management of habitat is a first step for bird conservation, but species interactions and biogeographic factors inevitably complicate simple management prescriptions. We recommend a management scheme that integrates traditional habitat management prescriptions, landscape-level planning, and continuous monitoring of local bird populations.

INTRODUCTION

Northern parts of the western Lake States (Minnesota, Michigan, and Wisconsin) encompass some of the most extensively forested landscape in the Midwest. The continuity of forest and the diversity of wetlands, lakes, and forest types makes this region particularly significant for neotropical migratory birds (Temple *et al.* 1979). We reviewed the ecological characteristics of forest landscapes in the western Lake States and their relevance to forest management and neotropical migratory birds. Although much remains to be learned, much is known about the bird populations in this region. Empirical findings provide opportunities for enlightened forest management that are unavailable in many other regions. Field evidence reveals that bird distributions and habitat interactions in northern forest landscapes are complex. We argue that simple prescriptions for bird conservation in these forests do not exist. Reliable field information, however, helps managers set species priorities and formulate specific conservation plans. The key to successful efforts, we maintain, is an ongoing, stepwise assessment of bird species and other resources at several levels of resolution (e.g., Probst and Thompson 1996), culminating in carefully targeted surveys to achieve a reliable information base that is actively incorporated into forest management activities.

Western Great Lakes Forests

The Upper Midwest is characterized by a continental ecotone between grasslands and mostly forested landscapes which extend into Canada. The region described here (fig. 1) corresponds with the western portion of the Laurentian Mixed Forest Province of Bailey (McNab and Avers 1994, see fig. 2 in Probst and Thompson 1996). Climatic and ecological gradients extending from the southwest to the northeast (Curtis 1959), together with complex glacial topography (Paul and Paul 1990), produce a forest landscape that is transitional in character over a broad geographic area. Extensive areas of spruce-fir, upland conifers,

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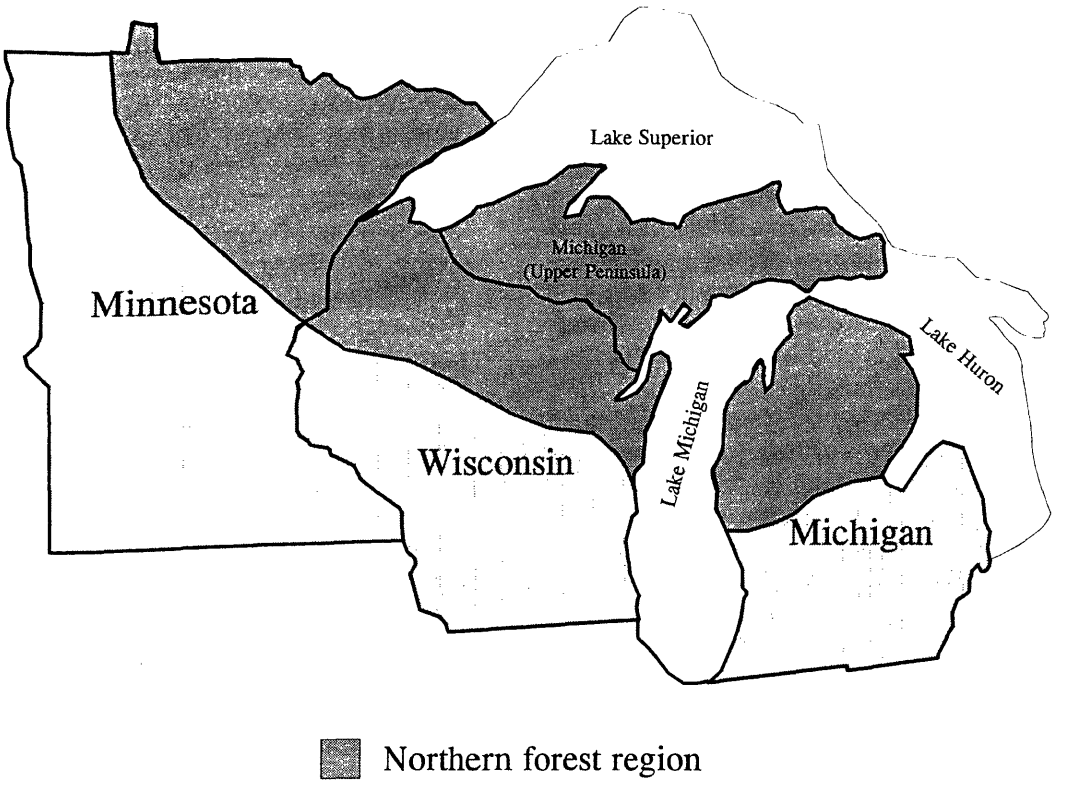

Figure 1.—*Distribution of western Great Lakes forests, corresponding to the western section of Bailey's (1994) Laurentian Mixed Forest Province.*

and northern hardwoods are associated with finer ecological divisions of the region (Albert, in press). Minnesota has the highest proportion of spruce-fir forests, but the lowest proportion of northern hardwoods. Michigan has the largest area of northern hardwoods and pine forest.

Mesic northern hardwood forests dominated by sugar maple (*Acer saccharum*), with varying amounts of beech, hemlock (*Tsuga canadensis*), yellow birch (*Betula lutea*), green ash (*Fraxinus pennsylvanica*), and basswood (*Tilia americana*) occupied approximately 47 percent of the presettlement forest landscape in the western Lake States (Frelich 1995). Other major forest categories included swamp conifers (13 percent), red/white pine (12 percent), spruce-fir-birch (10 percent), oak-hickory (9 percent), riverbottom forest (6 percent), and jack pine (4 percent). Frelich estimated that 89 percent of the original northern hardwood forests and 68 percent of all forests in this region existed as old growth.

Studies of remnant old-growth forests by Mladenoff and Pastor (1993) demonstrate that northern forest landscapes are complex and highly heterogeneous, rendering current forest classification and forest type delineation somewhat limited and possibly misleading for broader applications. Davis (1983) has shown that the geographic ranges of hemlock, beech, and other species are still expanding in response to post-glacial environmental changes. Hardwood forests of northeastern Wisconsin, for example, are richer in species than those of northwestern Wisconsin because beech, yellow birch and hemlock decrease in abundance along a moisture gradient from east to west (Curtis 1959). For reasons such as this, ecologists are devising multi-factional Ecological Classification Systems (ECS) that nest and network biotic distributions in a biophysical hierarchy (McNab and Avers 1994).

Pre-settlement Ecology / Disturbance Regimes

Pre-settlement landscapes of the western Great Lakes region were dynamic as a result of natural disturbances and ecological succession (Stearns 1990, Frelich and Lorimer 1991, Mladenoff and Pastor 1993). Fire was most important on pine-dominated uplands and in boreal environments, where disturbance intervals were in the order of 100 years (Heinselman 1973). Large-scale disturbances in hardwood-hemlock forests were less frequent (> 1000 years), most often the result of windthrows (Canham and Loucks 1984). Canopy openings caused by small, local windthrows represented the most common source of disturbance (Frelich and Lorimer 1991). Outbreaks of insect herbivores, disease, and browsing by large mammals also played roles in these natural disturbance regimes (White and Mladenoff 1994).

Natural forest succession in northern forest landscapes involves a variety of tree species combinations, with aspen (*Populus tremuloides* and *P. grandidentata*), birch (*Betula papyrifera* and *B. populifolia*), balsam fir (*Abies balsamea*), and pin cherry (*Prunus pensylvanica*) prominent in mesic sites after disturbance. Alder, black spruce, and tamarack are typical of early-successional wetland sites, while jack pine, red pine, and oaks occur in open or frequently disturbed dry sites (Curtis 1959, Temple *et al.* 1979). Later-successional mesic forests include hardwoods (sugar maple, beech, basswood, yellow birch, white ash (*Fraxinus americana*) and ironwood (*Ostrya virginiana*)), white pine (*Pinus strobus*) and hemlock. Northern white-cedar (*Thuja occidentalis*), balsam fir, American elm (*Ulmus americana*), and black ash (*Fraxinus nigra*) dominate wet sites, while northern red oak (*Quercus borealis*) and red maple (*Acer rubrum*) are characteristic of drier sites. Just as local conditions affect the old growth forest composition in this transitional region, successional patterns are complicated by climate, soils, topography, and the nature of disturbance.

History of Management and Land Use

The naturally dynamic nature of this landscape has been further complicated by dramatic alteration of pre-settlement forests since the late 1800's (Stearns 1990). Frelich (1995) reports that only about 1.1 percent of the presettlement primary forest of the western Lake States remains in a condition that has not been significantly modified by humans. About 19.8 million ha of forest currently exists in the northern forest region, compared with 32.7 million ha during presettlement times. Using unlogged landscapes in the Sylvania Wilderness (6,070 ha) and the Porcupine Mountains (14,164 ha) of Upper Michigan as reference, Frelich estimates that 90 percent of the presettlement northern hardwoods forests consisted of old growth, dominated by trees 120 years old or older; today, only 9.7 percent of forests near the Sylvania Wilderness and Porcupine Mountains reach this age. Only 0.2 percent of the original forest remains unlogged or unburned as a result of human activity.

The species composition of this forest also has changed since European settlement. Notably, the extent of aspen-birch has increased from 1.4 percent to 22.6 percent; upland spruce-fir from nearly 0 (in this northern hardwoods region) to 10.5 percent; and pine-dominated forests from 1.4 percent to 5.0 percent. The species composition of northern hardwoods forests (which have been reduced in extent from 97.1 to 61.2 percent of the landscape) also has been altered by selective elimination of hemlock, white pine and other less prominent species. Temple *et al.* (1978) concluded that today northern forests of the Midwest are more homogeneous locally than the forests in which the resident birds evolved, a view that is supported by the more recent investigations of Frelich and Lorimer (1991), White and Mladenoff (1994) and others.

Conifer forests, particularly those dominated by swamp conifers, have experienced comparatively less modification in this landscape than have hardwood forests. Nevertheless, only 3 percent of the original area of jack pine forest, 0.6 percent of the red-white pine forest, and 4.4 percent of the swamp conifer forest remains unmodified by logging. Suppression of fire has led to further changes, even in the wilderness landscape of the Boundary Waters Canoe Area in northeastern Minnesota, the largest single block of primary forest in the Lake States (Frelich 1995). As a result of lower fire frequency, the area of aspen-spruce-fir-birch forest has increased at the expense of forests dominated by red and white pine. Mladenoff and Pastor (1993) argue that destructive logging, post-logging fires, and other human influences have "made recovery to any semblance of the presettlement state impossible."

Current Forest Conditions and Ownership Patterns

Total forest acres are similar among the three Lake States, but are highest in Michigan (table 1). More than half of Minnesota's forests are publicly owned, approximately twice the proportion in Wisconsin. Altogether more than 38 percent of the forest lands in the Lake States are publicly owned, and a significant fraction of the remainder is managed as private industrial forest. The government agencies responsible for forest management, however, vary significantly among the three states (table 1).

Most of the public forests in the Lake States are managed for multiple uses; in general, the more locally administered the forest (e.g., county vs. federal), the more intensive the management policies in terms of rotation age and harvest levels. Management of national forests, however, has probably been most controversial (Alverson *et al.* 1988, Kuhlmann 1990, Alverson *et al.* 1994). According to Frelich (1995), only 0.8 million ha (approximately 4 percent) of today's forest is reserved from logging, mainly in federally designated wilderness areas or their state equivalents, including the Boundary Waters Canoe Area Wilderness in northeastern Minnesota, Isle Royale National Park in Michigan, Porcupine Mountain State Park in Upper Michigan, and the Sylvania Wilderness of the Ottawa National Forest.

BIRDS OF WESTERN GREAT LAKES FORESTS

General Description of the Avifauna

Like the forest itself, the avifauna of the Upper Midwest is transitional and ecologically complex (Temple *et al.* 1979). Species assemblages in this region have varied in space and time since the retreat of the Wisconsin glacier 10,000 years ago (Davis 1983, Graham 1986). Nevertheless, a core assemblage of bird species occurs today throughout virtually all forested landscapes in the western Lake States. Systematic surveys using similar methods in the Nicolet National Forest (Howe *et al.* 1995), Chequamegon National Forest (Hawrot *et al.* 1994) and Superior and Chippewa National Forests (Hawrot *et al.* 1994) have identified the same common species (table 2). Forest composition and bird species differ among state, county, and privately owned forests, but ovenbird, red-eyed vireo, and several other familiar bird species (least flycatcher, black-throated green warbler, chestnut-sided warbler, Nashville warbler, hermit thrush) can be found commonly across most of the western Great Lakes forest region.

As in most species assemblages (Preston 1962, Brown *et al.* 1995), the majority of species inhabiting western Great Lakes forests are uncommon or rare (fig. 2). Howe *et al.* (1995) showed that only about 20 percent of the 150+ species in the Nicolet National Forest occur in

Table 1.—*Land ownership of forests in the western Lake States (from Powell* et al. *1994). Numbers indicate forest area in acres x 1000.*

Ownership type	Minnesota	Wisconsin	Michigan	Total
Public	(7,602)	(4,215)	(6,196)	(18,013)
Federal	2,019	1,429	2,438	5,886
State	3,078	580	3,571	7,229
County/Local	2,506	2,206	187	4,899
Private	7,171	10,706	11,225	29,102
Industrial	(751)	(1,179)	(1,981)	(3,911)
Total	14,773	14,921	17,442	47,136

Table 2.—*Relative frequency of common bird species in point surveys of national forests in the western Great Lakes region. Numbers indicate the percent frequency of each species relative to the frequency of the most abundant species (ovenbird). Numbers in parentheses indicate the rank abundance of each species in terms of frequency. Nicolet National Forest data were derived from randomly chosen roadside points sampled during 1993-1994. Data from the other national forests are from Niemi and colleagues. Neotropical migrants are shown in bold. Note that several important Neotropical migrants (e.g., black-throated blue warbler, olive-sided flycatcher) are well established in these forests but are not among the most common species listed here.*

Species	Relative Abundance (% frequency of most abundant species)			
	Nicolet NF (n=200)	Chequamegon NF (n=396)	Superior NF (n=522)	Chippewa NF (n=413)
Ovenbird	100 (1)	100 (1)	100 (1)	100 (1)
Red-eyed vireo	83 (2)	89 (2)	75 (4)	98 (2)
American robin	53 (3)	40 (7)	36 (12)	22 (24)
Chestnut-sided warbler	47 (4)	40 (8)	65 (5)	51 (6)
Rose-breasted grosbeak	46 (5)	29 (16)	34 (14)	20 (26)
Nashville warbler	44 (6)	58 (4)	89 (2)	68 (3)
White-throated sparrow	43 (7)	36 (9)	81 (3)	46 (8)
Mourning warbler	40 (8)	22 (19)	44 (9)	24 (23)
Black-capped chickadee	37 (9)	29 (15)	17 (27)	24 (23)
Blue jay	37 (10)	34 (11)	22 (22)	29 (17)
Hermit thrush	36 (11)	48 (5)	33 (17)	46 (9)
Black-throated green warbler	34 (12)	61 (3)	37 (11)	27 (19)
American crow	31 (13)	5 (51)	2 (62)	8 (43)
Least flycatcher	28 (14)	45 (6)	34 (14)	50 (7)
Indigo bunting	25 (15)	6 (45)	2 (64)	4 (53)
Song sparrow	23 (16)	13 (27)	14 (31)	31 (12)
Chipping sparrow	23 (17)	8 (40)	17 (28)	29 (17)
Veery	20 (18)	36 (10)	61 (6)	60 (4)
Cedar waxwing	19 (19)	3 (65)	8 (39)	13 (34)
Eastern wood-pewee	19 (20)	33 (13)	10 (33)	35 (11)
Winter wren	18 (21)	30 (14)	44 (8)	29 (15)
Scarlet tanager	16 (22)	20 (20)	10 (34)	30 (14)
Black-and-white warbler	15 (23)	33 (13)	46 (7)	20 (25)
Common raven	14 (24)	5 (51)	2 (58)	2 (66)
Common yellowthroat	14 (25)	23 (18)	21 (25)	51 (5)
Yellow-rumped warbler	14 (26)	28 (17)	32 (18)	30 (14)
American redstart	14 (27)	12 (30)	27 (19)	37 (10)
Golden-winged warbler	14 (28)	4 (55)	3 (54)	12 (36)
Great crested flycatcher	13 (29)	16 (24)	2 (62)	18 (27)
Yellow-bellied sapsucker	12 (30)	19 (23)	21 (25)	25 (21)
Blackburnian warbler	9 (34)	19 (21)	43 (10)	25 (21)
Brown creeper	9 (42)	19 (23)	11 (32)	13 (33)
Red-breasted nuthatch	12 (31)	15 (25)	19 (26)	15 (31)
Brown-headed cowbird	9 (35)	14 (26)	0 (85)	16 (29)
Yellow-bellied flycatcher	1 (85)	13 (28)	27 (20)	12 (37)
Canada warbler	1 (99)	12 (29)	34 (15)	5 (51)
Northern parula	6 (44)	11 (32)	23 (21)	17 (28)
Pine warbler	4 (51)	11 (33)	4 (50)	29 (17)
White-breasted nuthatch	9 (35)	10 (35)	3 (54)	15 (30)
Golden-crowned kinglet	2 (67)	5 (51)	14 (30)	11 (38)
Magnolia warbler	5 (48)	3 (62)	34 (16)	5 (51)
Swainson's thrush	2 (75)	2 (67)	16 (21)	2 (63)
Tennessee warbler	0 (119)	1 (81)	21 (23)	1 (77)

more that 10 percent of the points sampled. Patterns of relative abundance, based on frequency of occurrence among sample points, are similar among the four national forests; the 10th most common species, for example, are 37 percent, 36 percent, 33 percent, and 37 percent as frequent as the most abundant species in the Nicolet, Chequamegon, Superior, and Chippewa National Forests, respectively (table 2)

Virtually all bird species of these forests can be found in other parts of North America. Only five (Nashville warbler, black-throated blue warbler, blackburnian warbler, chestnut-sided warbler, and Canada warbler) have the centers of their geographic range and abundance within the region of mixed northern forest Udvardy (1963). Results from the North American Breeding Bird Survey (Price *et al.* 1995), however, show that the western Lake States support some of the continent's richest assemblages of bird species, particularly long-distance neotropical migrants, flycatchers, thrushes, and warblers. Several bird species not mentioned by Udvardy also seem to have centers of abundance or at least regional centers of abundance in the western Lake States and nearby parts of Canada, including broad-winged hawk, ruffed grouse, black-billed cuckoo, yellow-bellied sapsucker, pileated woodpecker, yellow-bellied flyctcher, least flycatcher, brown creeper, sedge wren, golden-crowned kinglet, veery, golden-winged warbler, magnolia warbler, northern parula, Cape May warbler, black-throated green warbler, pine warbler, black-and-white warbler, ovenbird, mourning warbler, Connecticut

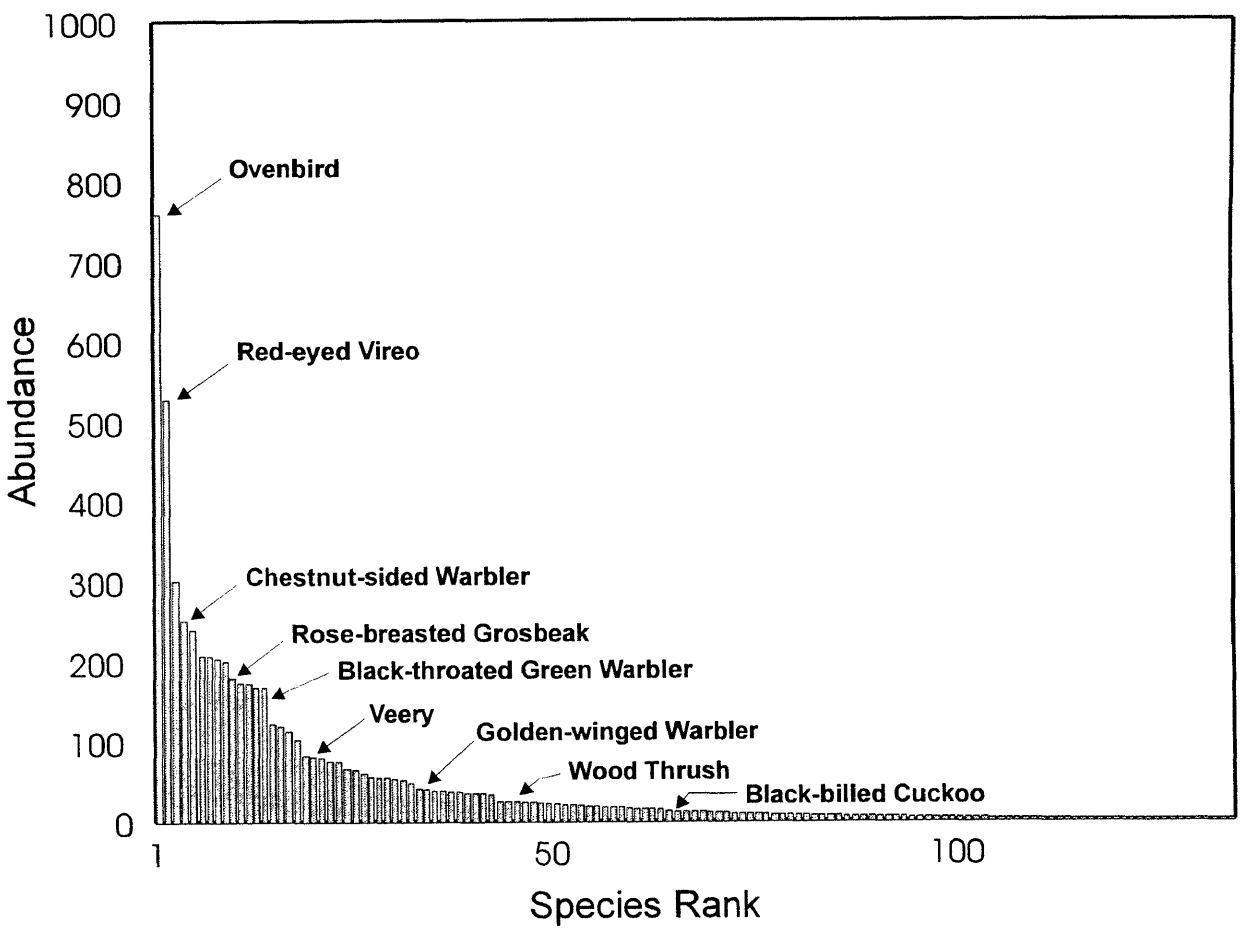

Figure 2.—*Rank abundance of bird species at 451 roadside point counts sampled during the Nicolet National Forest Bird Survey between 1992 and 1995. Abundance is the total number of individuals seen or heard during all 451 counts combined.*

warbler, rose-breasted grosbeak, purple finch, pine siskin, and evening grosbeak (Price *et al.* 1995). Kirtland's warbler, of course, breeds only in this region. Temple *et al.* (1979) concluded that the rich diversity of birds in the western Lake States is due to the co-occurrences of northern and southern bird species. Other explanations include the widespread mix of conifer and deciduous forests (related to Temple *et al.*'s conclusion), the complex glacial topography and associated wetlands, the large extent of forest habitat, and perhaps biophysical effects associated with the Great Lakes.

Population Trends

Except for the passenger pigeon, a species probably at the edge of its range in the western Lake States (Schorger 1955), no bird species of this region has gone extinct during historic times, and only one breeding neotropical migrant (Kirtland's warbler) is considered to be globally endangered or threatened. On a continental scale, however, several NTMBs characteristic of Lake States forests have declined significantly since the 1960's (Peterjohn and Sauer 1994, Price *et al.* 1995), including olive-sided flycatcher, eastern wood-pewee, wood thrush, veery, golden-winged warbler, and indigo bunting. Others, such as least flycatcher, Tennessee warbler, Nashville warbler, Cape May warbler, mourning warbler, Canada warbler, and rose-breasted grosbeak, have declined significantly during the past decade. Decreasing regional trends also have been documented for least flycatcher, golden-winged warbler, blackburnian warbler, and northern parula (Hunter *et al.* 1995). Significant continental increases have been reported for hermit thrush (a short-distance migrant), solitary vireo, Philadelphia vireo, red-eyed vireo, blackburnian warbler, yellow-rumped warbler, ovenbird, and pine warbler (Peterjohn and Sauer 1994, Price *et al.* 1995).

Blake *et al.* (1994) described significant annual changes in abundance for approximately half of the neotropical migrant bird species in northwestern Wisconsin and Upper Michigan between 1986 and 1992. Declines followed severe drought during 1987 and 1988, but by 1992, most species had recovered to pre-drought population levels. Wood thrush, mourning warbler, and chestnut-sided warbler continued to show lower population levels, and golden-winged warbler declined sharply after an increase between 1986-1989. Trends in Wisconsin and Michigan were significantly different for 5 of 16 neotropical migrants (red-eyed vireo, Nashville warbler, northern parula, ovenbird, and rose-breasted grosbeak). The complexities of population changes noted by Blake *et al.* and other investigators (e.g., Sauer and Droege 1992, Villard and Maurer 1995, James *et al.* 1996) suggest that trends in neotropical migrant bird populations are typically not uniform in time and space.

Of 47 bird species for which the Midwest is of particular importance (Probst and Thompson 1996), 36 are present in the western Lake States, including 9 grassland species, 9 deciduous and 8 coniferous forest species, and 13 species of wet or dry shrublands. (Several species are listed in more than one category). Most of the "shrublands" represent early stages of forest succession. Early seral stages in the Lake States have particular importance for sedge wren, golden-winged warbler, chestnut-sided warbler, and mourning warbler. The region provides exclusive habitat (early successional jack pine) for Kirtland's warbler (*Dendroica kirtlandii*). Northern forests appear to be important centers of abundance for least flycatcher, veery, black-throated blue warbler, Nashville warbler, blackburnian warbler, Canada warbler, and rose-breasted grosbeak (Price *et al.* 1995). The region probably provides valuable source habitat (Brawn and Robinson 1996) for broadly distributed species like wood thrush, ovenbird and black-throated green warbler. Many of the bird species found in wet shrub, lowland conifer, and upland mixed forests (e.g., Cape May warbler, northern parula, northern waterthrush) have centers of abundance in neighboring parts of Canada, while others characteristic of deciduous forest types (e.g., Cerulean warbler, scarlet tanager) have centers of their ranges to the southeast.

Geographic Patterns

Because the majority of species are rare or uncommon (fig. 2), gaps occur in the geographic distribution of many forest bird species in the western Lake States. Even a relatively common species like least flycatcher shows a localized and somewhat unpredictable distribution pattern (MacQueen 1950, Montgomery 1995). In the Nicolet National Forest, for example, this species exhibits a strong preference for northern hardwoods (table 3),

yet individuals are present at only about 50 percent of all point counts in mature or immature northern hardwood forests. Individuals are observed consistently at an unexpectedly high number of sites, and are consistently absent from an unexpectedly high number of other sites (fig. 3). Davis (1996) used Monte Carlo randomization tests to show that 34 of the 65 most common forest or woodland bird species in the Nicolet National Forest show aggregations at some scale, even taking into account the spatial distribution of forest types. Non-random or patchy distributions imply that factors such as geographic gradients, fine scale habitat characteristics, landscape context, local catastrophes, and perhaps socially mediated "centers of abundance" significantly affect the distribution of breeding birds in northern forest landscapes.

At least 11 species of neotropical migrants show statistically significant differences in frequency between the southern and northern portions of the Nicolet National Forest, a maximum distance of only 160 km (Howe *et al.* 1995, Davis 1996). These differences are not

Table 3.—*Habitat associations of forest birds in the Nicolet National Forest based on results of 736 point counts between 1989-1994. Results indicate the number of counts where the species was recorded (n) and the Chi² value from a contingency table based on the assumption that birds should occur in proportion to the total number of counts in each of 10 forest categories. Nine species which occurred in >30 counts (black-billed cuckoo, common flicker, common raven, downy woodpecker, great crested flycatcher, hairy woodpecker, pileated woodpecker, white-breasted nuthatch, and wood thrush) are not included because they showed no significant forest habitat associations (Chi² < 16.92, P>.05). American robin (n=228) was not included even though its Chi² value was marginally significant (Chi² = 17.17).*

Species	n	Chi²	Preferred Forest Type(s)	Avoided Forest Type(s)
American crow	76	29.14	Aspen/Birch, Balsam fir/Spruce	Hemlock, Mature hardwoods
Black-and-white warbler	101	57.48	Lowland conifers, Lowland hardwoods	Immature hardwoods
Blackburnian warbler	92	83.33	Hemlock, White pine	Imm. hardwoods, Aspen/Birch
Black-capped chickadee	188	43.54	Balsam fir/Spruce	Imm. hardwoods
Black-throated blue warbler	41	33.73	Imm. hardwoods, Mat. hardwoods	Balsam fir/Spruce, Hemlock
Black-throated green warbler	256	172.41	Mature hardwoods, Hemlock	Lowland conifers
Blue jay	232	43.30	Red pine, Balsam fir/Spruce	Mature hardwoods
Brown creeper	69	31.86	Lowland hardwoods	Aspen/Birch
Brown-headed cowbird	36	20.08	Jack pine	Lowland conifers
Canada warbler	22	53.79	Lowland hardwoods, Balsam fir/Spruce	Mat./Imm. hardwoods
Cedar waxwing	91	45.78	Lowland conifers, Red pine	Mat. hardwoods
Chestnut-sided warbler	144	92.51	Aspen/Birch	Hemlock, Imm./Mat. hardwoods
Chipping sparrow	57	114.54	Red pine, Balsam fir/Spruce, Jack pine	Imm./Mat. hardwoods
Eastern wood pewee	146	99.77	Mat. hardwoods, Imm. hardwoods	Lowland conifers
Golden-crowned kinglet	52	59.69	Lowland conifers, Balsam fir/Spruce	Aspen/Birch
Golden-winged warbler	30	29.21	Lowland conifers, Aspen/Birch	Mat./Imm. hardwoods
Hermit thrush	267	32.31	Jack pine, Lowland conifers	Mature hardwoods
Indigo bunting	66	40.97	Aspen/Birch	Mature hardwoods
Least flycatcher	170	138.28	Mat. hardwoods, Imm. hardwoods	Lowland conifers, Balsam fir/Spruce
Mourning warbler	122	31.25	Aspen/Birch	Hemlock, Jack pine
Nashville warbler	212	234.99	Lowland conifers	Imm. hardwoods, Mat. hardwoods
Northern parula	72	39.75	Lowland conifers	Aspen/Birch, Red pine
Ovenbird	559	222.37	Imm. /Mat. hardwoods, Aspen/Birch	Lowland conifers
Pine warbler	28	98.08	White pine, Red pine	Imm. hardwoods, Mat. hardwoods
Red-breasted nuthatch	89	39.38	Balsam fir/Spruce, Hemlock, Red pine	Immature hardwoods
Red-eyed vireo	477	197.89	Mat./Imm. hardwoods, Aspen/Birch	Lowland conifers, Red pine
Rose-breasted grosbeak	262	93.49	Mat./Imm. hardwoods, Aspen/Birch	Lowland conifers, Jack pine
Scarlet tanager	133	20.67	Balsam fir/Spruce, Mat. hardwoods	Lowland conifers, Jack pine
Solitary vireo	55	25.92	Lowland conifers, Hemlock	Mat. hardwoods, Aspen/Birch
Veery	131	18.52	Imm. hardwoods, Lowland hardwoods	Red pine
White-throated sparrow	237	192.68	Lowland conifers, Balsam fir/Spruce	Imm. hardwoods, Mat. hardwoods
Winter wren	144	82.33	Lowl. conifers, Lowl. hwds., Hemlock	Imm. hardwoods, Aspen/Birch
Yellow-bellied flycatcher	41	113.97	Lowland conifers	Mat./Imm. hardwoods, Aspen/Birch
Yellow-bellied sapsucker	83	41.86	Lowland hardwoods, Imm. hardwoods	Red pine, White pine
Yellow-rumped warbler	92	72.48	Lowland conifers, Red pine, Jack pine	Mature hardwoods, Imm. hardwoods

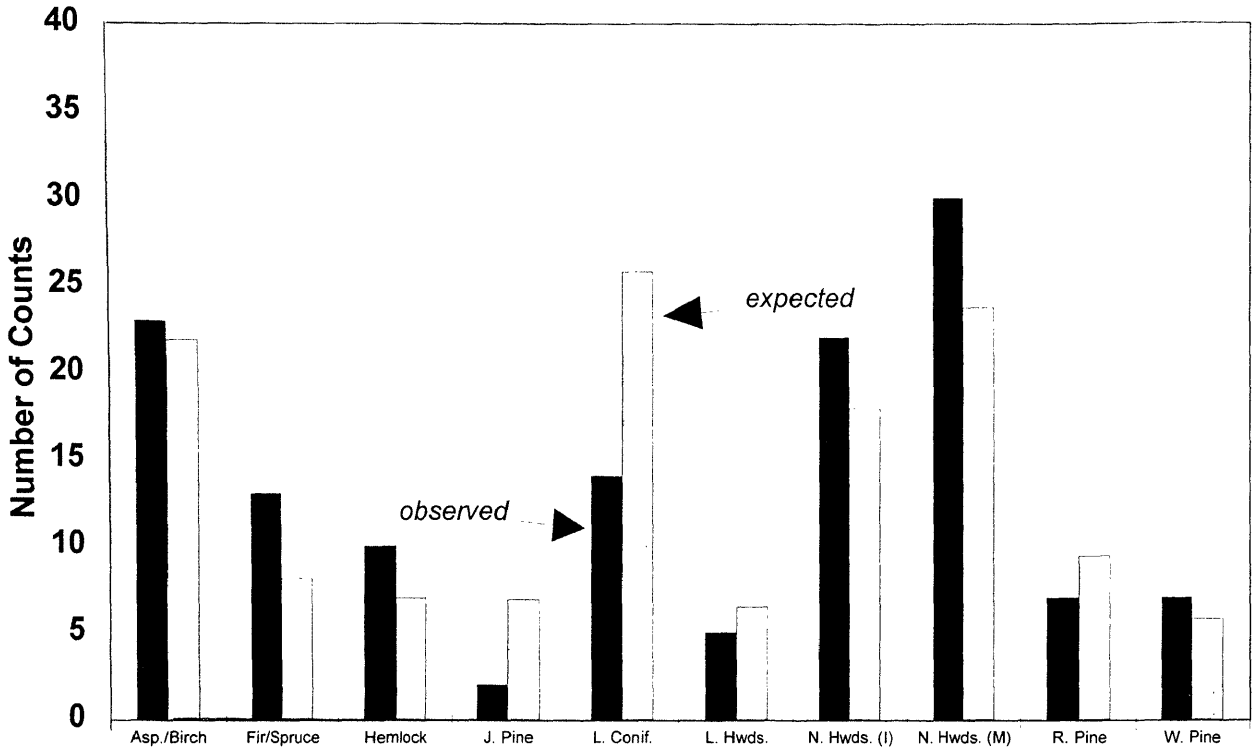

Figure 3.—*Distribution of scarlet tanagers among different forest types in the Nicolet National Forest based on habitat-based point counts between 1989-1994. Number of counts is the total number of point counts in a given habitat where scarlet tanagers were observed. Forest types are defined by dominant tree species: Asp./Birch = aspen/birch, J. Pine = jack pine, L. Conif. = lowland conifers, L. Hwds. = lowland hardwoods, N. Hwds. (I) = immature northern hardwoods (dominated by trees 31-70 years old), N. Hwds. (M) = mature northen hardwoods (dominated by trees > 70 yrs. old), R. Pine = red pine, and W. Pine = white pine. Expected numbers of counts were calculated by assuming that scarlet tanagers occur randomly among sites, so that the probability of an individual being detected in a given forest type is directly proportional to the number of counts in that type.*

due to the absence of favored habitat types, although the overall extent of many habitat types varies from south to north, as do the centers of distribution of the bird species. Yellow-billed cuckoo, great crested flycatcher, northern oriole, indigo bunting, scarlet tanager, and wood thrush are more common in southern half of the Forest, while olive-sided flycatcher, least flycatcher, black-throated blue warbler, chestnut-sided warbler, and black-throated green warbler are more common in the northern half. Results from the Michigan Breeding Bird Atlas (Brewer *et al.*, 1991) show both an extension and a parallel to these geographic trends over a broader north-south gradient.

Bird / Ecosystem Relationships at Landscape and Local Scales

Landscape relationships

On a larger scale, landscape variables have been shown to be correlated with bird abundance in the northern forest region. Hawrot and Niemi (1995) found that breeding bird species were influenced by the extent of different habitat types and the local abundance of forest edge. Pearson (1994) found that habitat types surrounding a forest stand influenced the relative abundance of some bird species within the stand. For instance, if a mature aspen stand is surrounded by coniferous forest, then bird species associated with

coniferous trees are more likely to be found within the stand, even if the predominant trees are deciduous. A similar result was found by Elias (1996). McRae (1995), working with data from the Nicolet National Forest Bird Survey and high altitude photographs, showed that the local abundances of 10 neotropical migrants (least flycatcher, wood thrush, Swainson's thrush, red-eyed vireo, solitary vireo, black-throated green warbler, blackburnian warbler, black-throated blue warbler, black-and-white warbler, and scarlet tanager) are significantly correlated with landscape variables such as the percent upland conifer-hardwood forest within 500 m (positively) and the percent upland open habitat within 250 m (negatively). These studies are important because they show that bird species composition and abundance are influenced by the configuration of forest vegetation *surrounding* a local site, thus explaining much of the local variability discussed below. They also demonstrate the utility of landscape-level tools such as high altitude images and geographic information systems in evaluating bird habitat quality.

Succession

Several studies in Laurentian mixed forests have evaluated the relationship between breeding bird abundances and forest succession. Webb *et al.* (1977), Steffen (1984), Morgan and Freedman (1986), Probst *et al.* (1992), and Helle and Niemi (1996) examined bird species composition in stands of different ages after logging. Probst *et al.* (1992) noted an almost complete turnover in bird species during succession from clearcuts to older aspen forests in Minnesota and Michigan. Bird species are added during early succession as vegetation life forms (e.g., shrubs, tree canopy, bark surface) become more prominent parts of the forest ecosystem. Steffen's (1984) comparison of young vs. older aspen stands is generally consistent with the results of Probst *et al.* Helle and Niemi (1996) found that bird species diversity increased during succession up to the mature forest stages, then declined slightly in the oldest forests. Neotropical migrants of early successional stands include black-billed cuckoo, gray catbird, golden-winged warbler, common yellowthroat, Nashville warbler, chestnut-sided warbler, mourning warbler, and indigo bunting. Important neotropical migrants in mature northern forests include broad-winged hawk, least flycatcher, eastern wood-pewee, great crested flycatcher, wood thrush, red-eyed vireo, yellow-throated vireo, black-throated green warbler, blackburnian warbler, ovenbird, and scarlet tanager. Veery, rose-breasted grosbeak, American redstart, black-and-white warbler, black-throated blue warbler, and Canada warbler reach highest densities in intermediate-aged forests, but these species also occur in mature forests where canopy gaps modify the forest composition and structure.

Forest types

Beyond the coarse preference of species for general vegetation structure, bird-habitat relationships at the local level are complex and poorly understood. The ranges of most birds in the western Great Lakes forests are broad and encompass variations in habitat. Scarlet tanagers, for example, occur in nearly every forest habitat type in northern Wisconsin (fig. 4), even though they tend to prefer upland hardwood forests and avoid lowland conifers.

If birds show no preference for forest types, then their frequency in point samples should be proportional to the number of samples representing each type. Expectations based on the hypothesis of no preference can be compared with observed frequencies by a simple Chi^2 test of independence (Conover 1980). Results for birds of the Nicolet National Forest show some interesting patterns (table 3). Six of nine species which show no significant associations with forest type are cavity nesters. Apparently within-stand features (undoubtedly including the presence of suitable cavity trees) are more important than dominant tree species. Of the 35 species which were common enough to show habitat associations, 12 prefer lowland conifers, while only 10 species prefer upland hardwoods (mature or immature), the most widespread habitat type in the Nicolet National Forest. These simple tests ignore the effects of forest age, although regenerating stands (< 10 yrs old) were excluded from this analysis and only a few, small old-growth stands were available for sampling. Chi^2 values tend to be correlated (positively) with frequency of occurrence ($r = 0.66$, $p < 0.01$). Taking this relationship into account, strongest habitat associations are shown by Nashville warbler, white-throated sparrow, black-throated green warbler, least flycatcher, yellow-bellied flycatcher, and chipping sparrow (table 3). But conservation

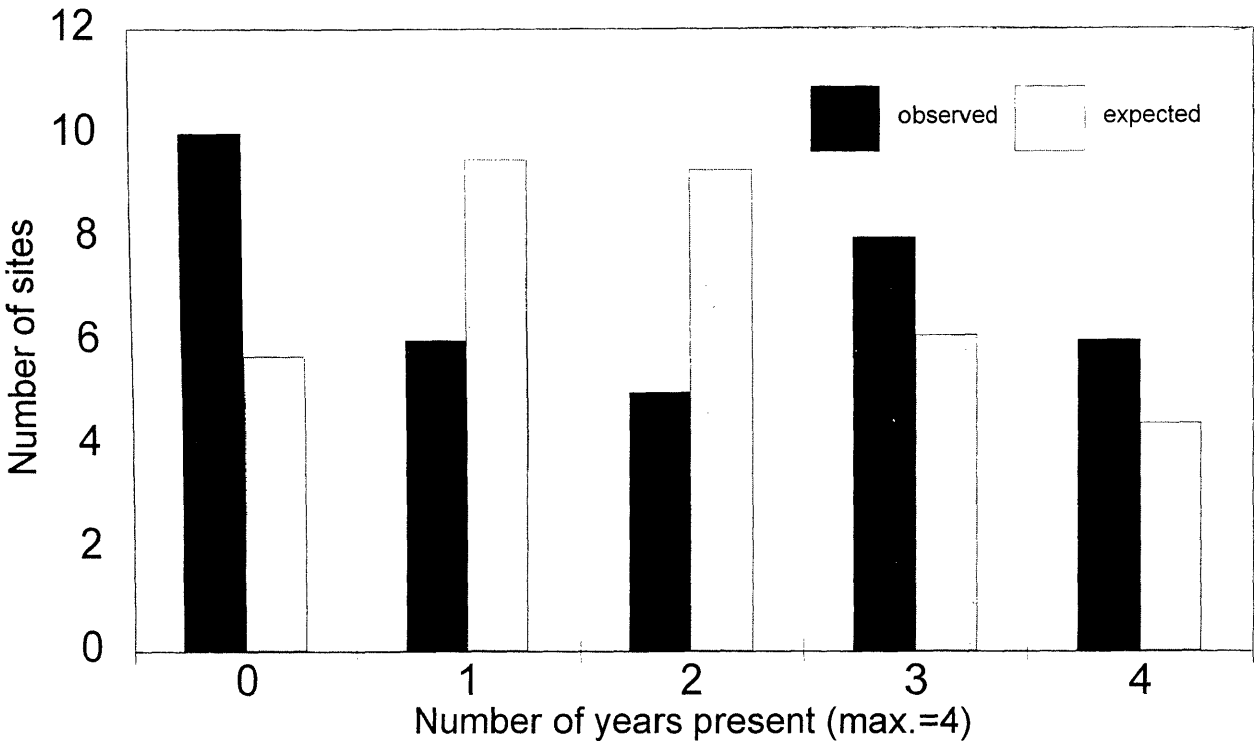

Figure 4.—*Fidelity of least flycatchers to 35 point localities dominated by northern hardwoods (> 31 yrs. old) in the southern Nicolet National Forest. Each point was sampled 4 times (bi-annually) between 1989 and 1995. Histograms show the number of sites where least flycatchers were observed during all 4 years, during all 3 years, etc. Expected numbers are means from 1,000 computer trials, where the bird occurrences were randomly allocated to the 35 sites over 4 "years." Note that the birds tended to occur more oftern than expected at certain sites, and less often than expected at others.*

biology concerns the rare or less common species, so there is a need to design step-wise assessments for them at appropriate scales.

Regional differences in bird-habitat associations are evident for a number of species. Black-throated green warblers in Door County, Wisconsin, for example, are abundant in lowland conifer forests (Zovnic and Howe 1995). In contrast, this species avoids lowland conifers in the Nicolet National Forest (table 3). Connecticut warblers are associated with jack pine barrens in northern Wisconsin (Robbins 1991), whereas they occur within bogs in Minnesota (Niemi and Hanowski 1992) and at bog edges and in aspen parklands in Michigan (Brewer *et al.* 1991). Thus, it is difficult to extrapolate detailed surveys about abundance or frequency from one subregion, landscape or ownership to other contexts without completing local bird surveys.

Habitat features

Dominant tree species do not necessarily define optimal or suboptimal habitats. MacArthur *et al.*'s (1962) classical study demonstrated that bird species diversity is positively correlated with the vertical diversity of foliage layers. Beals (1960) and Temple *et al.* (1978) showed that veery, black-throated blue warbler, and Canada warbler increase in abundance with increasing density of understory vegetation. Zovnic (1995) observed that increased reproductive success of ground nesting songbirds (ovenbird, hermit thrush, veery, and wood thrush) in the Nicolet National Forest is positively associated with the density of shrubs and composition of the ground layer (especially the abundance of *Lycopodium*). Pearson (1994) found that the abundance of veeries in north-central Minnesota is correlated negatively with the frequency of balsam

fir (which promotes a sparse understory) and percent canopy cover. Winter wrens favor sites with fallen logs or extensive woody debris (Wolf and Howe 1992).

FORESTRY AND BIRD POPULATIONS

Controversies have arisen because studies from other ecosystems have been applied to forestry impact assessments in the western Lake States. Kuhlman (1990) argues that forest harvesting has reduced populations of migratory birds in the Great Lakes region. Lorimer (1994), on the other hand, sees little evidence that conventional timber harvest in North America has been a significant factor in declines of neotropical migratory bird populations. The complex nature of population trends and the limited availability of baseline data make either claim speculative, but evidence from recent field studies provides some means for assessing the impacts of management activities on birds of the western Great Lakes landscape.

Habitat Destruction

Elimination of forest habitat obviously reduces local populations of forest-dependent bird species. Questions about conservation of NTMBs as well as other species must begin with at least a general estimate of species' population sizes. A sample of 200 points distributed approximately randomly in the Nicolet National Forest yielded 2,549 individual birds of 88 species (fig. 2), excluding aquatic species (e.g., common loon, great blue heron), strictly open country species (e.g., bobolink, barn swallow), and nocturnal species (e.g., barred owl, common nighthawk). Most of the detections were singing males; for the sake of this simple exercise, let us assume that they all represent resident, mated and monogamous males, leading to an estimate of 2,549 pairs (however, studies have shown that many males detected are transient). Studies by Wolf *et al.* (1995), have shown that most singing birds can be detected within 125 m. The 200 randomly sampled points therefore cover about 0.25 percent of the 389,000-ha Nicolet National Forest. Extrapolation from these samples (but see above) gives an estimate of 1,010,563 singing males representing more than 100 species (see Preston 1962). The entire western Lake States region described by Frelich (1995) is about 51 times larger than the Nicolet National Forest; therefore we estimate a regional population of at least 51.5 million singing males. Approximately 109 species of forest birds (excluding strictly open country species, etc.) are known to breed in this region. Based on our documented pattern of relative abundance (fig. 2), at best 15 to 20 species are likely to be represented by more than a million breeding pairs in the western Great Lakes forests, assuming that the Nicolet National Forest is representative of the region as a whole. (Of course, populations of most species also occur in Canada and elsewhere in the U.S.) At the other extreme, 24 of the 88 species in our sample were represented by fewer than 5 individuals; 10 species were encountered only once, and at least 20 potentially breeding species were not encountered at all. Again, using our assumption that the Nicolet National Forest is representative of the region, populations of these species in northern forests must be less than 100,000. This analysis is misleading if species that are rare in the Nicolet National Forest are common elsewhere, but our earlier findings (table 2) show that species which are common in the Nicolet National Forest also are common in other national forests of the western Great Lakes region and vice versa. Woodland or forest edge birds (e.g., brown thrasher, yellow-billed cuckoo, rufous-sided towhee) clearly are better represented in other less extensively forested regions, but we are still left with a significant number of forest or forest/wetland birds (table 4) which occur in very low numbers. Several of these species (yellow-bellied flycatcher, Canada warbler, magnolia warbler, Tennessee warbler) are at least locally common in more northern regions; even in the Superior National Forest, however, only Canada warbler is among the 15 most abundant species.

Destruction or degradation of habitats occupied by these and other uncommon species obviously can have serious consequences for their long-term survival. In these cases, specific distribution patterns must be identified, and specific breeding localities must be documented in order to avoid inadvertent loss of critical areas. Clearly, multi-scale studies need to be designed to assess the distribution and dynamics of less common species. These species may be highly selective or variable in their distribution.

Table 4.—*Northern forest NTMB's that are rare or uncommon across most of their geographic range. Species are included in this list if they are known to breed in the western Lake States and fewer than 400 (of >3000) Breeding Bird Survey routes (= # BBS Routes) are used to calculate their North American population trends between 1966 and 1993 (from Price* et al. *1995).*

Species	# BBS Routes
Yellow-bellied flycatcher	243
Philadelphia vireo	189
Golden-winged warbler	341
Tennessee warbler	332
Cape May warbler	242
Palm warbler	81
Bay-breasted warbler	215
Cerulean warbler	326
Connecticut warbler	109

Habitat Degradation

Land use by humans can affect the *quality* as well as the quantity of habitats, even for relatively widespread bird species. Howe *et al.* (1991) and others (Donovan *et al.* 1996) have shown that even local habitat degradation can cause extinction of widespread populations if significant density independent dispersal occurs from high quality habitats. Old growth forests dominated by trees > 100 years in age have been replaced extensively during the past century by younger forests (Frelich 1995). Hence, we might expect that species characteristic of old growth have declined and perhaps are now vulnerable to extinction. Howe and Mossman (1996) have compared birds of the Sylvania Wilderness in northern Michigan with birds of nearby managed forests. In general, differences in species composition are quantitative rather than qualitative. Red-shouldered hawk, and chimney swift, for example, are significantly more abundant in old growth than they are in managed forests, but no bird species is today restricted to old-growth forests in the western Lake States. Of course, presence of a bird in managed forest does not insure that the habitat can sustain a population (Van Horne 1983, Donovan *et al.* 1996), so a multi-scale approach to assessment is essential (Freemark *et al.* 1993).

Howe and Mossman (1996) found that more intensively managed (even-aged) hardwood forests support significantly lower species richness and abundances of neotropical migrants than do less intensively managed (uneven-aged) forests. Several species characteristic of forest gaps and understory (e.g., veery, black-throated blue warbler) show higher abundances in uneven-aged managed forests than in old growth. These results parallel findings from other regions (Thompson *et al.* 1992, Welsh and Healy 1993).

Evidence from our recent field studies suggests that the selective elimination of hemlock and other conifers from Lake States forests affects several neotropical migratory species negatively (also see Benzinger 1995). Blackburnian warbler, black-throated green warbler, pine warbler, and solitary vireo are locally common in the region as a whole, but populations are generally absent or less abundant in sites with few large conifers (Howe and Mossman 1996).

Certain neotropical migrants clearly have increased as a result of forestry practices. Chestnut-sided warbler, mourning warbler, magnolia warbler, golden-winged warbler, Canada warbler, and Nashville warbler were uncommon during pre-settlement times (Morse 1989), but populations increased as older forests were replaced by forests of aspen and young hardwoods. More recently, several of these species have decreased again as secondary forests have matured (Peterjohn and Sauer 1994). Golden-winged warblers have expanded from shrub swamps and open tamarack swamps to clearcuts and other young seral stages, but their populations today are declining. Canada warbler, Magnolia warbler, and black-throated blue warbler are usually associated with "gaps" in Lake States forests caused by natural disturbances or selective logging.

Effects of forest management practices on neotropical migrants deserve further study. Even in the cases described above, where the consequences of land use on neotropical migratory bird populations are somewhat predictable, the effects are species-specific. In short, no single recipe of land management affects all species in the same way, so broad-scale planning is necessary to accommodate all species and other objectives of land management (Thompson *et al.* 1993). Evidence has shown that many species are capable of using alternative habitats if their original

habitats are modified, but our inadequate knowledge about these habitat responses justifies long-term studies and population monitoring.

Landscape Modification and Biogeography

Area and isolation

In addition to its effects on the quantity and quality of available habitat, forest management also affects the configuration of habitats (Freemark *et al.* 1995). The familiar relationship between species richness and habitat area (MacArthur and Wilson 1967, Lynch and Whigham 1984, Robbins *et al.* 1989, Johns 1993) has been documented for birds of true islands in the Lake Superior region (Beals 1960, Rusterholz and Howe 1979) and for birds of forest habitat islands in Ontario (Freemark and Merriam 1985, Villiard *et al.* 1995) and elsewhere. Isolation effects in northeastern North American forests have been documented by Fritz (1979) and Benkman (1994). Area and isolation effects probably also apply to birds in discrete habitats like conifer bogs, sedge meadows, and even clear cuts, but these biogeographic patterns are more obscure when the matrix between optimal patches is habitable. Old-growth forest remnants, for example, are both small in area and isolated from other such remnants in the western Lake States (Frelich and Lorimer 1992). Most birds of these old-growth forests, however, also occur in managed forests. The complex juxtaposition of different habitat types complicates our understanding of population dynamics of northern forest birds (see Donovan *et al.* 1996). Future investigations along the lines of those by McRae (1995), Hawrot and Niemi (1996), and Elias (1996) are likely to be fruitful in understanding the biogeography of neotropical migrants in the western Great Lakes forests. Studies by Probst and Hayes (1986), Donovan *et al.* (1995) and Zovnic (1995) suggest that source-sink dynamics might be important for both rare and common species in this region, although demographic data are available for only a few species. Given recent emphasis on large-scale management policies (Kessler *et al.* 1992), additional research on geographic distributions and spatial dynamics of NTMB populations will help provide more specific guidance for decision makers.

Edge effects

Besides affecting the configuration of feeding and nesting resources, changes in the forest landscape can significantly influence species interactions. Indeed, large-scale changes in species interactions might comprise a greater and more insidious threat to breeding bird populations than reduction of habitat area. Perhaps the best-studied (and most controversial) effect of landscape changes on species interactions is the relationship between forest edge and nest predators or brood parasites.

Historically, edges were thought to be good habitats for wildlife. Edges represent the places where two distinctly different habitats merge. Often they are areas of relatively high productivity (Angelstam 1992), but many recent studies have shown that edges also are associated with increased incidence of nest predation and nest parasitism by brown-headed cowbirds (e.g., Wilcove 1985, Brittingham and Temple 1983, Robinson *et al.* 1995). Most of these studies, however, have been conducted at distinct edges (often called *hard edges*) such as those between forests and agricultural fields. Edges in the western Great Lakes Forests are more likely to be transitory or *soft edges*, occurring between qualitatively different forest or woodland habitat types.

Detailed studies of nest predation and nest parasitism within a predominately forested landscape are uncommon. Robinson *et al.* (1995) studied nest predation and nest parasitism rates in a variety of forested areas in the midwestern United States. They found that both nest predation and nest parasitism rates were negatively related to the percentage of forest cover in the landscape. Nest predation and parasitism rates were highest in areas with the most open agricultural or urban land area and lowest in areas with the most forest area. Robinson *et al.* (1995) showed that in certain areas predators destroyed as many as 80 percent of the nests for some bird species, but it is not clear if high predation is the result of the landscape composition or edge effects. Ambuel and Temple (1983) report that the negative effects of edges may penetrate 200 m or more into the forest interior.

The effects of nest parasitism by brown-headed cowbirds are known to be concentrated near habitat edges. The brown-headed cowbird evolved in the western United States,

primarily in open country where it was closely associated with large mammals such as the American bison (*Bison bison*). As land to the east was cleared for agriculture and livestock, the brown-headed cowbird expanded to the east and north (Mayfield 1965). Female brown-headed cowbirds can move relatively long distances, sometimes 7.5 km or more in order to find suitable host species (Rothstein *et al.* 1984, Thompson 1994). Forest birds such as flycatchers, thrushes, vireos, warblers, and tanagers have became regular victims of brown-headed cowbirds in today's agricultural/forest landscape. Currently more than 100 bird species are known to be host. Cowbirds are relatively common in the western Great Lakes region, but they are still relatively uncommon or even rare in areas that are predominantly forested (e.g., northeastern Minnesota, parts of northern Wisconsin, and Upper Michigan). Even in these areas, however, the species can be locally common in forest areas that are fragmented by agricultural or urban environments, especially if livestock or horses are present.

Bird densities in predominantly forested landscapes often are higher near forest edges (e.g. Gates and Gysel 1978; Hanowski *et al.* 1993, 1995, 1996), but predation and nest parasitism rates in general are not well documented for extensively forested regions (Paton 1994). Those studies that have been published offer little consensus about the effects of edges on forest bird populations. Some studies have shown that forest fragmentation increases nest predation and reduces breeding success (e.g., Wilcove 1985, Small and Hunter 1988). However, increased predation rates associated with edges have not been found in all studies (e.g., Ratti and Reese 1988, Rudnicky and Hunter 1993, Small and Hunter 1988). Two studies on nest productivity within a logged forest mosaic in north central Minnesota showed mixed results. Fenske's (1995) study of more than 500 artificial nests found that predation rates were higher near "soft" edges between medium-aged (3-19 yr) and mature (>40 yr) aspen forests than near "hard" edges between recently logged (2-4 yr old) and mature aspen forests. Fenske (1995) also found that predation rates tended to decrease toward the forest interior at distances of 50 m and 100 m from both the soft and hard edges. Moreover, using a camera with a motion detector he recorded 28 nest predation events. The most common predator (8 of 28 events) was the fisher (*Martes pennanti*), with seven other mammal species recorded as predators.

In the same area, Hanski *et al.* (ms) found 311 natural nests of 33 bird species. They identified precise locations for each nest using a geopositioning system and calculated the nest success rates in relation to various edges. No relationships were found with distance to edges, but predation rates were highest for species nesting within the forest (62 percent) compared with birds nesting in open (42 percent) or regenerating (47 percent) habitat types. Brown-headed cowbird parasitism rates were relatively low (10 percent) and unsuccessful (2 percent). These studies emphasize that context of region, landscape, ecosystem type and age, and species associations must be considered before extrapolating local nest monitoring results.

Nest predation and parasitism are primary factors affecting reproductive success in forest birds (Martin 1992). These factors need to be studied with multi-scale approaches and well-defined hypotheses in varying forest landscapes. We can expect to find considerable variation in rates of reproductive success among different forest environments because of the underlying variation in regional populations and relative species abundances, the relative abundances and mix of predators, the abundance of brown-headed cowbirds, and the mix of forest types and ages across the landscape.

Ecological Imbalances and Species Interactions

The expansion of brown-headed cowbirds into the Lake States represents one of many ecological changes that affect the quality of Laurentian forest landscapes for NTMBs. Suppression of spruce budworm outbreaks and selective elimination of balsam fir negatively affect Cape May warbler and other species which specialize on local budworm outbreaks (Morse 1986). Invasions of gypsy moth populations into the Lake States (and perhaps the methods used to control them) have at least local effects on insectivorous birds (DeGraaf 1987). Increases in the abundance of crows due to high numbers of road-killed deer may lead to higher rates of nest predation on open-nesting songbirds. Recent increases and re-introductions of mammalian

predators like fisher and pine marten have led to increased nest predation rates, perhaps exacerbated by the absence of top-level carnivores like wolves and mountain lions in much of the region. Expansion of blue-winged warblers into the western Lake States affects the local abundance of golden-winged warblers through hybridization and competitive interactions (Murray and Gill 1978). Subtle (but important) ecological interactions like these are rarely addressed by biologists or resource managers because evidence about their severity is difficult to obtain. Despite our ignorance, complex species interactions are pervasive in nature and surely deserve less traditional approaches by researchers; their elusiveness and potential significance underscore the need for general surveys as a framework for continuous population monitoring (Freemark *et al.* 1993).

MANAGEMENT RECOMMENDATIONS

Our current understanding of bird populations in western Great Lakes forests provides several tools for NTMB conservation and management. Given the high diversity of bird species in this region, general planning cannot address the complex habitat associations and local distributions of all species. On the other hand, individual management plans for 50 or more species cannot be formulated at high levels of detail, let alone implemented, given today's limited conservation budgets. The most effective approach under these circumstances is to establish a clear problem orientation, leading eventually to species priorities. Thompson *et al.* (1993) used several criteria to rank the conservation priority of NTMBs in the Midwest but priorities may change rapidly. Data from specific management units (fig. 5) provide one means for identifying local species

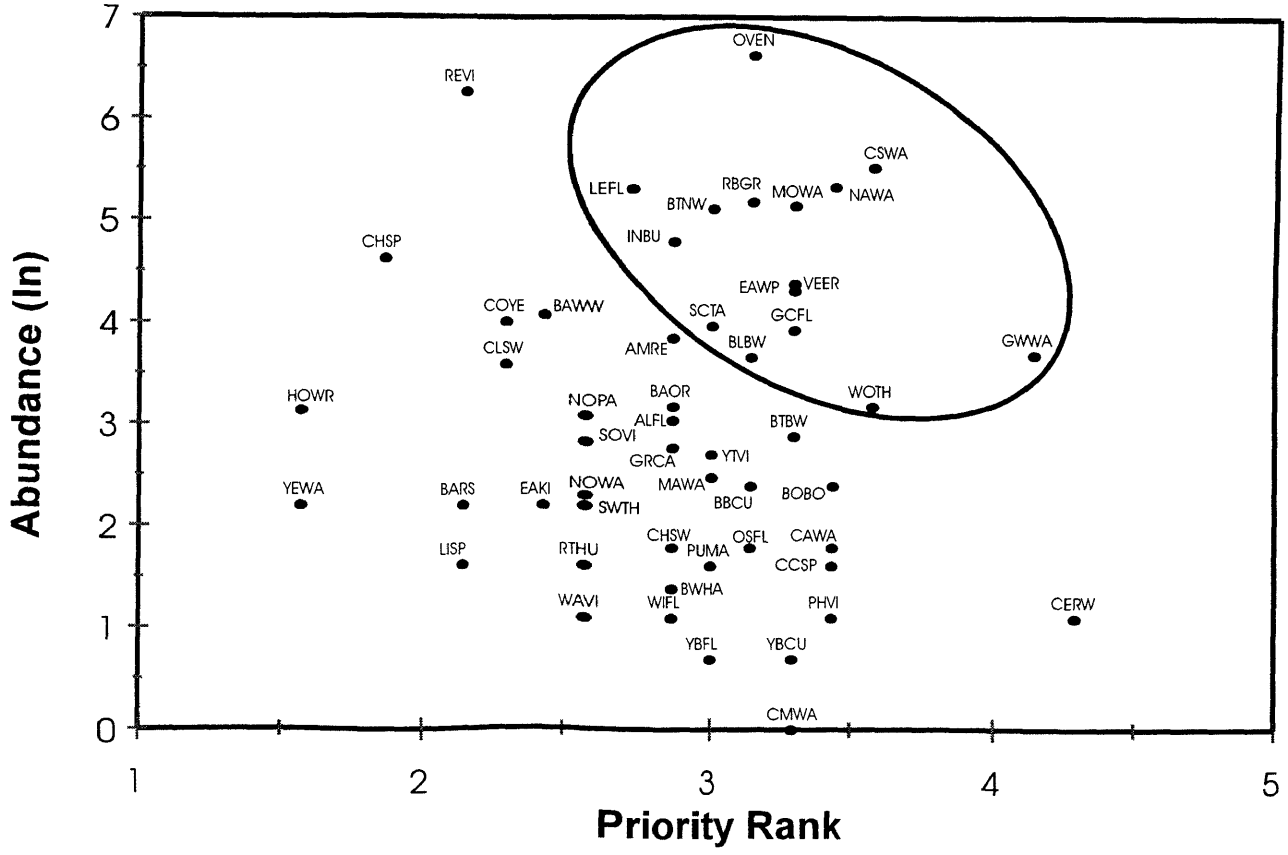

Figure 5.—*A suggested scheme for identifying conservation priorities of NTMB's in the Nicolet National Forest based on abundance in random roadside counts (1992-1995) and regional priorities recommended by Thompson* et al. *(1993). Priority species (circled) are both highly ranked by Thompson* et al. *(1993) and are relatively abundant in the Forest. Species abbreviations are standard American Ornithologists' Union codes formed by taking the first four letters of the bird's common name (if one word) or the first two letters of each word in its name (if two words), etc. Exceptions include the black-throated green warbler (=BTNW), blackburnian warbler (=BLBW), barn swallow (=BARS), and Cerulean warbler (CERW).*

priorities, which may differ from a continental perspective. If we accept the ranking scheme of Thompson *et al.*, (for the present) conservation actions will be most effective if aimed at species that are both highly ranked and abundant enough contribute to global populations. In other words, we look for species in the upper right of figure 5. In the Nicolet National Forest one species, golden-winged warbler, stands out. Other species with high priority include wood thrush, chestnut-sided warbler, Nashville warbler, mourning warbler, veery, rose-breasted grosbeak, great-crested flycatcher, eastern wood-pewee, and blackburnian warbler. Middle priority species with declining populations (e.g., olive-sided flycatcher) deserve special attention (Probst and Thompson 1996). Abundant species like ovenbird, black-throated green warbler, and least flycatcher also fare well in this analysis. If we use a ranking system from the northeastern U.S. and adjacent parts of Canada (Smith *et al.* 1993), or from the rest of the Midwest (Probst and Thompson 1996), black-throated blue warbler and Canada warbler also emerge as high priorities.

Of course, these priority ranks do not address globally rare species, year-round residents, and short distance migrants. Species like northern goshawk, yellow-bellied sapsucker, and brown creeper deserve attention in the western Great Lakes forests because their population densities are low or because the region encompasses a significant part of their geographic ranges. A separate system of ranking and population assessment (e.g., for raptors) will need to be developed for these species. Finally, NTMBs that are uncommon across their ranges (table 4) should be protected wherever they occur, especially since BBS data are less likely to detect population declines in these species.

We have emphasized the importance of specific information about the distribution and ecology of priority bird species. Even the best designed habitat protection plan will be ineffective if the target species is not present and breeding in the management area. Effective conservation plans must target specific areas within a much broader range where these species are known to occur and breed successfully (just as conservation efforts currently are aimed at bald eagle nests, etc.). Such information-intensive management is not possible for all organisms and issues, but the high public interest in birds and the foundation of information already available makes a top-down framework compatible with a empirically-based management program. Although local-level detail is important, scientists also must seek broad-scale patterns in order to implement step-wise, successive approximation of more integrated plans.

A systematic, standardized information base promotes cooperation among resource managers within and beyond the Lake States. We have documented significant geographic variations in abundance of many species, sometimes over distances of less than 200 km. Bird conservation measures will be most effective if they are aimed at areas of highest reproduction. Many bird species inhabiting this region's wet shrubs, lowland conifers, and upland mixed forests, for example, have a large portion of their geographic ranges in Canada, where conservation efforts might be more critical. Lessons from theory and practice, however, warn against ignoring peripheral populations (Takekawa and Beissinger 1989, Howe *et al.* 1991, Lesica and Allendorf 1995). Ultimately successful species protection will depend on informed, geographically diverse, and properly focused management plans.

High priority species occur in virtually all forest types and age categories (Probst and Thompson 1996, table 3). Indeed, several of the highest priority species in the Midwest as well as the western Great Lakes (fig. 5, table 3) occur in early successional forests. This can be interpreted as good news for advocates of intensive forestry, but the importance of mature forests also must be emphasized. Ongoing studies of birds in old-growth and managed forests (Howe and Mossman 1996) show that both neotropical migrants in general and priority species in particular are more productive in old-growth forests than in even-aged managed forests. This is not surprising given the overwhelming extent of old growth in pre-settlement landscapes (Frelich 1994). Thus, a regional perspective is needed for planning silvicultural systems across ecosystems and ownerhsips (Thompson *et al.* 1993).

Whereas existing information helps us establish species priorities and critical areas for conservation, our knowledge about ecological interactions in western Great Lakes forests is grossly inadequate. Land use activities influence area and edge effects, predator-prey

dynamics, source-sink interactions, and other landscape level processes; the specific consequences of forest management activities on these phenomena are very difficult to predict. The complex forest environment and the richness of bird species imply that meaningful predictions might never be possible with studies based on bottom-up interpretations of local populations.

However, ignorance about cumulative and indirect species interactions is not bliss for bird conservation. We suggest a simple approach for improving our knowledge about the ecological impacts of forest management. Each year, timber sales covering (overall) thousands of acres are administered by public agencies in the western Lake States. These sales are equivalent to experimental "treatments" of great significance for future planning efforts. If a sample of timber sales (i.e., "treatments") could be preceded by quantitative inventories of birds and their reproductive success, and followed by subsequent inventories using the same methods, the short-term, local effects of forest management activities could be tested directly. A data base of results, ideally shared across agencies and states, would yield a large and statistically powerful method for assessing the impacts of forest management. However, the method would be conceptually weak if not framed in a regional, multi-scale context (e.g. Thompson *et al.* 1992, Probst and Weinrich 1993). Continuous population monitoring of benchmark "controls," designed within a multi-scale framework of targeted surveys could help guide truly enlightened *adaptive management* (Walters 1979) of forest bird populations.

In summary, our recommendations for management of NTMB populations in western Great Lakes forests are modest: (1) outline realistic conservation goals at several administrative levels; (2) establish species priorities based on local field inventories and global or regional priority schemes (e.g., fig. 5); (3) identify where specific populations of priority species occur; (4) implement appropriate habitat management (or habitat preservation) measures at these specific localities, perhaps guided by ongoing experimental field studies; (5) coordinate planning strategies among forest management units and at multiple scales; and (6) design monitoring efforts strategically within a continental perspective. This multidimensional approach will improve chances that local efforts will have lasting global significance.

Answers to challenging questions about the impacts of regional population fluctuations, landscape configuration, area effects, harvest levels, edge effects, or altered species interactions on NTMB populations simply aren't available for the western Great Lakes forests, and extrapolation from studies in highly fragmented forest landscapes, or any local situation, are not necessarily valid. We have proposed a mechanism for obtaining answers to such questions by step-wise successive approximation (Freemark *et al.* 1993, Probst and Thompson 1996) based on continuous population monitoring. Although results and cumulative effects from such studies might not be evident for many years, these results provide tests of broader-scale assessments (Probst and Thompson 1996, Thompson *et al.* 1993) for long term forest management and bird conservation. Some of the most innovative management policies today might be those which generate answers for tomorrow's conservation problems.

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